Ultimate Causes of State Formation: The Significance of Biogeography, Diffusion, and Neolithic Revolutions

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Abstract

The timing of early state formation varies across the world. Inspired by Jared Diamond's seminal work, we employ large-n statistics to demonstrate how this variation has been structured by prehistoric biogeographical conditions, which have influenced the timing of the transition from hunter/gatherer production to agriculture and, in turn, the timing of state formation. Biogeography structures both the extent to which societies have invented agriculture and state technology *de novo,* and the extent to which these inventions have diffused from adjacent societies. Importantly, we demonstrate how these prehistoric processes have continued to shape state formation by influencing the relative competitiveness of states until the near present.

Key words: State formation, Neolithic revolution, Agriculture, Biogeography

The history of states is a tale about variation. States emerged in ancient Mesopotamia as early as 5000 years ago, whereas centralized governments did not appear on the English Isles until 3000 years later or in North America until about 400 years ago. One might explain this variation in the timing of early state formation by pointing to the role of great individuals that abound in the history of state formation. However, in this paper, we pursue the argument that such differences across time and space are not arbitrary but systematic. Building upon the work of Jared Diamond (1997), we present a line of reasoning accentuating the imprint of a set of prehistoric biogeographical conditions, which continuously shaped state development since its very beginning.

In their most simple form, we seek to answer two questions. First, why has the timing of state formation varied so markedly across the world? Second, what have been the long-term consequences for stateness of these differences? In its most simple form, our answer is that the timing of the rise of complex political organization was structured by the timing of the Neolithic revolution, i.e., the transition from hunter/gatherer production to agriculture, which set off an autocatalytic process of centralization eventually leading to state formation. The introduction of agriculture was, in turn, massively influenced by the fact that the last ice age left different parts of the world with different conditions in form of climate and fauna, which again influenced the costs and therefore the timing of the Neolithic revolution.

These factors matter, we argue, because they have continuously structured the relative competitiveness of states. Territories experiencing early state formation have simply been more likely to uphold stateness throughout history. Therefore, they have a competitive edge vis-à-vis other territories with late or no state formation in the regional and later global struggle about who occupied or colonized whom. In sum, we pursue the claim that, to a significant extent, when the glaciers of the last ice age withdrew and left the system of climate zones we know today, the destinies of the different regions in terms of state formation was being determined.

In developing this account, we move beyond the state literature's traditional focus on the European national (sovereign) states and their formation (e.g., Spruyt, 1994; Ertman, 1997). Rather, we focus on states as a more general mode of organization including, for example, city-states, feudal states, and empires. Specifically, we follow Charles Tilly (1992: 1-2) and understand states as ”coercion-wielding organizations that are distinct from households and kinship groups and exercise clear priority in some respects over all other organizations within substantial territories”. Our framework for understanding the emergence of this general class of organization focuses on two sets of factors both influencing the timing of transition at each explanatory stage: preconditions and diffusion. More particularly, each stage in the development from hunter-gatherer food production to the formation of a large-scale state can be reached through two principally different pathways. First, the necessary technological advances (e.g., the cultivation of crops suitable for agriculture) can be generated *de novo*. Second, these advances can be acquired from adjacent societies through processes of diffusion. Nevertheless, both preconditions and potential for diffusion are heavily structured by biogeography relating to continental extension, climate, and fauna. Based on these two sets of factors, we set up a sweeping model to explain the links between 1) hunter-gatherer economies, 2) agricultural production, 3) early state formations, and 4) subsequent state formations and levels of stateness, i.e., the degree to which a given territory is ruled by a locally based government above the chiefdom level.

In his book, *Guns, Germs, and Steel*, Diamond (1997) utilized a wide range of detailed case studies to develop this account of state formation. Inspired by Diamond's work, our ambition is to test his argument using large-n quantitative statistics. Thus, while extant anthropological case studies of state formation have established links between state emergence and the Neolithic revolution, "controlled comparisons employing large samples of cases and statistical methods are virtually non-existent" (Peregrine et al., 2007: 76).

Our endeavor is made possible by the pioneering data collection efforts of the economists Douglas Hibbs and Ola Olsson (2004; Olsson and Hibbs, 2005) and Louis Putterman. Focusing on measures of economic performance, they have used quantitative methods to explore and confirm the basic validity of the importance of biogeography for the timing of the Neolithic and subsequent economic development. Supplementing and using their data, we improve on the modeling of the causal sequences and extend the findings to the realm of politics by investigating the causes and effects of the timing of the Neolithic revolutions in the context of state formation.

One caveat is due: We fully acknowledge that the human history of state formation is full of twists and turns and surprising events. But the scope of this article does not allow us to discuss them further. 13,000 years of history is encompassed, meaning that our explanatory dynamics have to be placed at a high level of generality. Ideographic specialists might find these sweeping explanations too simplistic and point to specific cases at odds with the general trends we outline. This said, however, we are confident that we – empirically speaking – are significantly more right than wrong, *on average*. To achieve such general results is, after all, the basic premise and goal of this inquiry.

Timing of the Neolithic Revolution and the Origin of the State

States as central political organizations are an extremely recent invention in the evolutionary history of humans. All available evidence suggests that our species, Homo sapiens, evolved in societies with far less complex economic and political organizations. Economically, the Homo-lineage has since its advent with Homo Ergaster 1.8 million years ago depended entirely on hunted and gathered food (Boyd & Silk, 2003). Hence, early human societies were foraging societies. Politically, current evidence suggests that social obligations beyond simple friendship were defined exclusively in terms of kinship. According to van Creveld (1999: 2), "there were no superiors except for men, elders, and parents, and no inferiors except for women, youngsters, and offspring including in-laws". Archaeological evidence suggests that a change of these political conditions originates from approximately 3000 BC. Over thousands of years, bands and tribes, i.e., kin-based forms of political organization, gave way to more centralized forms of government in the form of increasingly complex chiefdoms followed by the first archaic states in ancient Egypt and Mesopotamia. Importantly, these political processes were paralleled by changes in economic conditions, especially, early inventions and promotions of agriculture (Allen, 1997; Maisels, 1990).

The parallel developments in the spheres of subsistence economy and political organization are far from accidental. Rather, the transition from a hunter-gatherer economy to agricultural production was essential for the formation of chiefdoms and, subsequently, states as agriculture enabled and advanced central political organization. By implication, the earlier a society shifted to agricultural production, the earlier a state could emerge. Therefore, we argue, the timing of the Neolithic revolution in a given region should determine the timing of the origin of state in that very region. This argument needs to be unfolded in more detail.

The available archaeological and anthropological evidence strongly suggests that when we talk about the Neolithic revolution, the rise of agriculture preceded the effects of political organization; research has yet to discover a prehistoric society with centralized political organization but without agricultural food production (Putterman, 2008; Wright, 1977). Agriculture provides a number of preconditions for the emergence of states as centralized political organizations governing over territory (see e.g., Diamond, 1997; Peregrine et al., 2007). First, hunter/gatherer-groups are nomadic whereas, in contrast, agriculture allows groups to settle and, hence, to take control over a territory. Second, compared to hunting and gathering, agriculture is an extremely efficient mode of calorie production. Hence, agriculture allows populations to grow to a size when it becomes meaningful and even necessary (see below) to rely on more formalized forms of social organization. Third, agriculture and fixed settlements enable food storage. Storage of food is linked to important features of the state as it allows taxation and subsequently the emergence of division of labor. In hunter/gatherer-societies, all members are involved in the subsistence economy whereas storage of taxed food allows a part of the population to devote their full time to non-subsistence related activities. Thus, storage provides the precondition for social classes not directly involved in production such as public servants and professional soldiers.

These arguments imply that agriculture provides the preconditions for state formation. However, the links between the two phenomena run deeper. Hence, in the words of Gellner (1988: 21), the Neolithic revolution “encourages, and often perhaps necessitates, the emergence of specialized agencies of coercion”, i.e., the formation of states. In their comprehensive account of anthropological research on the evolution of human societies, Johnson and Earle (2000) argue that the population growth following agricultural transition ignites an autocatalytic process when population growth creates a pressure for the intensification of the subsistence economy which, subsequently, causes further population increase and further production intensification etc. These accelerating pressures for production intensifications have a number of important consequences. First, they leave fewer buffers against starvation in bad years making collective systems of risk management more attractive. Second, they facilitate resource competition (and ultimately, warfare) which fuels group-wide integration and allow efficient leaders to emerge (see also Graber & Roscoe, 1988). Third, they put premium on more sophisticated production technology, a development that requires community-wide collaboration. Fourth, they increase the benefits of trading and thereby also the transfer of decision-making power to single individuals such as the head trader (Johnson & Earle, 2000: 30-32). In sum, based on current anthropological research, Johnson and Earle (2000) argue that managerial problems associated with the consequences of the Neolithic revolution create pressures to develop more centralized political organizations, a process which leads to the formation of the early states (see also Stanish, 2001).

Current research suggests that the Neolithic revolution is significant for the rise of complex political organization; however, the transition to agriculture did not take place at the same time in all parts of the world. For example, the first time agriculture emerged in Mesopotamia was around 8500 BC, but it did not commence in Western Europe until five thousand years later. Likewise, in Australia humans lived for 46,000 years without agriculture until the Europeans eventually introduced it in the late 18th century. Hence, it might be more appropriate to talk about revolutions in plural than about a single revolution. To the extent the state developed to solve managerial problems arising from agricultural production, this different timing of the reliance on domesticated plants and animals in different regions should become a key variable in explaining the timing of early state formation. As Diamond (1997) also argued, the earlier a region moved from a subsistence economy based on hunting and gathering to an agricultural subsistence economy, the earlier the chain reaction is ignited, and the earlier it should culminate with the emergence of a state. In other words, we expect the timing of the Neolithic revolution in a region to predict the timing of the origin of the state. This predicted causal relationship constitutes our first empirical hypothesis (H1, see figure 1).

Figure 1 about here

Explaining Neolithic Revolutions

Therefore, state-based political organizations first emerged in Mesopotamia because agriculture was first invented in this very region. However, in many ways, this just begs the question: Why did agriculture emerge so early in this region? In answering this more fundamental question, we are most indebted to Diamond's work. His fundamental insight is that while the timing of the Neolithic revolution varies markedly across the world, this variability is far from random. According to Diamond, the transition from hunter-gatherer economy to agricultural production constitutes a highly structured – but not necessarily intentional – assessment of transitional opportunities. This assessment is affected by a set of clearly defined factors relating to the regional existence of plants and animals suitable for domestication. Hence, to understand the ultimate reasons for why states emerged early in, e.g., the Middle East and not in, e.g., Oceania, we need to understand the dispersion of domesticable plants and animals. Moreover, this condition urges us to move one step further back in the causal chain to investigate the significance of climatic differences.

A crucial element for the success of agricultural experiments is "to have good material to work with" (Olsson & Hibbs, 2005: 916; cf. Peregrine et al., 2007). Some animal species are simply more suitable for domestication than others because of lack of aggressive temperament, herbivorous diet, and a psychology adapted to dominance hierarchies. More particularly, out of the world's 148 species of big, terrestrial, and herbivorous animals, only fourteen have ever been domesticated. Importantly, nine of these originated in Western Eurasia including important species such as the wild ancestors of goats, sheep, pigs, and cows. In fact, these four species, which even today predominate agricultural production, come from the Mesopotamian areas, labeled the Fertile

Crescent, where agriculture first originated (Diamond, 1997: 140-141), and where the world's first states emerged some 5500 years later. Equally, some plant species are more suitable for domestication. In this regard, size and taste are of course important factors, but crop suitability is affected by a number of other more subtle features such as plant life cycle, seed-dispersal mechanisms, and pollinating biology (Diamond, 1997: 120, 136-137). Also in the domain of plant species, Western Eurasia in general and the Fertile Crescent specifically were allotted a massive portion of the world's material for domestication; out of the 56 heaviest-seeded plant species, no less than 33 originated in Eurasia.

By implication, when the glaciers of the last ice age retreated 11,000 BC and changed the regional opportunities for hunting and gathering, the costs and benefits associated with agriculture as an alternative subsistence strategy was differently dispersed across the regions of the world. Biological preconditions for agriculture simply differed across regions. Some regions – such as the Middle East – had many animals and plants suitable for domestication, other regions – such as the Pacific Islands – had virtually none, which, of course, can be expected to affect the timing of the Neolithic revolution in the specific place. The less the transitional costs due to a high number of suitable animals and plants, the earlier the transition to agriculture should occur, and the earlier the autocatalytic effects on state formation should take off. Our second hypothesis (H2) tests the effect of biological conditions on the timing of transition to agriculture.

The final step in this first causal account of the rise of early states focuses on Diamond's (1997) proposition saying that the existence of favorable fauna for the rise of agriculture is related to basic climatic conditions of the region. The Mediterranean climate, which dominates large parts of Western Eurasia, is specifically superior to the emergence of agriculture compared to other climates.[1] First, the climate is more fertile and more hospitable to plants and large animals than in more extreme climate zones as deserts or tundra. Second, diseases harmful to potential domesticable animals and crops are far less prevalent compared to otherwise bio-diverse climate zones as the tropics (Kamarck, 1976). Third, the Mediterranean climate also affects the availability of domesticable material in more subtle ways due to the mild wet winters and long dry summers in this climate zone, which specifically selects for plants with an annual life cycle (Blumler, 1992; Blumler & Byrne, 1991). Due to their short life span, annual plants invest heavily in the growth of

[1] Notice, however, that even though the Mediterranean zone of Western Eurasia showed the most valuable domestic plants and animals, the other four Mediterranean zones (California, Chile, South Africa, and Southwest Australia) were not sites of independent origins of agriculture. Moreover, the other eight areas of independent agricultural origin lie outside of Mediterranean zones (Diamond, 1997: 99, 138).

seeds, which they use for reproduction, and invest significantly less in wood and stems (Diamond, 1997: 136). Because seeds constitute the edible parts of the plant, annual plans are highly attractive to the prospective farmer. Consequently, the Mediterranean climate specifically selects for plants particularly suited for agricultural production.

Given this, our third hypothesis (H3) is that prehistoric climate indirectly conditions the timing of the Neolithic revolution through its effect on the available biological material. Accordingly, we do not expect the difference in the timing of the autocatalytic process of production intensification, ultimately leading to early state formation, to be caused by a *random* dispersal of domesticable plants and animals. Rather, we expect this dispersal to be highly structured by even more basic climatic factors.

To some extent, H2 and H3 have been tested by Hibbs and Olsson (2004; 2005) in their important and pioneering work, in which they subject Diamond's account to an empirical test using quantitative data. However, while their analyses of the relationship between climatic and biological conditions are placed at the country-level (n = 112), the analyses of the effect these conditions might have on the timing of agricultural transition are placed at the region-level (n = 6). Therefore, these latter analyses are based on a very small number of cases and, as Putterman (2008) argued, do not allow for the modeling of different pathways to agricultural production within the same region. Furthermore, the analyses fail to provide a test of the causal sequence of the argument. Hibbs and Osson (2004) demonstrate that climatic factors are correlated with domesticable material, which again is correlated with agricultural transition, but they do not directly test the clear suggestion in Diamond's account that climatic factors should influence agricultural transition *mediated* by the availability of domesticable material. We remedy both these shortcomings and take the causal sequence one step further by including the timing of state formation.

Diffusion Processes

In many ways, the model outlined so far is blind to the fact that humans interact not only within societies, but also between societies and even over great distances. Thus, archaeological evidence clearly supports the notion that large-distance social exchange has been with our species for hundreds of thousands of years (Cosmides & Tooby, 2005) thereby suggesting different pathways through which societies can develop an agricultural subsistence economy and form a state. First, societies might invent these economic and political technologies *de novo*. Thus, in the upper part of figure 1, our model focuses on area-specific preconditions for independent agricultural innovations and the state. Second, however, the existence of exchange between prehistoric societies makes it possible for societies to learn from other societies (Putterman, 2008). As Diamond (1997) argued, diffusions of knowledge and technology from one society to another transform the transitional costs involved in both agricultural transition and state formation and, hence, can be expected to affect the timing of both events.

In this section, we describe how diffusion processes facilitate the autocatalytic process of state formation at these two stages. Notice that although diffusion processes surely are social in nature and governed by human agency, we expect that the opportunities for engaging in successful diffusion at both stages are structured by basic biogeographic factors.

Agriculture is apparently only invented *de novo* in six or nine places across the entire world (Diamond, 1997: 100). Everywhere else, agriculture was introduced through diffusion, i.e., crops and animals already domesticated were disseminated from a founder society to a neighboring society and beyond. Yet, the speed with which crops and other technologies of food production spread from its founding sources varies (Diamond, 1997: 177). Tellingly, detailed archaeological analyses of agricultural transition show how specific crops from the Fertile Crescent spread extremely rapidly outwards to Western Europe and reached Greece around 6000-5000 BC, central Western Europe between 5000 and 3800 BC, and outer areas such as Portugal and Scandinavia between 3800 and 2500 BC (Diamond, 1997: 181). In contrast, in the Americas, agriculture was founded independently at least at two different locations (Mesoamerica and Andes/Amazonia), and crops and domesticated animals spread at a much slower pace and less far. Diamond argues that continental differences in the speed with which domesticated material were diffused relate to differences in the shape of continents. Specifically, domesticated material travels easier in parallel to than across the latitude of an original starting point and therefore spreads more easily across continents with an East-West axis orientation (e.g., Eurasia) compared to continents with North-South oriented axes (e.g., the Americas) (Diamond, 1997: 176-191). The reason is simply that climate zones extend in parallel with latitudes, and that both crops and animals are adapted to climate-specific environments. Plants, for example, use climate-specific seasonal changes in day length, temperature, and rainfall to trigger basic processes of seed germination, flower development etc. (Diamond, 1997: 184).

Diamond's argument implies that societies – located within a climate favorable to agriculture – should be less dependent on the existence of original domesticable material, because they will be more able to make use of material cultivated by others. Hence, in these societies the transition to agriculture should be eased not only because their climate selects for domesticable material (cf. H3), but also because the availability of original domesticable material in itself becomes less important. However, Diamond's explanation of the agricultural diffusion points to an additional factor that needs to be considered: It is not enough for a society to be able to exploit crops and animals domesticated elsewhere; it is equally important that available societies are within reach in order to diffuse crops and animals. From the perspective of a specific society, one general determinant of whether such material is available would be the size of the continental land mass located within the climate belt favorable to agriculture. A larger belt should, *ceteris paribus*, imply a large number of available societies *from* where these materials could be diffused (either directly or indirectly through more proximate societies).

As Diamond observed, one clear way to measure the size of a climate belt on a given land mass is the East-West extension of the land mass. Hence, we predict that the following combination of geographical factors increases the likelihood of agriculture being diffused to a specific society; the society should have a climate favorable to agriculture, and it should be located on a land mass with a large East-West extension. Our fourth hypothesis (H4) is that the combination of these factors should facilitate agricultural transitions by making societies less dependent on the existence of original domesticable species. In effect, H4 postulates the existence of an interaction effect between these geographical conditions and the biological conditions for agriculture so that these biological conditions become less important when geography allows the biological materials to be diffused from elsewhere.

Just as the transition to agriculture is technology-intensive, so is the transition to state-level political organization. Centralized control over a territory requires technological solutions to the problems of administration and social control. According to Algaze (2001: 213), these solutions were historically provided by "cumulative innovations in the ways knowledge were gathered, processed and transmitted" relating to, (e.g.), systems of writing and accounting. The importance of administrative technology supports that diffusion also operated on the processes leading to state formation after the Neolithic revolution. In fact, archaeological evidence suggests that states only emerged independently of outside influence in a few territories such as southern Mesopotamia, China, the Indus Valley, and Mexico whereas all other processes of state formation were influenced by diffusion of technology (Price, 1978).

Trade and other routine social interactions between societies with different levels of political complexity were important factors in diffusion-based state formation (Price, 1978;

Parkinson & Galaty, 2007). This observation is critical because it suggests that the early diffusion of administrative technology flowed through already-established channels of exchange and, as a result, is regulated by the same basic structural factors first to mold these channels of exchange. Based on a similar reasoning, Diamond (1997: 261-264) suggests that the geographic factors examined above not only impinge on the diffusion of food production but also on the diffusion of administrative technology. In Diamond's (1997: 190) own words, "societies that engaged in intense exchange of crops, livestock and technologies related to food production were more likely to become involved in other exchanges as well". Hence, societies placed within these geographically structured networks of exchange should not only develop agricultural food production at an earlier stage (cf. H4), but the economic revolution should also more easily and more quickly translate itself into a political revolution in terms of state formation.

The East-West extension of the continent where a society is located also taps another geographical condition that might independently influence the potential for diffusion of administrative technology, namely the sheer size of the continent. A large continent creates, all else equal, a higher number of available societies from which administrative technologies can be diffused (Diamond, 1997: 257). Hence, presumably, our compound of geographical conditions not only facilitates diffusion of administrative technology through already established channels, but also through new channels. Big land masses with large East-West extensions simply have more opportunities to create the latter.

The fifth hypothesis (H5) concludes our model of state formation. It predicts that the geographical compound of climatic and continental factors influences the time span from agricultural transition to state formation because it regulates to which extent societies can learn administrative technologies through both new and established exchange channels. Correspondingly, H5 postulates the existence of an interaction effect between these geographical conditions and the timing of the Neolithic Revolution in a given society such that the timing becomes less important for the subsequent timing of state formation when geography allows for diffusion.

Hibbs and Olsson (2004; Olsson and Hibbs, 2005) and Putterman (2008) have provided the most thorough test of these arguments to date. Regarding H4, Hibbs and Olsson's (2004) analyses demonstrate strong linear effects of the outlined geographic conditions on the availability of domesticable material and on the timing of agricultural transition. Putterman has replicated and refined these analyses with more detailed measurements of agricultural transition. However, in both cases, they fail to model the interactive relationship specified in H4, presumably, because Hibbs and Olsson's scores of the measure of domesticable material are assigned on a regional rather than a national basis. As all countries within a region are assigned the same scores, it simply becomes more difficult to model diffusion processes within a region. Yet, as we show in our analysis, even in face of this conservative test condition, H4 is still supported. Regarding H5, the present study is to our knowledge the first to provide a systematic quantitative test of this hypothesis. Importantly, however, Putterman (2008) provides some initial evidence for the hypothesis by showing that regional measures of agricultural transition, which take diffusion effects into account, are superior to country-specific measures in predicting subsequent economic developments in individual countries.

Timing of Transitions and Developments in Stateness

We have argued for the existence of an unbroken causal chain that began with the withdrawal of the glaciers of the last Ice Age and ended with the formation of a state within a certain territory. For some countries, this causal process has culminated within the last few centuries, but for a large number of countries the emergence of state-level political organization took place several thousand years ago. Hence, one might wonder whether these archaic processes are relevant for understanding the subsequent course of states, and more specifically whether the effects of the timing of the archaic economic and political transitions reveal themselves even in the modern political landscape. The core claim we pursue in this section is that, "the state is an adaptive success" (Price, 1978: 161). Thus, for the major part of state history, societies with more ancient states have had competitive advantages over, first, non-state societies and, second, societies with less developed states, meaning that the course of states' history has been significantly shaped by the timing of their formation (Diamond, 1997; see also Chanda & Putterman, 2007).

The success of the state as a form of political organization is related to both its internal and external strengths (Cohen, 1978). As argued earlier, the state is formed in parts because it solves specific internal problems relating to production intensification. These problems do not wither away with the formation of an initial state, but continue to intensify as the solutions brought about by a centralized political organization allow populations to increase further. This again requires further intensifications of food production, and subsequently increased social coordination and centralization etc. (Johnson & Earle, 2000). In this respect, it is vital that the state is the first political organization in human history with seemingly unlimited growth potential which exactly allows it to continuously meet the increased demands of centralization and expansion. As argued by

Cohen (1978: 4), ”hunting bands, locally autonomous food producers, and chieftaincies each build up the polity to some critical point and then send off subordinate segments to found new units”, while the state “can expand without splitting, incorporate other polities and ethnic groups, and become more populous, more heterogeneous, and more powerful, with no known upper limit on its size or strength”. Because of increased intensification requirements and the states' ability to meet them, we expect that where states have initially been formed, territories do not reverse back to less complex modes of political organizations. The autocatalytic processes propelling the states into being also ensure their persistence and continued expansion.

These internal state functions are paralleled by external advantages of states over non-state societies in conflicts, violent as well as non-violent. The advantages consist of 1) more numerous forces of both labour and soldiers as a consequence of larger populations; 2) more coordinated production strategies (see e.g., Parkinson & Galaty, 2007) and, in the case of warfare, more coordinated attack and defence strategies; and 3) higher levels of technological development in general and more sophisticated technology of production and warfare in particular (Diamond, 1997: 281). The latter advantage relates to the simple fact that technological inventions require a certain level of specialization and division of labour which has solely developed in societies with state-level organizations. Because of these competitive advantages, more complexly organized societies have continuously outcompeted and overtaken less complex societies up to the point when almost all societies in the contemporary world are under some form of government control. Notice, however, that this set of factors is not only relevant for the relative power between states and non-state societies but also for the relative power between different states. This means that more populated, more centralized, and more technologically developed states should, all things being equal, dominate less populated, less centralized, and less developed states.

Population growth and intense technological developments are continuous processes, which are triggered at the very point in time when societies adopt agricultural modes of production, and they are intensified by the emergence of state-level political organization. Therefore, we simply expect that differences in the timing of these events will influence the relative power of societies subsequently. There is one clear implication of this, viz. that territories with late state formation have had greater difficulties in achieving the status of independent statehood in the course of state history. In principle, we should expect these effects to hold up to the near past. However, as argued and demonstrated by Putterman (2008; Chanda & Putterman, 2007), diffusion processes again impinge on the effects of timing and do so in more dramatic ways than before. With the great voyages of discovery, beginning in the late 15th century and headed by pioneers such as Christopher Columbus, Vasco da Gama, and Ferdinand Magellan, the European colonization of the Americas, Sub-Saharan Africa, and Oceania, it took off.

As a result, diffusion processes extended over far greater ranges than before in human history and were much less blocked by ecological and geographical barriers. Previously, diffusion involved conquests of neighbouring societies largely influenced by the same geographical and biological conditions as the conquerors. In these cases, differences in the social complexity of the conquered and the conqueror were relatively minimal. Post-Columbian colonizations, in contrast, broke the links between social complexity and biogeography because developments in transportation technology (e.g., the invention of long range ships) allowed states to colonize societies, whose history had been shaped by highly different biogeographical factors. In this way, state institutions diffused to societies with low levels of complexity and technological development. When these colonies subsequently received independence, their inherited level of technological development was at odds with the actual timing of their agricultural transition and first state formation.

Accordingly, we expect that the timing of agricultural transition and, especially, the timing of state formation to predict, consistently and strongly, a given territory's levels of stateness in the pre-Columbian period, i.e., up until 1500. However, the effects of these predictions begin to unravel in the post-Columbian period and to accelerate after around 1800 when the Western powers got serious about taking over the globe. These predictions constitute our hypotheses 6 (H6) and 7 (H7) as illustrated in figure 2.

Figure 2 about here

Putterman (2008) has provided the most thorough tests of these hypotheses to date. Using large-n quantitative methods, he has demonstrated that the timing of the Neolithic revolution is a strong predictor of cross-country differences in economic performance in 1500, but a much poorer predictor of performance in 1997. However, our hypotheses expand on these findings in two ways. First, by proposing that these findings are also present when the dependent variable is the timing of first state formation, and when independent variables are subsequent levels of local state control. Second, we predict that timing *consistently* predicts the existence of a state over the full pre-Columbian period, and that 1500 constitutes the *exact* moment in history – a critical juncture – when the relationship begins to unravel.

As Putterman (2008) also argued, the unravelling of the relationship predicted by H7 is a direct consequence of the basic theoretical argument outlined in the previous sections of this paper. The background for the described patterns of colonization is exactly that biogeographical factors endowed different continents with different obstacles for development. Hence, Diamond's (1997) main thesis is that the Europeans conquered the New World and not vice versa because Europe had more favorable conditions for agriculture and state formation compared to the Americas, which thus accelerated Europe's technological and institutional development.

Measurement

To minimize problems of selection bias, we have compiled data for as many countries as possible. Hibbs and Olsson base their analyses on 112 countries, whereas our dataset is complete for 171 countries concerning all the variables of the basic model from geographic background conditions to state formation. We use today's countries as observational units although the most relevant units of analysis have changed significantly over time. The main reason is that most of our measurements are based on the datasets and coding rules provided by Hibbs and Olsson, on the one hand, and Putterman, on the other. Moreover, like them, we are interested in studying possible impacts of ultimate factors on contemporary differences and similarities.

The measurement of the conditions is necessarily rough, but Hibbs and Olsson and Putterman have suggested and constructed reasonable proxies. As regards the geographical conditions, they are measured by three variables. The first variable is the East-West extension as measured by the continent's distance in longitudinal degrees between the points most to the east and west not situated in the infertile regions near the poles. Or, if there is no direct connection with the core landmass of a continent, the horizontal extension of the island or island group is used. Hibbs and Olsson divide the East-West distance with the North-South distance to construct a measure of the orientation of the landmasses. However, even though Diamond emphasizes the importance of a continent's axis, the theoretically important aspect is whether the horizontal, land-based diffusion of plants, animals, technology etc. is facilitated; a relationship, which is not modified by a long North-South distance. We thus argue that the broadness of a continent is more important than its axis. Empirically speaking, this adjustment does not make much of a difference since the landmasses with a horizontal axis also tend to have the longest East-West extension and vice versa. Note, furthermore, that the correlation of our measure of broadness shows an extremely high correlation with landmass size (island, island group, continent) on which the country is situated (Pearson's $r=0.911$, $p < 0.000$). In this way, the variable also reflects size as emphasized in the elaboration of the diffusion hypotheses.

Concerning climate, we follow Olsson and Hibbs (2004) and measure the condition by using two variables. The first, a four-point scale, distinguishes between climates according to their favorability to agriculture. This measure is based on the Köppen climate classification system[2] that combines average annual and monthly temperatures and precipitation and the seasonality of precipitation. The other variable used to capture climate is distance from equator in absolute latitude degrees.[3] We use the scores (regression method) from the first principal component of these two variables to measure the climate. To measure the geographic potential for diffusion, we employ the first principal component scores of all three geographic variables.

The biogeographic factor is also captured by variables constructed by Hibbs and Olsson. First, the number of domesticable plants in the region, that is, annual or perennial wild grasses known to exist in prehistory with a mean kernel weight exceeding 10 milligrams. Second, the number of domesticable animals in the region, that is, big mammals weighing more than 45 kilos present in prehistory.[4] In our model, the scores derived from the principal component of these variables to construct a combined measure. Note that the scores of this variable have been assigned on a regional rather than national basis. Hence, diffusion is already integrated in the measure, meaning that our diffusion condition faces a very conservative test when it comes to explaining agricultural transition.

There is a similar problem with Hibbs and Olsson's data on the transition from reliance upon gathering and hunting to reliance upon agriculture. Fortunately, Putterman has constructed a more detailed, country-specific dataset on the number of years before the present (i.e., 2000 A.D.) since such transition took place. The dataset is based on readings of expert judgments of when people in particular areas got more than half of their calories from cultivated foods and domesticated animals. For countries with little archaeological evidence available, an estimate, by means of interpolation,

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[2] The data used are from Hibbs and Olsson's (Hibbs, 2005) dataset. When filling in the missing values, we employed their coding rules.

[3] The data are from the World Bank (1999) – also used by Hibbs and Olsson – supplemented with information from CIA's The World Factbook in case of missing values.

[4] The specific data are from Hibbs and Olsson's (Hibbs, 2005) dataset, but, in contrast to them, we do not assign the United States, Canada, Australia, and New Zealand the same values as Europe. When filling in the missing values, we employed their coding rules.

was based on evidence about the flow and spread of farming in neighboring countries and the region. We use Putterman's data to capture the timing of the Neolithic revolution.[5]

The 'endpoint' of our basic model is initial state formation. To operationalize this variable, we have gathered information on when a government above the tribal/chiefdom level, such as kingdoms, empires, city-states, national states etc., was originally initiated in or induced upon the area represented by present-day countries. The variable is measured in number of years before the present (i.e., 2000 A.D.). We have primarily relied on a corresponding component in Putterman's State Antiquity Index based on the historical accounts presented in the Encyclopaedia Britannica. However, this dataset does not include a number of small countries, and it only dates back to year 1 A.D., when many areas had long had significant experiences with state formation, some even for several thousand years. Thus, to support our analysis, we have assigned scores according to information provided by different country-specific, historical, and regional entries in the same source for an additional 65 countries.[6] Having done so, we can only comply with Putterman's (2007) remark that coding this issue has been "extremely difficult because the demarcation between tribes and states is imperfect and includes many shades of gray. Also, the available information is often quite incomplete", especially regarding the remote past. This said, however, the dataset is the best available given the request of a scope general and broad enough to suit our investigation.

Moving beyond the operationalization of the basic model, we use Putterman's State Antiquity Index to measure the degree of stateness. The index scores cover each of the 39 half centuries dividing the period from 1 to 1950 A.D. They are based on evaluations of three questions: 1) Is there a government above the tribal/chiefdom level? (yes=1 point, no=0 points); 2) Is this government foreign or locally based? (locally based=1 point, foreign based/colony=0.5 points, local government with substantial foreign oversight=0.75); 3) How much of the territory of the modern country was ruled by this government? (over 50 percent=1 point, between 25 percent and 50 percent=0.75, between 10 percent and 25 percent=0.5 points, less than 10 percent=0.3). The scores on the three questions have been combined through multiplication and then multiplied by the number of years, i.e., 50. In this way, a country has been assigned the value of 50 if it was an autonomous state in the period in question, 25 if the entire area was ruled by another country, 0 if it had no government above the tribal/chiefdom level, etc.

[5] We have supplemented the dataset with eight additional cases, all small countries, following Putterman's guidelines. Documentation of the sources will be provided upon request.

[6] Documentation of the specific information used to score the cases will be provided upon request.

Finally, it should be noted that the importance of inter-regional diffusion processes implies that countries from the same region are more similar than countries from different regions. As our observational units are countries, this violates the assumption of independence of observations. To avoid estimation bias, we use cluster robust estimators. Specifically, in all analyses the following nine regions are specified as clusters: 1) Pacific Islands, 2) Australia, 3) South America, 4) Central America, 5) North America, 6) Sub-Saharan Africa, 7) Southeast Asia, 8) East Asia, 9) Near East, Europe and North Africa. This division follows the systems of agricultural diffusion (Hibbs & Olsson, 2005).[7]

Results

We begin our empirical of the derived hypotheses in the distant end of the causal sequence established theoretically. Hence, our initial analyses demonstrate how geographical and biological factors influence the timing of the Neolithic revolution in different areas by serving as preconditions and by regulating the potential for diffusion. Subsequently, we turn to the main variable around which our argument has been organized – i.e., the timing of the first state formation in a given area – and investigate the diverse effects of Neolithic revolutions and biological and geographical conditions. Finally, we show how early states consistently seem to have been endowed with competitive advantages with respect to stateness from 0 AD up to the near past.

In Table 1, we test H3, which links climatic factors to the availability of domesticable material within an area. The data show strong support for our hypothesis. As revealed in Table 1, the effect of a favorable climate for agriculture on the biological conditions for agricultural transition is highly significant and explains 54 percent of the variance in prehistoric differences in available domesticates.[8] This only replicates Hibbs and Olson's (2004) earlier conclusions, but also testifies to the robustness of Diamond's account as our data contains around 65 percent more cases.

Table 1 about here

In table 2, we investigate whether these conditions also influence the timing of transition to agriculture. Our causal model suggests that climatic factors should indirectly accelerate

[7] The only exception is that Hibbs and Olsson classify the Pacific Islands and Iceland together because both lack prehistoric domesticable material. As we are interested in correcting for regional similarities, we instead classify Iceland with the rest of Europe.

[8] Notice that the explanatory power would probably have been even higher if diffusion had not been integrated in the measure of biological conditions.

the transition to agriculture by regulating the prehistoric availability of domesticable material which is tested in models 1 and 2. Model 1 demonstrates a highly significant and positive effect of climate on the timing of the Neolithic revolution. Specifically, the agricultural transition happens around 3800 years before in areas where the climate was favorable to agriculture compared to areas with unfavorable climate. As expected, this positive effect of climate disappears in model 2, where we control for the more proximate factor in the causal sequence, i.e., biological conditions in the form of prehistoric availability of domesticates. In line with H2, biological conditions have a significant, positive, and large effect on the timing of the Neolithic revolution in a given area; therefore, societies with the most favorable conditions on average shift from hunting and gathering to agricultural modes of production 5600 years before societies with the least favorable conditions. The inclusion of this factor boosts the explained variance to 64 percent. Hence, we are able to replicate the findings of Hibbs and Olsson using a much larger number of cases and a more fine-grained measurement of the timing of agricultural transition. Furthermore, for the first time, we have provided general evidence of the causal sequence between climate, domesticable material, and the timing of the Neolithic revolution. This indirect effect of climate through the availability of domesticable material can be further tested using Sobel's formal test of mediation. In line with our causal sequence, we find that the measure of biological conditions significantly mediate the relationship between climate and the timing of agricultural transition (Sobel's $z = 10.612$, $p < 0.000$).[9]

Table 2 about here

In model 3, we test H4, which states that prehistoric endowments of domesticable material is less important for the timing of agricultural transition in areas with favorable geographical conditions for diffusion of domesticates from other societies. The hypothesis is tested by including our measure of geographical conditions and a two-way interaction term between the geographical and biological conditions. The negative sign of the interaction term confirms our

[9] While the biological conditions fully mediate any positive effect of climate on the timing of the Neolithic revolution, Model 2 reveals a significant negative effect of climate after inclusion of biological conditions. Presumably, the reason is that our climate variable measures the present and not the prehistoric climate. Whereas climate has generally not changed much over the period in consideration, in a range of the Middle-Eastern areas, where agriculture originally emerged, climate has changed significantly to the worse (Diamond, 1997: 410-411). Thus, these cases have low to average values on the climate measure but exceptionally high values on the transition measure, which – when controlling for biological conditions – facilitates a negative correlation between climate and the timing of agricultural transition.

expectation, and the term reaches significance. Hence, a society's initial endowment of domesticable material is less important when the geographical conditions are favorable for the diffusion of domesticates from other societies. The moderate p-value of the interaction term should be judged against the fact that the available measure of prehistoric biological conditions already takes some diffusion into account that reduces the variation left to be explained. Still, the data corroborate H4 and testify the importance of diffusion of domesticated crops and livestock for the timing of the Neolithic revolution. Thus, our tests of H3, H2, and H4 support Diamond's claim that the agricultural transition is structured by basic climatic, continental and biological factors. Far from being a random process, the different timings of the Neolithic revolutions in different parts of the world was largely linked to the different climatic and biological conditions, which appeared after the last ice age.

Our main argument says that agricultural transition triggers an autocatalytic process leading to the formation of the state, and, in particular, that the earlier this process is offset, the earlier centralized political organization has emerged in a given area (H1). The results linked to our test of these processes and their dependencies on geographically structured diffusion are presented in table 2. In order to evaluate the causal logic of our theoretical model, we begin our test of H1 by moving one step backwards in the causal chain and by investigating the indirect effects of biological conditions.

Model 1 reveals a strong and highly significant effect of biological conditions on the timing of the first state formation in a given area. The results indicate that states on average emerged 1800 years before in societies with favorable biological conditions for agriculture than in societies with unfavorable conditions. Model 2 integrates the timing of the Neolithic revolution, and in line with the outlined causal sequence this inclusion removes any effect from the biological conditions for agriculture. Not surprisingly, formal tests of mediation reveal that the timing of the agricultural transition significantly mediates the effect of biological conditions for agriculture on state formation ($z = 8.703$, $p < 0.000$). Furthermore, the data clearly support H1. The measure of agricultural transition is highly significant and positive, as expected, and the timing of the agricultural transition alone explains a massive 61 percent of the variance in the timing of state formation. Thus, the two transitions are directly linked, and the earlier a society moved from reliance on hunting and gathering to reliance on agricultural food production, the earlier a state emerges. Specifically, the first state in a given area is on average about 40 percent as old as agricultural production in the same area. An inspection of the empirical pattern suggests that the relationship between the timing of the two events is not strictly linear but more curvilinear. To avoid misspecification, this relationship is modeled in model 3, where a quadratic term for the timing of the Neolithic revolution is included. The quadratic term is highly significant, and this more refined modeling of the relationship raises the explained variance slightly. The precise nature of this quadratic relationship is discussed below.

In model 4, H5 is tested by including our measure of geographical conditions for diffusion and a diffusion term in the form of a two-way interaction term between the conditions and the timing of the Neolithic revolution. The interaction term is highly significant and increases the explained variance to 68 percent. To ease the interpretation of this highly complex model involving both quadratic and interactive effects, figure 3 graphically displays the effects.

Figure 3 about here

If we first focus on the curvilinear relationships, we see that, when we move closer to the present, they are caused by accelerating processes of state formation. Presumably, this acceleration is the result of the exact diffusion processes under investigation. Hence, as we move towards the present, the administrative technology that societies receive through diffusion has become continuously more sophisticated which again has allowed for a quicker transition to state formation.[10] In line with this explanation, the interaction effect reveals that this curvilinear effect is strongest among the societies with the best geographical potential for diffusion. In fact, if we split the measure of geographical conditions in three and conduct separate analyses for each group, we find no quadratic effect in the group with the worst geographical conditions. This finding supports H5. We have thus demonstrated that not only the timing of a society's agricultural transition but also the timing of the creation of state is strongly affected by two ultimate factors, which structure the diffusion of technological innovations: the climate zone in which the society is embedded and its location in the East-West extension of the continent.

In sum, our analyses support our causal model displayed in figure 1. Furthermore, these analyses, to our knowledge, provide the first valid quantitative demonstration of Diamond's (1997) account of state formation and the most extensive tests in general of the biogeographical processes operating behind early state formation. Now that the explanation of the timing of state formation is established, we turn towards investigating the effects of this timing. Our basic

[10] For a related discussion on diffusion of agricultural technology, see Putterman (2008).

hypothesis is that the timing of the state influences its relative competitiveness such that societies with earlier states are more likely to retain independence over their territory (H6). However, as predicted by H7, we expect this relationship to unravel with the great voyages of discovery and the unprecedented diffusion of stateness following in their wake, first and foremost through the processes of colonization and subsequent decolonization.

Figure 4 displays Pearson's correlations between the measures of the societies' level of stateness once in every half-century from 0 AD to 1950 AD and the timings of societies' agricultural transition and first state formation, respectively. To ease interpretation, we have marked the year 1500 in the figure.

Figure 4 about here

At the outset, one should notice both the remarkable similarity in the effects of the timing variables and the consistent differences in the effects of the variables. Across the entire period (except for the last data point), the timing of the first state formation has a larger effect on stateness than the timing of agricultural transition, which is highly expected, as the effect of the former should be indirect through the latter. Furthermore, from 0 AD and up to about 1300, we see extraordinary high and consistent effects of the timing variables on stateness. The correlations are positive, which, in line with H6, means that earlier states are more likely to show high degrees of stateness. After 1300, we see a slight drop in the effect sizes. But they are continuously above 0.50 until 1500, when we – as predicted by H7 – see stronger decline in the correlation coefficients. From around 1800, they drop dramatically when the West European states became heavily occupied with the colonization of the rest of the world. Hence, both H6 and H7 are supported by our data.[11]

Conclusion

[11] We can make a preliminary test of whether diffusion actually accounts for the unraveling of the relationship. If processes of European colonization and subsequent decolonization are responsible for the unraveling of the relationship, we should be able to adjust for these effects by adjusting for the migration of Europeans to the colonies. In line with this, Putterman (2008) demonstrates that present levels of income are much better predicted by historic data when adjusted for the migration of Europeans. Specifically, for societies outside Europe, we control for the population's proportion of European descendents (Acemoglu et al., 2001). As this measure specifically taps the proportion of descendents in 1975, we limit the analyses to the two data points closest to 1975, i.e., 1900 and 1950. Before control, Pearson's correlations between timing of first state formation and stateness are 0.11 ($p = 0.19$) and 0.06 ($p = 0.48$), respectively. After control, the correlations rise to 0.19 ($p = 0.02$) and 0.17 ($p = 0.046$). Hence, in both 1900 and 1950, early states have significantly higher levels of independent stateness after control for post-Columbian migration of European settlers. However, without this control, the effect is insignificant and practically nil.

Today, states are among the most important factors in shaping the conditions of life and death of people around world. As Tilly (1992: 4) argues, “anyone who dreams of a stateless world seems a headless visionary”. Yet, the state is a recent invention in the course of human evolution, which for millennia has been predominated by small hunter-gatherer groups with flat hierarchies (Boyd & Silk, 2003). How, then, did this – on an evolutionary time scale – rapid transformation occur from a world without states to a world where the non-existence of states is almost unthinkable?

The account we have put forth emphasizes that this transition is not as much about the individual excellence of certain populations or entrepreneurs.[12] Rather, the state-centered political world of today is the outcome of deep structural forces and, especially, the fact that after the last ice age certain biogeographical configurations facilitated a transition to more effective calorie production. Consecutively, it created a need for more effective mechanisms of social control over expanding populations locked in competition with other similarly expanding populations. Our key argument in this regard has been that the regional differences in biogeography influenced the timing of the Neolithic revolution and, in turn, the timing of state formation.

In essence, the study has provided a statistical test of Diamond’s wide-ranging account of the transition from the small-scale politics of ancestral hunter/gatherer groups to large-scale state-centered politics. While this is not the first quantitative study to explore Diamond’s account of the impact of biogeography and the Neolithic revolution, it is the first to focus on state formation and the most comprehensive attempt to model the causal logic of Diamond’s argument. Hence, we have been able to show, first, that climatic factors influenced the timing of the Neolithic revolution *because* they regulated the availability of domesticable material. Similarly, we have shown that this availability influenced the timing of the early state formation *because* it regulated the timing of the Neolithic revolution. Second, we have shown that climatic and continental differences influence the timing of both agricultural production and state formation through two different pathways. Hence, these biogeographic factors have shaped both the extent of different societies' ability to invent the necessary technology *de novo* and the potential for diffusion of these technological advances from other societies. Finally, we have demonstrated that the timing of early state formation is an important factor in later historic processes. Hence, early states have consistently had a competitive edge compared to later states in a large part of the history of states.

[12] Even though there are good reasons to dismiss the role of great individuals in most cases, we are open to espousing their role in certain types of cases. Early states did not arise from simple tribal societies but from already complex chiefdoms. Whereas great individuals could not turn a tribe into a state, several cases show that great individuals can turn developed chiefdoms into states (Jared Diamond, personal communication).

As expected, this relationship unraveled after 1500. Around 1500, the great voyages of discovery offset processes of colonization and subsequent decolonization, which facilitated massive diffusions of agricultural and state technology to societies with less favorable prehistoric conditions.

On the one hand, with focus on early state formation, we have been able to move beyond the traditional scope of the state formation literature. This literature has been preoccupied with the European formation of national states and has perceived this experience as providing the general model of state formation processes. In contrast, we have focused on states as the more general phenomenon of political coercion-wielding organizations above the level of chiefdoms that not only includes national states but all kinds of states, for example, empires and feudal states. This broader conception of the state also allowed us to move beyond Europe and investigate more ultimate factors behind state formation. On the other hand, however, the present study provides important pieces to the puzzle of why it, specifically, was the European model of the state that came to dominate in the world of today and, in turn, why the traditional focus on the literature indeed has been fruitful in understanding modern state formation. Hence, as demonstrated, the competitiveness of European states grew (at least, in part) out of the continent's biogeography, which facilitated both an early transition to agriculture and the emergence of early states. In the European case, these biogeographic factors seem to have interacted with other local circumstances facilitating the development of highly competitive and expansion-oriented states. Especially the existence of a larger number of small states continuously contending each other in contrast to large and long-lasting empires, such as in China and the Middle East, tends to be a decisive factor (cf. Tilly, 1992; Jones, 2003; Darwin, 2008).

These considerations also imply that it would be wrong to take the unraveling of the relationship between the measures of the timing of early state formation and of current stateness as an indicator that timing does not matter today. First, indirectly, it obviously matters as it has set the stage for the modern historical processes. Second, today all countries with very few exceptions (e.g., Iraq, Somalia, and Afghanistan) display stateness in the sense of having independent control over their territory. The state as a type of organization has spread throughout the whole world and is an adaptive success in this sense too. Hence, if the timing of first state formation matters today, it matters to factors beyond stateness. Economic studies have for example shown that the timing of the Neolithic revolution influences current GDP pr. capita and other features of economic capacity (Putterman, 2008). Similarly, we might find that earlier states have greater state capacity, are more politically stable, or have more effective administrations. Quite simply, one might expect that the longer a state has been able to learn, the more effective it will be in devising social control. Further research will tell whether this is indeed the case.

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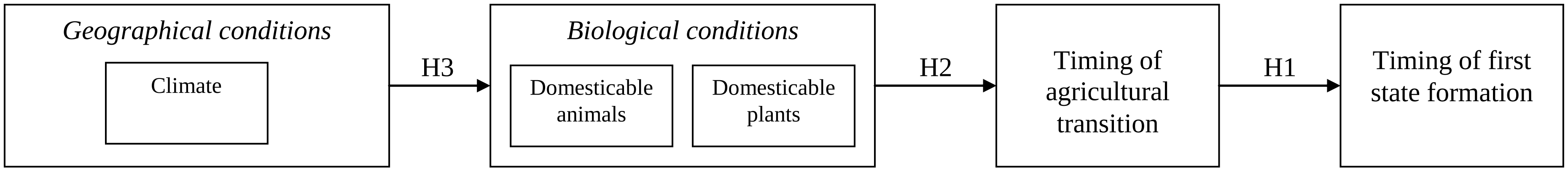
Figure 1. Graphical display of hypotheses H1-H5.

Model without diffusion



Model with diffusion

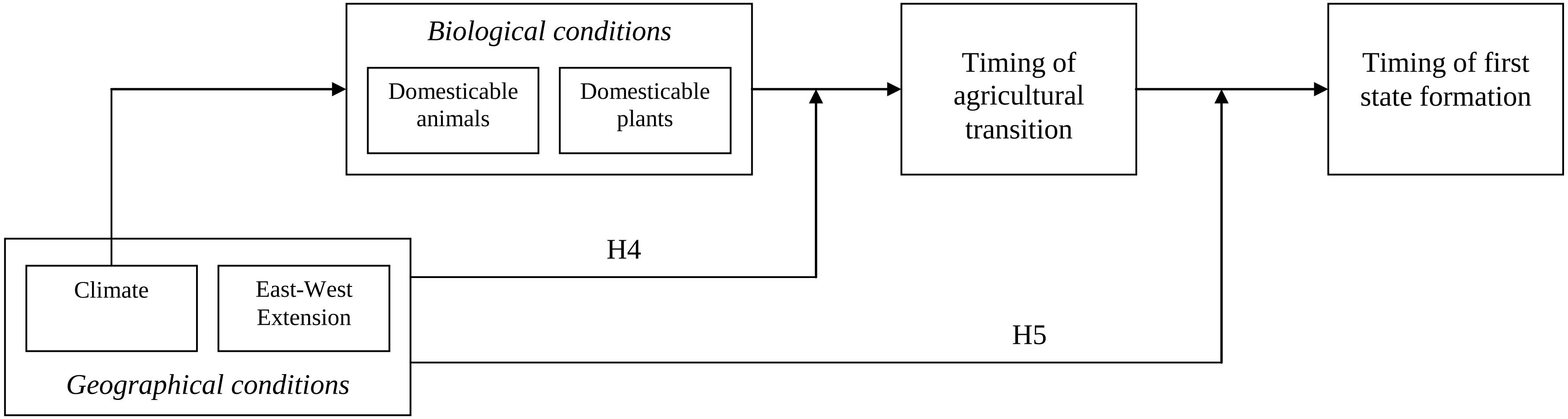


Figure 2. Expected development over time in correlation between the timing of first state transformation in a given territory and degree of stateness in the territory

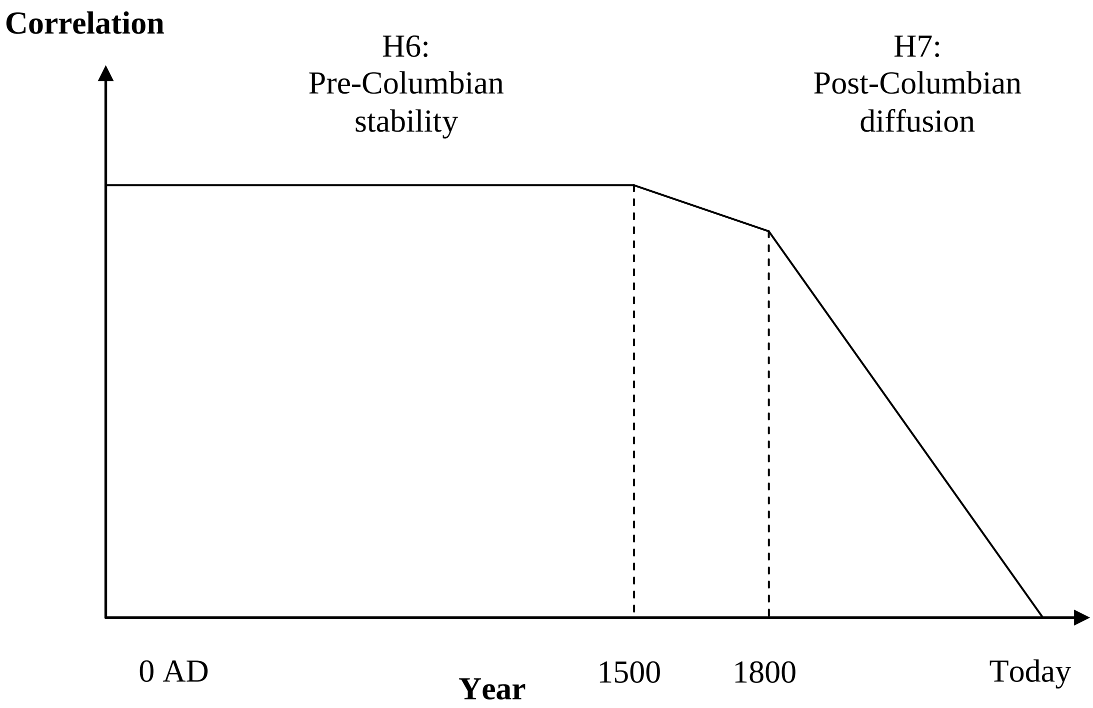


Figure 3. Relationship between the timing of the Neolithic revolution in a given territory and the timing of first state formation in the territory. Predicted values

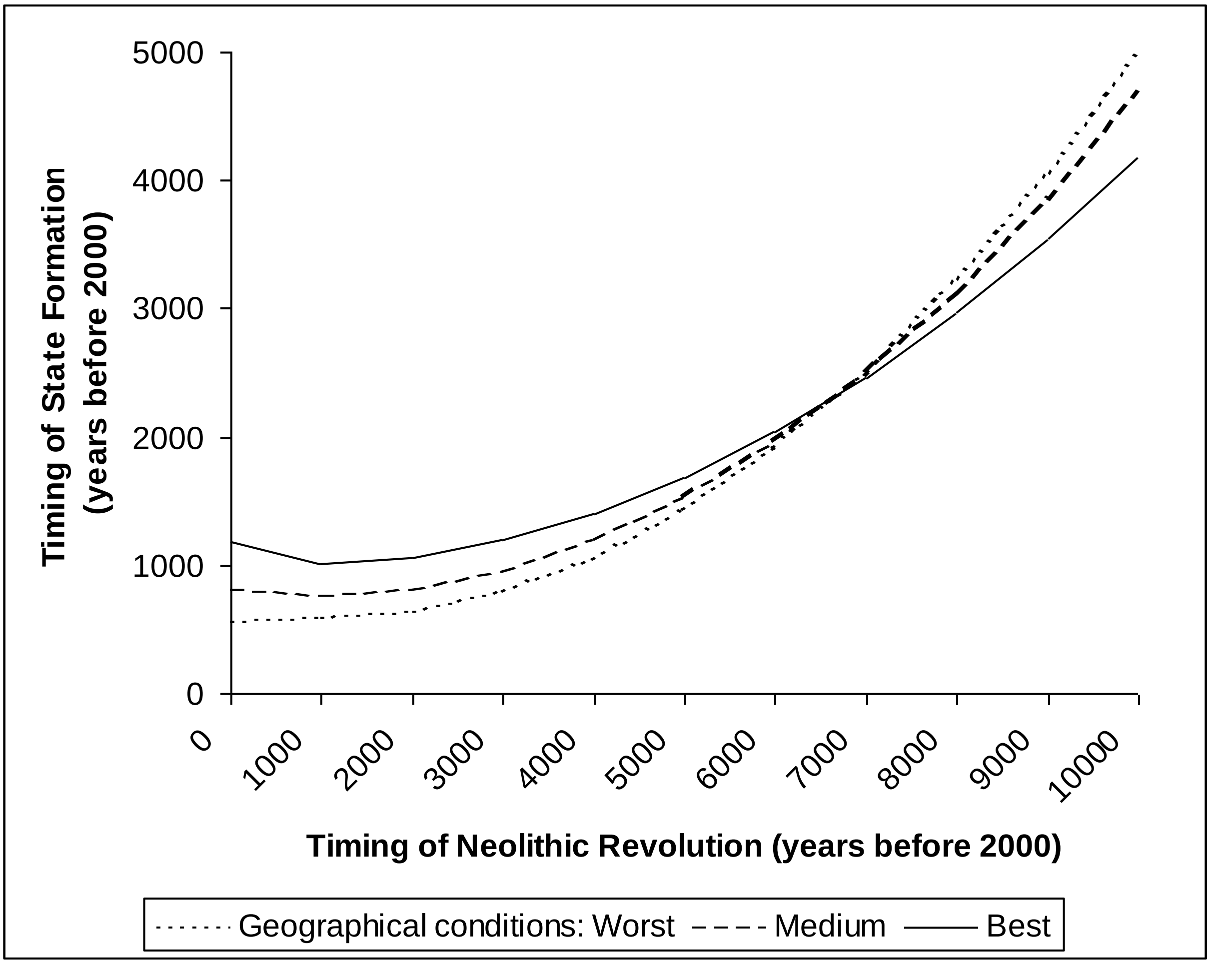


Figure 4. Development over time in correlation between timing for events and degree of stateness in a given territory.

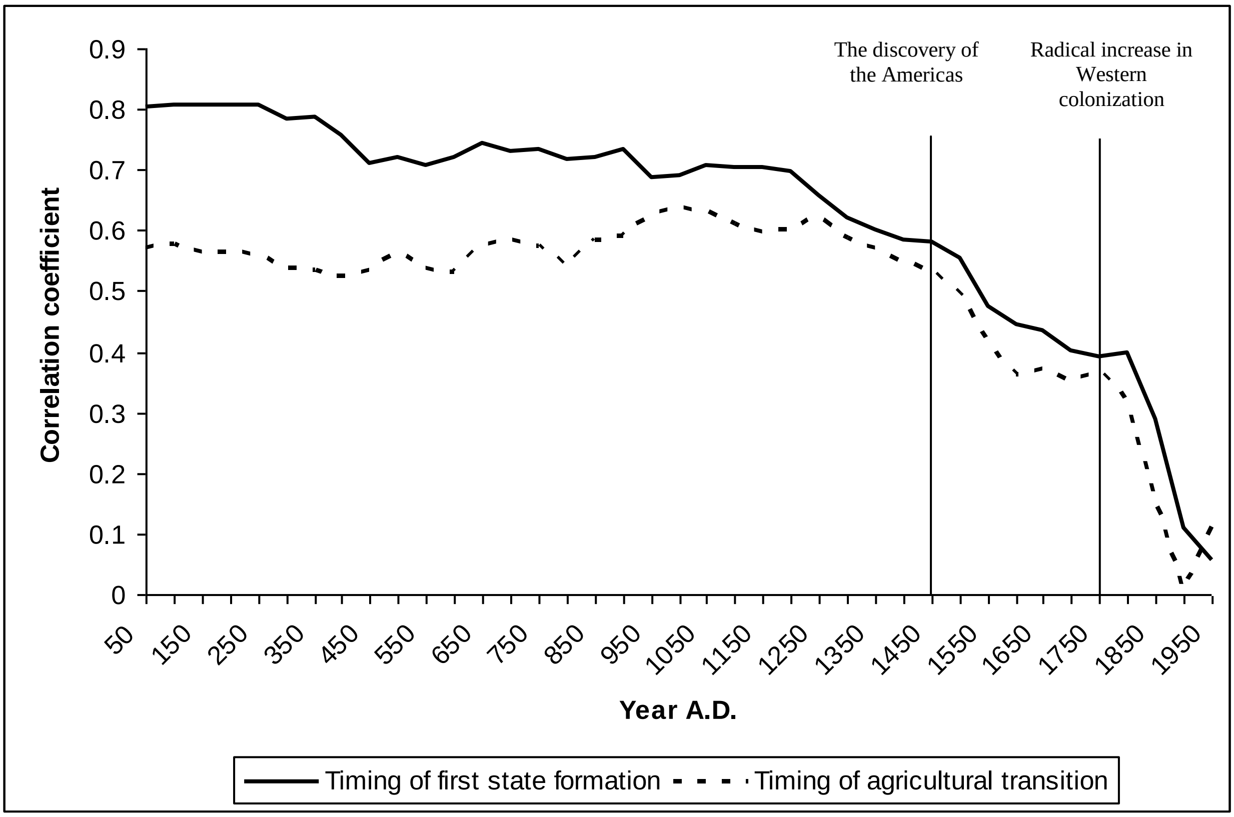


Table 1. Explaining the Existence of Biological Conditions for the Neolithic Revolution.

	Model
Intercept	-0.006 (0.037)
Climate	1.042*** (0.065)
R^2 (adj.)	0.539

Notes. N=171. Cases are contemporary countries. Entries are OLS-regression coefficients with cluster robust standard errors in parentheses. Measures of climate, biological and geographical conditions are scaled between 0-1, where 0 equals least favourable conditions and 1 equals most favourable conditions.

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$ (two-sided t-tests)

Table 2. Explaining the Timing of the Neolithic Revolution.

Model #	Model 1	Model 2	Model 3
Intercept	2986.159*** (261.264)	3019.186*** (165.58)	2752.164*** (370.282)
Climate	3755.623*** (514.862)	-2093.570** (520.221)	-5855.345*** (1169.682)
Biological conditions	-	5613.769*** (396.552)	5395.770*** (890.507)
Geographical conditions	-	-	6547.441*** (1094.293)
Diffusion term: Geographical × Biological conditions	-	-	-2328.725* (1583.946)
R^2 (adj.)	0.209	0.643	0.684

Notes. N=171. Cases are contemporary countries. Entries are OLS-regression coefficients with cluster robust standard errors in parentheses. Measures of climate, biological and geographical conditions are scaled between 0-1, where 0 equals least favourable conditions and 1 equals most favourable conditions.
* p < 0.05 ** p < 0.01 *** p < 0.001 (two-sided t-tests)

Table 3. Explaining the Timing of the First State Formation in a Given Territory.

Model #	Model 1	Model 2	Model 3	Model 4
Intercept	702.649*** (89.478)	-346.980 (111.378)	317.817 (131.931)	206.482 (179.331)
Biological conditions	1808.492*** (193.128)	-32.920 (259.808)	46.824 (259.706)	746.457* (314.860)
Timing of Neolithic revolution	-	0.406*** (0.044)	0.065 (0.086)	0.050 (0.091)
Quadratic term: Timing of Neolithic revolution^2	-	-	3.2×10^{-5}** (6.69×10^{-6})	4.83×10^{-5}*** (6.54×10^{-6})
Geographical conditions	-	-	-	627.754 (505.390)
Diffusion term: Geographical $\times$ Timing of Neolithic Revolution	-	-	-	-0.352*** (0.102)
R^2 (adj.)	0.366	0.605	0.636	0.675

Notes. N=171. Cases are contemporary countries. Entries are OLS-regression coefficients with cluster robust standard errors in parentheses. Measures of climate, biological and geographical conditions are scaled between 0-1, where 0 equals least favourable conditions and 1 equals most favourable conditions.
* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$ (two-sided t-tests)