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**A Western Reversal Since the Neolithic?
The Long-Run Impact of Early Agriculture**

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A Western Reversal Since the Neolithic? The Long-Run Impact of Early Agriculture*

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Abstract

While it is widely believed that regions which experienced a transition to Neolithic agriculture early also become institutionally and economically more advanced, many indicators suggest that within the Western agricultural core (including Europe, North Africa, the Middle East, and Southwest Asia), communities that adopted agriculture early in fact have weaker institutions and poorly functioning economies today. In the current paper, we attempt to integrate both of these trends in a coherent historical framework. Our main argument is that countries that made the transition early also tended to develop autocratic societies with social inequality and pervasive rent seeking, whereas later adopters were more likely to have egalitarian societies with stronger private property rights. These different institutional trajectories implied a gradual shift of dominance from the early civilizations towards regions in the periphery. We document this relative reversal within the Western core by showing a robust negative correlation between years since transition to agriculture and contemporary levels of income and institutional development, on both the national and the regional level. Our results further indicate that the reversal had become manifest already before the era of European colonization.

Keywords: Neolithic agriculture, comparative development

JEL Codes: N50, O43

1 Introduction

A striking feature of current world development is that most of the countries near the "cradle of civilization" in Southwestern Asia are now in serious disorder. Countries like Iraq, Egypt and Syria - all with a history of at least 5,000 years of statehood and advanced urbanized economies - have recently experienced numerous symptoms of state collapse; mass political violence, desperate people looting stores, and governments that cling on to power through brute military force. When the US armies invaded Iraq in 2003 and toppled Saddam Hussein's autocratic and repressive government, military tanks drove over ancient

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cities sometimes 7,000 years old, prospering due to sophisticated irrigation management and carefully coordinated collective action.

Meanwhile, people in the Nordic countries, in the northern periphery of the Western cultural zone, continue to benefit from peace and stability with some of the least corrupt governments the world as well as highly advanced economies. In a long-run perspective, this relative prosperity of the northern periphery is equally striking. At about the same time that massive temples and city walls were erected in the Mesopotamian cities (3500 BCE), the first farmers migrated to Scandinavia and settled among hunter-gatherers, bringing wheat and goats that were originally domesticated in the Middle East. Civilization in terms of statehood above tribal level, did not generally emerge here until after 1000 CE. Yet, the current income per capita in for instance Sweden is about 45 times higher than in Iraq. Is this fundamental reversal of fortune within Western civilization a historical accident?

This paper re-investigates how the Neolithic Revolution may have affected modern economic outcomes through its impact on early institutions. The Neolithic Revolution was a momentous event which introduced agriculture to humans around the year 10,000 BCE. It marked for the first time humans' departure from their hunter-gatherer lifestyle for agriculture and sedentary living. Our main argument is that regions in the Western core that made an early transition to Neolithic agriculture also experienced a long history of autocratic rule, intense rent seeking, and high income inequality. Due to institutional persistence, these adverse effects of early agriculture and statehood eventually hampered the economic progress of the early civilizations and led to relatively low levels of development today. Conversely, regions that made the transition later were more likely to experience more democratic rule, low rent seeking and corruption, low inequality, and technological innovativeness, and ultimately a more sustained process of economic growth.

A straightforward hypothesis from this argument is that there should be a negative (reduced-form) relationship between the time since a region's transition to Neolithic agriculture and current income per capita. In order to test this hypothesis, we first create a new data set of countries' and regions' average date of transition to agriculture, using information from 765 georeferenced archaeological sites in Europe from Pinhasi et al (2005). We then carry out an empirical investigation on three levels; an analysis among 1,371 European regions, a cross-regional study of 107 Italian regions, and lastly a cross-country study of 64 countries within the Western core.¹

Our results demonstrate that there is a robust negative relationship between time since transition to agriculture and current levels of GDP per capita. Although some of our historical transmission channels are unobservable, the strong association in the predicted direction between time of agricultural transition and current levels of corruption, democracy, and income equality strongly indicate that institutions are a key intermediate channel between the Neolithic transition and current development. Using historical data

¹In an online appendix, we also provide a more in-depth case study comparative analysis between two extreme countries in our sample; Sweden and Iraq.

on proxies for economic development in 1500 CE, we further show that the reversal of fortune appears to have been in place at least 500 years ago, i.e. before Western colonization and industrialization, and seems to have manifested itself between 1000-1500 CE. We argue that although industrialization in particular contributed critically to the massive divergence between countries that emerged during the last 200 years, our analysis suggests that the relative prosperity of North European regions followed a longer trajectory with roots in the Neolithic.

Our paper is related to a huge literature on Western economic and social history.² In his classic work on the long-run impact of plant and animal domestication, Jared Diamond (1997) argues that the region making up the Fertile Crescent in the Middle East (roughly Israel, Lebanon, Syria, Southeastern Turkey, Iraq, and Western Iran) was the first to make the transition to agriculture by about 9000 BCE because of its superior access to plants and animals suitable for domestication. Even though other regions also developed agriculture independently (for instance China, Mexico, the Andes region, Papua New Guinea, etc), the highly favorable biogeography in the Fertile Crescent and in large parts of the rest of the Western agricultural core (encompassing Europe, South Asia including western India, and North Africa) implied that this part of the world could develop civilization, statehood, science, military technology, and political strategy much earlier. By 1500 CE, these advantages of an early start allowed European countries to colonize and dominate much of the rest of the World.³

In subsequent research, what might be referred to as a "naive" version of Jared Diamond's (1997) hypothesis has been tested: That current income levels across the world should have a positive relationship with biogeographical suitability for agriculture in pre-history and/or with the timing of the agricultural transition (Hibbs and Olsson, 2004; Olsson and Hibbs, 2005; Putterman, 2008; Ashraf et al, 2010, Putterman and Weil, 2010; Bleaney and Dimico, 2011). Most of these studies have confirmed a positive relationship on a worldwide basis, suggesting that countries that made the transition early had a long-term advantage that is still detectable in current levels of prosperity.⁴

In this paper, we argue that this positive relationship is mainly driven by differences between agricultural core region averages, whereas the relationship *within* the Western core (the region that made the transition first) is actually negative.⁵ Figure 1 illustrates

²An incomplete listing of the most important works includes Jones (1981), Kennedy (1988), Mokyr (1990), Landes (1998), Pomeranz (2000), Clark (2008), and Morris (2010).

³Other important contributions to our understanding of the Neolithic transition include Harlan (1995), Smith (1998), and Bellwood (2005). In the economics literature, see Ashraf and Michalopoulos (2011) for an account of the spread of agriculture in Europe using the data from Pinhasi et al (2005). Weisdorf (2005) reviews the arguments on the transition to agriculture.

⁴Ashraf and Galor (2011) use Olsson and Hibbs' (2005) cross-country measure of plants and animals suitable for agriculture and Putterman's (2006) data on time since agricultural transition as proxies for levels of technological advancement before 1500 AD. The authors show that an early transition to agriculture gave rise to high population density but not to higher income per capita in 1500 AD, in line with the Malthusian model.

⁵A more detailed analysis in the last section suggests that the relationship between time since agricultural transition and current income levels is negative also in within two other agricultural cores; Sub-Saharan Africa and East Asia.

this point and also summarizes one of the key insights of the paper. The graph shows the bivariate relationship between log GDP per capita in 2005 and the time (in years) since agricultural transition for 158 countries. As the figure shows, the relationship is positive when all 158 countries are included in the regression (black line). However, when the relationships within agricultural core areas (Western, Sub-Saharan Africa, and East Asia) are investigated separately, we see in the graph that the relationships turn negative. The negative relationship for the Western core region in the upper right corner, is the main finding of this paper that we document in various ways.

Figure 1

In line with this evidence, we suggest a new and extended version of Diamond's model: Average income levels per capita are higher in the Western core than in all other parts of the world due to the advantages of an early transition to agriculture and civilization, but in comparisons within agricultural core areas, early adoptions of agriculture led to a relatively low level of current economic development. In the original Diamond model, Neolithic biogeography played an important role for Eurasia as a whole by introducing agriculture to the hunter-gatherers in the continent earlier than any other regions in the world. The continent in turn witnessed a headstart in technological advances and complex institutional development to support increasingly sedentary and dense population, such that the rise of statehood and empires closely followed agricultural adoption timing. In the extended version, we analyze variations within the Western core, and argue that it was the timing of expansion of the early farmers which determined different types of institutions and economic performance in the long run.

Our analysis demonstrates that the impact of the timing of agricultural adoption mattered to income levels, independent of soil quality. That is, we show that regions with same types of biogeographical endowment during the Neolithic times do not necessarily have the same income levels today. These findings demonstrate that the reason behind long term divergence in current incomes cannot be solely attributed to natural surroundings. For example, both Spain and Turkey were occupied by Dry Steppe vegetation at the advent of the Neolithic Revolution, but have vastly different income levels today. Furthermore, it may be that once Europe acquired the advantage of domesticable species that the Fertile Crescent introduced, Europe naturally had climatic and soil advantages relative to the Fertile Crescent. The Fertile Crescent lacked Europe's thick fertile glaciated soils and was exposed to more landscape degradation due to its dry climate. The explanation of the reversal of fortune within the Western agricultural core however still cannot be explained by biogeography alone. Various parts of Italy currently endowed with productive lands still lack the institutions that Scandinavian countries enjoy.

A second highly related tradition in the literature is the *institutional* view of Western long-run history, associated with North and Thomas (1973), North (1990), and a string of important contributions by Daron Acemoglu, Simon Johnson, and James Robinson, summarized in Acemoglu et al (2005a) and Acemoglu and Robinson (2012). In their most

recent work, Acemoglu and Robinson (2012) downplay the importance of "geography as destiny" and argues that economic outcomes are a result of an interplay between political and economic institutions that can be either *inclusive* (democratic and with strong private property rights) or *extractive* (autocratic with monopoly rents for a favored elite). Countries embark upon their major paths of development at certain *critical junctures* in history and are otherwise subject to institutional drift.⁶

According to Acemoglu and Robinson (2012), such a model better explains why Britain and the United States ultimately developed institutions conducive to industrial development than models based on geography. The authors argue, for instance, that it is hard to use Jared Diamond's model of biogeographical potential to explain why peripheral Britain with its late transition to civilization could become the engine of industrialization. In the analysis of this paper, this institutional view can be reconciled with our emphasis on the crucial importance of the Neolithic. The key difference is that in our model, the developmental advantages of Northern Europe in more recent history did not come about as a result of institutional drift but due to a long-run trajectory from the onset of agriculture.

A third emerging tradition in economics focuses on the importance of other long-term trajectories. Ahlerup and Olsson (2012) and Ashraf and Galor (2012) show that the spread of modern (hunting-gathering) populations out of Africa in prehistory implied that regions that were colonized late had a lower genetic diversity than in the African "homeland". Ahlerup and Olsson (2012) show that this has resulted in a lower ethnic diversity in more recently settled countries (like Sweden) whereas Ashraf and Galor (2012) demonstrate that there appears to exist a trade-off between more or less genetic diversity such that countries with a medium level have had the highest levels of economic development throughout history.⁷ Ashraf et al (2010), show that geographical isolation has had a positive effect on economic development and argue that the result is explained by a greater reliance on own innovations in the periphery. Using newly constructed data on the levels of technological sophistication in countries from about 1000 BCE, Comin et al (2010) argue that there has been a strong tendency for technological persistence through history. When we use their data for the Western sample, we show that there has actually been a technological reversal from the origins of agriculture to 1500 CE.

In summary, we believe the paper makes the following contributions to the literature. Firstly, we present a new theory with supportive evidence of a reversal of fortune since the Neolithic within the Western core area. Secondly, we create new data for the emergence of agriculture among all Western countries as well as among nearly 1,400 regions. Thirdly, we demonstrate how previous results of a positive association between time since agriculture and current income can be reconciled with our evidence of a negative relationship within

⁶Institutional drift is a metaphor borrowed from genetics where genetic drift describes how two otherwise identical phenotypes might develop very different traits after separation over time due to random processes that have nothing to do with natural selection. See Ahlerup and Olsson (2012) for an economic treatment of cultural drift.

⁷The importance of genetic differences originating in prehistory is also studied by Spolaore and Wasziarg (2009).

the Western agricultural core.

The paper proceeds in the following order: Section 2 describes the argument behind agricultural transition and development, whereas Section 3 introduces the data used for empirical results as well as the econometric strategy. The same section then proceeds with the empirical findings, whereas Section 4 discusses external validity and our extended model. Finally, Section 5 concludes by summarizing the findings and offering avenues for future research.

2 The argument

2.1 Agricultural transition and current levels of development

In his widely acclaimed work on the long-run importance of the Neolithic revolution, Jared Diamond (1997) outlines a theory arguing that societies that transitioned early into agriculture in prehistory achieved a head start over other societies in terms of social, political, and technological development which ultimately explained why it was Europeans who colonized the native Americans rather than vice versa. The early onset of agriculture in the Western core was in turn explained by a superior access to suitable plants and animals for domestication.⁸ When the transition to sedentary agriculture was completed, civilization very soon emerged with codified language, large public monuments, organized religion, hierarchical power structures, and statehood. After having experienced thousands of years in densely populated and intensely competitive agricultural states, it was only natural that the Western colonial powers could dominate most of the world outside Eurasia from 1500 CE onwards.

Later works such as Hibbs and Olsson (2004), Olsson and Hibbs (2005), Putterman (2008), and Putterman and Weil (2010) take this analysis one step further and argue that the timing of the transition to agriculture should still matter for comparative levels of wealth and institutional development around the world. Indeed, when we use data from Putterman (2006) on the date of first transition to agriculture for all 152 countries in the world and correlate that with log of GDP per capita in 2005, we find a clear positive relationship as in Figure 1. Results like these might thus be interpreted as giving support to the idea that an early transition to Neolithic agriculture is advantageous to countries even today.

However, this type of cross-country analysis has been criticized on the grounds that independent agricultural transitions basically happened within a few "macroregions" in the world such as Europe/Southwest Asia, East Asia, Sub-Saharan Africa, and in three different parts of America (Smith, 1995). For instance in Olsson and Hibbs (2005), the analysis was based on data on access to suitable plants and animals for domestication

⁸Like Diamond (1997) and Morris (2010), the regions that we refer to as the "Western core" include Europe, North Africa, the Middle East, and South Asia including India and the countries west thereof. All these regions were connected through trade and migration and based their economies on domesticated plants and animals from the Fertile Crescent.

for six such macro regions. The difficulty of differentiating between areas within macro regions impeded a more complete analysis of the causality from biogeographical potential to agriculture to levels of development in individual countries.

Furthermore, when considering the history of the first macro region to make the transition to full-fledged agriculture - the Western core - it is a striking fact that some of the countries that once made up the cradle of agriculture and civilization in the "Fertile Crescent" now are relatively much less developed than countries in the periphery of the macro region. Take for instance Iraq and Syria, hosting some of the very earliest agricultural villages known to exist (around 9,500 BCE) and some of the earliest signs of civilization already by 4,000 BCE. Both countries are today close to being regarded as failed states with a very weak rule of law, a long history of autocratic government (in Iraq, at least until 2003), and stagnant economies. Compare that to for instance Sweden in the very periphery of the European/Southwest Asian zone. Sweden adopted agriculture only 3500 BCE and did not host a state above tribal level until around 1150 CE. Despite this very late start as a "civilization", Sweden (as well as most of its north European neighbors) is now one of the most economically prosperous, egalitarian, and democratic countries in the world.

Casual observations like these suggest that although the countries in the Western core doubtlessly owe some of their relatively high average levels of development to their long history of agriculture and statehood, it is less apparent that an early transition to agriculture was advantageous for comparative development *within* the macro region. Indeed, when we use the same data as above on time since agricultural transition and contemporary levels of GDP for 62 Western countries, there rather appears to be a negative relationship between time since transition and GDP, as shown in Figure 1. Figure 2 displays this relationship in more detail. The unconditional negative relationship is moderately significant ($t=-1.98$).

Figure 2

How can we reconcile the two tendencies in the graphs above? This is what we turn to in the section below.

2.2 Our model

In an extremely simplified sense, our basic model for explaining the negative reduced-form relationship between current income and time since agriculture in the Western core can be summarized by the following hypothesized causal relationship:

Early transition to agriculture \implies *Extractive institutions* \implies *Weak current economic performance*

Late transition to agriculture \implies *Inclusive institutions* \implies *Strong current economic performance*

Figure 3 below shows a more detailed exposition of our argument. It shows the timing of transition to agriculture as the ultimate historical factor working through intermediate channels to affect current levels of economic performance. The horizontal axis shows a one-dimensional geographic space divided into regions and the vertical axis a time dimension where more recent times are found in the lower part of the figure.

Figure 3

Let us discuss each of these linkages in turn.

2.2.1 Early agriculture and extractive institutions

Firstly, specific geographical and biogeographical characteristics implied that the agricultural transition happened first in the Fertile Crescent. In this paper, we will not provide an exhaustive analysis of the determinants of early adoption.⁹ We will confine ourselves to noting a few main factors referred to in the literature: That people in the Fertile Crescent had local access to several suitable plants and animals for domestication, the East-West axis of the Eurasian landmass facilitated the spread of food technologies due to similar mid-latitude climates (characterized by relatively wet winters and dry summers), the Fertile Crescent was centrally located along this East-West axis, and the extended founder area included rivers such as Euphrat, Tigris, the Jordan and the Nile that if properly managed could provide a steady flow of water to an expanding agricultural population (Diamond, 1997; Olsson and Hibbs, 2005). In our analysis, the date of transition will thus to some extent inherently capture these specific geographical and biogeographical features.

It has often been suggested in the literature that there exists a strong link between the timing of agriculture and the rise of statehood (Diamond, 1997; Peregrine et al, 2007). This is also illustrated in Figure 3 where the rise of agriculture is a precursor to the subsequent emergence of statehood. Using new data on initial state formation from Borcan et al (2012) and a measure of average date of transition to agriculture that we have constructed from Pinhasi et al (2005) (see presentation of these variables in the data section below), we demonstrate a close relationship between the timing of the transitions to agriculture and statehood among 52 Western countries in Figure 4. Each dot is a country observation where the size of the dot increases with the level of GDP per capita in 2005. Visual inspection immediately informs us that the correlation between agricultural and state origins is very strong.

The estimated and significant regression coefficients for the simple bivariate association between the two variables is given by $Time\ since\ first\ state\ formation = - 5179 + 1.043 \times Average\ time\ since\ agricultural\ transition$ ($R^2 = 0.70$), indicating that a country in the Western core typically developed statehood about 5,200 years after the onset of agriculture.

⁹See for instance Smith (1995) or Diamond (1997) for general treatments and Ashraf and Michalopoulos (2011) for an analysis of the role of climate variation.

The slope coefficient (close to unity) further implies that each year of delayed transition to agriculture roughly implied a year later transition to statehood.¹⁰

Figure 4

An key argument in this model is that countries that made the transition to agriculture and statehood early also tended to develop what might be referred to as "extractive institutions" (Acemoglu and Johnson, 2012). Our definition of such extractive institutions includes unstable, autocratic forms of government with a weak rule of law, a concentrated wealth distribution largely controlled by an elite, and intense rent seeking activities, both within the country as well as from foreign aggressors. By bringing order and a capacity for collective action to previously anarchic hunter-gatherer societies, the initial economic advantages of extractive institutions in the early civilizations were often substantial. Food production was greatly rationalized which led to the emergence of specialized classes of priests, warriors, merchants, book-keepers, and engineers. Massive public monuments were erected and hordes of people from the countryside crowded into centrally planned cities.

But why and how did early agriculture lead to extractive institutions, as hypothesized in Figure 3? We believe that there are at least four reasons for such a causal link. Firstly, as mentioned above, the subsequent expansion of early agriculture into river valleys such as those of Euphrat and Tigris in an otherwise very dry area, was only made possible due to carefully coordinated collective irrigation activities involving the digging of dykes and dams, the construction of river gates, and the planning of fields and orchards. As discussed further in the Appendix section on Iraqi history, these collective action challenges in production appear to be closely linked with the emergence and presence of centralized local power. In a famous treatise, Wittfogel (1957) even claimed that river management provided the fundament for the emergence of despotic states in Mesopotamia, Egypt and China, and similar notions can be found in the works of Karl Marx and Adam Smith.

More recently, research by Elinor Ostrom and coauthors (see for instance Ostrom, 2010) has shown that populations have often been able to solve social dilemmas such as irrigation in an efficient manner without the involvement of the state. However, in a cross-country study, Bentzen et al (2012) demonstrate that irrigation potential in countries, proxied by potential yield gain from irrigation, is strongly correlated with autocratic forms of government. The result is robust to the inclusion of a range of control variables such as latitude and the fraction of arable land. Their analysis suggests that although irrigation might not necessarily give rise to states, countries with high irrigation potential tend to be more autocratic than countries that rely on rain-fed agriculture.¹¹

Secondly, the Euphrat-Tigris delta as well as the Nile riverbanks soon became densely populated agricultural regions with a great accumulation of wealth in urban centers.¹²

¹⁰The t-value for the estimate of *Average time since agricultural transition* is 10.04 and for the constant -7.02. See Borcan et al (2012) for a thorough analysis of this relationship.

¹¹See also Jones (1981) who makes a similar point regarding the advantages of rain-fed agriculture.

¹²See Appendix 1 for a more exhaustive account of the comparative history of Iraq in light of our model.

Such wealth naturally became a tempting target for more primitive populations in the neighboring regions of the founder region. When agricultural technology in the form of domesticated plants and animals and military technology featuring horses and bronze metallurgy had spread to these regions, they posed a mounting threat to the center. Very early in history, the various state formations in Mesopotamia were attacked by predating barbarians. After the decline of the Sumerian cities in the third century BCE, the Mesopotamian heartland became the prize in recurring conquest attempts by neighboring peoples including the Persians (6th century BCE), the Greeks (4th century BCE), Romans (1st century CE), Arabs (7th century), Mongols (13th century) and Ottomans (16th century). Being under constant threat of attack by invading foreign armies, the form of government in the region had a natural bias towards autocratic, military rule. Although some of the earliest known laws were codified in the area, the right of might was the order of the day rather than the rule of law and protection of private property.

Thirdly, Mesopotamia was constantly threatened by invasion not only due to its wealth. Being located right in the center of the European/Southwest Asian climate zone, Mesopotamia was a very natural place for roaming armies to stop by in their moves along the continent's east-west axis. As described by Morris (2010), both the Chinese and Western civilizations were frequently threatened by hordes from the central Asian steppes such as Huns and Mongols. Also Egypt had huge accumulated wealth due to its productive agriculture, but being located somewhat more isolated with surrounding deserts, Egypt was relatively sheltered from attacks by roaming barbarians.¹³ The strong correlation between the degree of centrality within the Western core and the timing of the transition to agriculture implies that variables capturing the date of the Neolithic revolution also will pick up geographical features, as suggested by Figure 3.

Fourthly, even though agriculture first appeared in the semi-dry areas of the Fertile Crescent, the relative advantage in terms of land fertility shifted northwestward as agriculture spread in this direction. In particular, the robust soils of continental Europe soon proved to give substantial crop yields. The river management economies of the Middle East, on the other hand, turned out to be quite ecologically sensitive. Agricultural lands in the area were under constant threat of salinization and some sources have even suggested that salinization was responsible for historical episodes of crop shifts and large-scale abandonment of certain settlements.¹⁴ As shown by Diamond (2005), overuse of resources and ecological failures of this kind have often led to internal warfare and even social collapse. Both the Egyptian and Mesopotamian river valleys were de facto circumscribed by desert, which made easy escape routes difficult for troubled farming populations. This probably contributed to extra social conflict in times of climate downturns.¹⁵

¹³Even Egypt was however affected from time to time by invading armies. Already around 1650 BC, the Hyksos, a Semitic people, could take control of the northern parts of the country. In later centuries, also neighboring Nubians, Libyans, and Assyrians were attracted by the Egyptian wealth and managed to install short-lived foreign regimes in the country.

¹⁴See Postgate (1995) for a discussion of these hypotheses. We owe the general point about ecological sensitivity to a comment by Jared Diamond.

¹⁵Another potential reasons for the historical presence of extractive institutions in the Middle East, not

As suggested by Figure 3, the thousands of years of agriculture and stratified societies gradually resulted in a worsening culture of autocratic rule and low trust which has persisted to the present day. In a companion paper to this one, Paik and Olsson (2012) show that an early transition to agriculture is associated with stronger contemporary norms towards obedience in the Western core. We argue that this culture was basically founded on the institutions of society, which in turn were founded on the structure of production. Hence, even groups that migrated into the agricultural heartlands of the Middle East soon adopted the same extractive institutions that had prevailed among the local population for millennia.

2.2.2 Later transitions and inclusive institutions

But even if the Middle East had all these special disadvantageous characteristics for long-run institutional development, why should there also within Europe be a gradient such that the timing of initial agriculture had a long-run impact on economic and institutional development? In Western history, there appears to be a pattern of a northwestward march of power; starting from the earliest city-states of 3500 BCE in the Fertile Crescent, power shifted west to the Hittite Empire around 1400 BCE; then to Greece around 330 BCE, when Alexander of Macedon conquered eastwards through the Fertile Crescent; then to Rome around 240 BCE, with Rome's conquest eastwards to Greece; then to western and northwestern Europe, which became richer and more powerful than Italy.¹⁶ Our model above suggests that while this shift may have been an outcome of successive waves of predation by less developed neighbors on a center, each empire or state that emerged also became progressively more innovative, learning from past experiences and mistakes.

As convincingly demonstrated by Bellwood (2005) and others, there are strong indications that Europe as well as the eastern parts of Southwest Asia were gradually settled by Indo-European farmers spreading from the agricultural core in the Fertile Crescent via Western Anatolia. Just like in more recent massive migrations (such as the emigration to the United States in the 19th and 20th centuries), it was almost surely marginalized groups without close access to power that fissioned off and formed new agricultural communities. The genetic record further suggests that these colonizing farmers interbred with local hunter-gatherer populations (Bellwood, 2005). The egalitarian nature of hunter-gatherer societies probably gave another impetus towards stronger equality among these early farmers.¹⁷ A characteristic feature of the so-called Linear Bandkeramik-culture (LBK), which spread along the Danube into central Europe and southern Germany by around 5400 BCE, was for instance a new tradition of villages with timbered longhouses hosting sev-

directly related to the transition to agriculture, includes the fact that countries in the area often became parts of large empires, which have been shown to be associated with a weak rule of law (Olsson and Hansson, 2011) and an absence of representative assemblies (Stasavage, 2011).

¹⁶See also Kennedy (1988) for a classic account of how power shifted northwards from around 1500 AD in Europe.

¹⁷In a very extensive combined study of primitive agricultural, horticultural, and hunting-gathering societies around the world, Mulder et al (2009) provide empirical evidence of a substantially higher income inequality among agricultural communities than among hunter-gatherers. See also Sahlin (1973).

eral families, suggesting a relatively egalitarian social structure and a fluid pattern of land ownership (Bellwood, 2005).

Eventually, also many of these new communities would accumulate wealth in urban centers and become the object of predatory attacks from more primitive neighbors. Wealth accumulation, combined with exogenous threats and a growing population, thus typically led to a gradual shift towards more autocratic rule also in these communities. However, the historical tradition of autocratic rule would be weaker and less pervasive in these societies than in the Middle East. Furthermore, the underlying geographical conditions in most core areas of Europe (such as the absence of major river valleys and the reliance on rain-fed agriculture) were still not as conducive to the maintenance of highly centralized, autocratic, urban states as in the eastern Mediterranean.

Consider for instance the territory of Italy, a centrally located region in Europe and of key historical importance for the history of the continent. The archaeological record suggests that the peninsula was originally populated by Neolithic farmers from the Eastern Mediterranean during the 7th millennium BCE.¹⁸ As shown in Figure 5, the first sites are predominantly found in the south-east. The north-central areas, roughly stretching from current Florence to the Alps, was the region where agriculture emerged the latest after 5200 BCE.

Figure 5

In line with our theory, statehood and civilization appeared earlier in the south of Italy than in the north. The first major civilizations in Southern Italy and Sicily were the Greek colonies that were founded during the 8th century BCE and implied that the South became an integrated part of the classical Greek and later the Hellenic world. The northern areas were dominated by Etruscan and Celtic tribes but did not develop centralized states. After defeating the Greeks under Pyrrhus' leadership in 275 BCE, Rome conquered Southern Italy and emerged as the dominant power on the peninsula, soon expanding also to conquer Sicily and the Northern parts. The area north of the river Rubicon, including the Po valley, was organized as Gallia Cisalpina which remained a Roman province until 41 BCE and was during these times not considered part of Italy proper.

Italy during the Roman Republican era was clearly a society with more equally dispersed wealth and power than during the subsequent Imperial era (starting with the rule of Augustus in 27 BCE). As recently emphasized by Acemoglu and Robinson (2012), the republican institutions with a senate as the center of power and with executive power in the form of consuls on a one-year tenure, combined with offices for representatives of the people such as tribunes, guaranteed a relatively widespread distribution of power. This gradually changed with the emergence of powerful generals who would become more and more influential politically until they could rule as autocratic emperors in a similar style as

¹⁸The associated culture is referred to as "Cordial Ware" after its shell-impressed pottery and also spread to other regions of the Mediterranean such as Southern France, Sardinia, and the Iberian coasts.

many Eastern rulers before them. Although Imperial Rome was very successful economically at least until the late 2nd century CE, income inequality and rent seeking increased and technological progress stalled (Morris, 2010; Acemoglu and Robinson, 2012).

All of Italy was part of the Roman empire until 476 CE, when the Western part collapsed as a result of predatory barbarian invasions. After some chaotic years, a pattern would emerge from about 800 CE with northern Italy being under the control of the Frankish and later Holy Roman empire, the center being controlled by the Papacy in Rome, and with the south changing hands between various rulers. From about 1200, the northwestern Italian regions in the Holy Roman empire splintered and became largely independent. This period marked the beginning of the Renaissance era with its important upswing in economic and cultural development. Cities like Genoa and Venice became dominant players in the Mediterranean trade and several of the North Italian cities developed representative assemblies, dominated by merchant families but still more inclusive than elsewhere in Europe at the time (Stasavage, 2011).

From around 1500, Spain became a major influence in southern Italy and for long periods ruled over the area. The Spanish feudal institutions were quite different from the institutions of northern Italy. Representative assemblies did not emerge during the Renaissance in this part and when Italy was united in 1860, it was already clear that the south was relatively backward, economically as well as institutionally.

To summarize, Italy clearly made the transition to agriculture later than in the Fertile Crescent and experienced a later rise of statehood and autocratic rule during imperial Roman times. But the peninsula as a whole still had a substantially shorter history of autocratic rule than the regions in the eastern Mediterranean and the northern cities even experienced periods of inclusive institutions.

Only in the most distant periphery of the western region, in Northwestern Europe, were the conditions decidedly not conducive towards the early emergence of autocratic, centralized states. The shores of the North Atlantic and the Baltic Sea were conquered quite late by farmers and probably faced tough resistance from relatively prosperous hunter-gatherers who lived well off the rich aquatic resources in the area (Bellwood, 2005). For instance, Denmark only made the transition to agriculture around 3500 BCE and to statehood 700 CE. Soils were further of poorer quality than on the North European plains which hindered the emergence of urbanism and high population density.

Communities in this part of Europe were relatively protected from predatory attacks by other peoples.¹⁹ Pagan Vikings from the Scandinavian countries raided several regions of Europe around 800-1000 CE and Viking colonizers assumed power in Russia (Novgorod), England, and Normandie. However, due to their geographical isolation and relatively infertile soils, these North European regions were largely spared from attacks by invading armies.²⁰ Absent this constant military threat and with no ancient culture of autocratic

¹⁹See Ashraf et al (2010) for an analysis showing that geographically isolated societies in prehistory tend to be relatively rich today. The authors argue that plausible channels for this relationship is protection from predation and a stronger reliance on indigenous innovative activity.

²⁰Sweden, for instance, fought many wars throughout its short history with the Danes and on the

rule, the people in these areas could maintain relatively egalitarian institutions with a stronger rule of law and with relatively influential popular assemblies. With no substantial concentrated wealth to capture, internal rent seeking and corruption never turned into a serious problem and foreign powers remained uninterested in conquering the northern areas.

In summary then, the countries that made the transition to agriculture first also experienced a long history of unstable, autocratic rule with a weak rule of law, high inequality and substantial rent seeking, internally and externally. The main reasons for this were related to the close association between irrigation technology and centralized power, the attraction of accumulated urban wealth on predatory neighboring peoples, their central location between east and west, and the environmental degradation that the first agricultural areas soon experienced. In central and western Europe, there were both periods of empires and autocratic rule as during the Roman and Frankish periods but also long periods of less autocratic states. In northern Europe, the transition to civilization happened late and hierarchical institutions like those in the original agricultural zones were not observed for any extensive periods. Authoritarian norms were never ingrained in society to the same extent as in the early civilizations.

2.2.3 Institutions and economic performance

The last intermediate link between transition to agriculture and current economic performance in Figure 3 is related to technological progress. In line with Acemoglu and Robinson (2012), we hypothesize that extractive institutions like those in the early agricultural communities were hostile to technological progress and innovation in sectors outside agriculture. The irrigated agriculture of Mesopotamia or the colonial plantation economies of the Caribbean are both examples of economies based on unfree labor. Also the Roman and Greek economies in antiquity were based on slave labor. As argued by Mokyr (1990), Sokoloff and Engermann (2000) and others, these economies provided weak incentives for labor-saving innovations since labor was extremely cheap. Economic growth in such societies can still be impressive and is typically based on increased specialization and trade, as in Mesopotamia or in Rome. But unless there are repeated major innovations and creative destruction, economic development will sooner or later run into diminishing returns and growth will not be sustained over the long run (Aghion and Howitt, 1992; Acemoglu and Robinson, 2012).

Finally, the last link in Figure 3 suggests that the inclusive institutions favoring technological innovation that were prevalent in the northern periphery, should imply a stronger economic performance during the more recent stages of history. Analogously, the extractive institutions and weak incentives for innovation that characterized the early agricultural societies for several millennia, should imply a weak economic performance today. But

continent, but its heartlands were never overrun by a foreign army. Because of its recent neutrality, the country has not been engaged in a single war during the last 200 years. See Appendix 1 for an extensive analysis of Swedish history in a comparative perspective.

when in history did the extractive economic institutions run into diminishing returns so that the reversal became manifest? After all, polities based on extractive institutions such as imperial Rome or Byzantium could thrive economically well into the Middle Ages.

From the point of our model, one would expect a reversal to start working in an era characterized by a technological paradigm that rewarded individual innovative efforts rather than central coordination. According to many accounts, the late Medieval period between roughly 1100-1500 CE was such a period (Mokyr, 1990; Morris, 2010). As already mentioned, the North Italian cities started to flourish culturally and economically during this period. Similar developments took place further north in the Flandern region. Also Dutch and North German cities became important centers of manufacturing and trade. Representative assemblies appeared and both science and technology made great strides. As will be shown below, by 1500 CE, countries that made a late transition to agriculture and civilization had become the first to develop inclusive institutions, which in turn had given them a decisive economic edge by the start of the Modern era compared to competing nations further south.

Figure 4 summarizes one of the basic empirical findings of the paper. Among the 52 Western countries in the figure, there is a clear pattern that countries that transitioned early to agriculture and statehood tend to be poorer today. The majority of the large circles (rich countries) are found in the lower-left corner of the figure, for instance most of the Scandinavian and North European countries, whereas the Middle Eastern countries are typically in the upper-right corner. We will return to more elaborate empirical tests of our model, using both countries and smaller regions as observations, in the empirical section below.

3 Empirical analysis

3.1 Data

The key explanatory variable in the empirical analysis is the time since the Neolithic transition.²¹ We develop a new variable *Average time since agricultural transition* for regions as well as for countries in the Western zone. In doing so, we use a sample of calibrated C14-dates from Neolithic sites in the Near East and Europe available from Pinhasi (2005). The data contains a full list of excavation sites (765 in total) that spans from the Fertile Crescent to Northwest Europe; the list includes the location coordinates as well as calibrated C14-dates estimated for each site. The oldest site in the sample is M'lefaat, near Mosul in Northern Iraq, dating back 12,811 years. Figure 6 shows the geographical distribution of all sites in the sample.

Figure 6

²¹Appendice 4-6 show the descriptive statistics for the variables used in the cross-regional, within Italy, and cross-country studies.

The use of a detailed set of carbon-dates spread across Europe allows for a measure of the initial agricultural adoption dates for each specific region in consideration. The average initial date of agricultural adoption is obtained by using the inverse distance weighting method and zonal statistics in ArcGIS. Appendix 2 shows the inverse distance formula used for the calculation. For the analysis, we obtain the average adoption date for each region or country by first interpolating the point data across the excavation sites and then calculating the mean date within the administrative border. Figure 5 shows an example of this methodology applied to the 78 Neolithic sites within Italy.

Taking the year 2000 as the benchmark year, the mean time since agricultural transition in our cross-regional sample is 7,055 years with a range from 5,243 to 11,320 (Appendix 4). This of course translates into a mean adoption date of 5,055 BCE and a first adoption date of 9,320 BCE. In the cross-country sample, the mean is 7,611 years, the minimum is 5,608 (Denmark) and the maximum 9,743 (Syria) (see Appendix 6).

Most cross-country studies that include the time since Neolithic transition as a variable have so far used the cross-country data set in Putterman (2006). For each country, Putterman (2006) determines a date of transition by using the first attested date of Neolithic agriculture within the country’s borders as stated by various specialized sources. We believe that our methodology offers several advantages as compared to Putterman (2006). As far as we know, the data in Pinhasi et al (2005) offer the most recent and most comprehensive compilation of transition dates for the Western region. Furthermore, our methodology provides the *average* date of transition for a country rather than the *first* date of transition, as in Putterman (2006).²² We believe that this practice will more accurately reflect the transition for the whole country since there might be large discrepancies in dates of transition between regions within countries, as also acknowledged by Putterman (2006). With our methodology, it is further possible to determine transition dates on a much finer geographical level.

We further introduce a novel set of data measuring Neolithic vegetation variation at the advent of the Neolithic Revolution. The Neolithic vegetation states are indicators of soil quality during the prehistoric period. The data on the Neolithic vegetation variables for Europe is based on the maps from Adams-Faure (1997) and Oak Ridge National Laboratory’s Environmental Sciences Division (www.esd.ornl.gov/projects/qen). Appendix 3 provides details on how the vegetation map is constructed, including the methodology used to address the endogeneity issue of human subsistence influencing prehistoric vegetation state prior to agriculture. The vegetation types listed on the maps are ranked from the best to worst in terms of agricultural suitability.²³ Each observation records the fraction

²²We average over the calculated scores for each region within countries to get the country score. The regional scores are used in the regional analysis.

²³The vegetation types are defined as follows. 1. Desert: very sparsely vegetated. 2. Dry Steppe: similar to Steppe-Tundra, with a more temperate climate, open woody vegetation types and low shrubs. 3. Ice. 4. Lake. 5. Polar Desert: very sparsely vegetated with only low herbaceous plants. 6. Semi-Desert: open scrub/grassland. 7. Steppe-Tundra: sparse ground cover, herbaceous with a few low shrubs. 8. (Warm) Temperate Forest: fairly tall, many broad-leaved evergreen/semi-deciduous angiosperm trees but moisture-requiring conifers also tend to be abundant. 9. Wooded Steppe (Cool Temperate Forest): closed

of each vegetation type occupying the unit of land, summing up to one. In the following empirical analysis, Neolithic vegetation control is a set of the fractions of each region occupied by eleven different Neolithic vegetation types. The geographical distribution of vegetation types in the Western core 10,000 years ago, is shown in Figure 7.

Figure 7

Finally, the roots of European growth is commonly seen in the Roman Empire (Landes, 1998, Jones, 1981), while the presence of Ottoman rule may have eradicated some nations' Roman traditions (Kuran, 2011) and the access to the Atlantic Ocean may have opened up trade opportunities and subsequent rise to economic powers among European nations (Acemoglu et al, 2005b). The Ottoman empire during its greatest expansion in the 17th Century also coincides with the spread of Islam. Blaydes and Chaney (2012) argue that Mamlukism - or the use of military slaves by Muslim sultans - beginning in the 8th century following the end of Roman hegemony, led to a process of political divergence in the Christian and Muslim worlds. The authors argue that the forms of executive constraint which emerged under Carolingian feudalism led to increased political stability, while Muslim sultan's reliance on mamlukism limited the bargaining strength of local vassal lords and led to ineffective executive constraint and shorter duration of rule. Under this argument, we would expect the long history of Mamlukism, which lasted up to the 19th century, must have negatively influenced the political stability of Islamic regions under the Ottoman rule, and under the Byzantine rule.

To investigate whether these heritage and geographical factors are important, we obtain indicator variables for whether a region was part of these empires or was an Atlantic trader, by using the EurAtlas (2011) historical georeferenced vectorial data. This set of data provides a series of maps describing the history of sovereign boundaries from 0 CE to 2000 CE for every hundred years, delineating the boundaries of the Roman, Byzantine and Ottoman empires. The variables used in the cross-country analysis give the fraction of the country's territory that was part of the empires in question at the time when the empires reached their peak (Rome in 200 CE, Byzantine empire in 500 CE and the Ottoman empire in 1600 CE). *Atlantic coastline to area-ratio* is taken from Acemoglu et al (2005b) and provides a measure of a country's exposure to the Atlantic and hence its potential for Atlantic trade.

The dependent variable in our regional and Italian analysis is the mean intrastate GDP per capita from Eurostat (2012) from 1997 to 2008. The level of disaggregation is NUTS-3, which gives a total number of 1,371 available observations for 30 countries. The dependent variable in the cross-country section is GDP per capita in 2005 from World Development Indicators.

forest, including mixed conifer-broad-leaved forest. 10 Forest Steppe: mainly herbaceous steppe, but with scattered clumps of trees or bushes in favourable pockets. 11. Montane Desert (Polar and Alpine Desert/ Dry Sparse Tundra): very sparsely vegetated with only low herbaceous plants/ mainly herbaceous or with low shrubs.

3.2 Econometric strategy

In our model in Section 2, we outlined a theory including three basic causal linkages: *1. Time since transition to agriculture* \Rightarrow *2. Institutions* \Rightarrow *3. Current economic performance*. In our econometric framework, we will mainly use data on 1 and 3 and we recognize that some of the institutional factors in 2, involving the often long historical experiences of countries and regions, are not always readily observable. The main focus of our attention will be on assessing the impact of the times since the transitions to agriculture on economic and institutional outcome variables that we have the most reliable measures on.

We will most often run reduced-form equations of the very simple form

$$Y_i = \alpha_0 + \alpha_1 T_i + \alpha_2 X_i + \epsilon_i \quad (1)$$

where Y_i is income per capita in region or country i in our Western sample, T_i is the time since agricultural transition, X_i is a vector of control variables, and ϵ_i is a normally distributed error term. The parameter of interest in this setting is of course α_1 , showing the reduced-form impact of agricultural history on economic performance. In the case when Y_i refers to the current income per capita of some country or regions, our hypothesis is $\alpha_1 < 0$, i.e. an adverse long-run impact of agricultural experience on economic prosperity.

A key identifying assumption in this setup is of course that Y_i did not in any way influence T_i . As has been discussed in previous chapters, once agriculture was invented in the Fertile Crescent, it gradually spread towards the northwest in a fairly regular pattern. Even regions with a similar biogeography such as Turkey and Spain experienced very different dates of adoption on the basis of their distance to the Fertile Crescent. Although local geographical and climatic conditions no doubt played a role in this diffusion (see for instance Ashraf and Michalopoulos, 2011), we think there are no good reasons to believe that current or historical levels of income per capita should have affected the date of agricultural transition. Agriculture typically appeared in a region as an exogenous intervention introduced by migrating agricultural populations.

3.3 Results

In this section we document the negative, reduced-form relationship between time since agricultural transition and levels of current economic performance. In the cross-country part, we also analyze the historical evolution of this relationship and make an assessment of the importance of institutions as an intermediate link. We use three levels of analysis: 1,371 European NUTS-3 regions, 107 regions within Italy, and lastly a cross-country study of 64 Western countries.

3.3.1 Cross-regional analysis

Table 1 shows the results for the cross-regional analysis among 1,371 Western regions in 30 European countries.²⁴ In the first six specifications, the coefficient value for the agricultural adoption date variable is strongly negative and statistically significant, even though the magnitude of the coefficient drops when the set of Neolithic vegetation variables are included in Columns 3-6.

Table 1

The estimate of the adoption date variable in Column 1 (measured in units of 1000 years) suggests that an earlier transition to agriculture by 1000 years implies an approximately 50 percent decrease in the current income level. When the Neolithic biogeography is controlled for, this magnitude drops by about 12 points, and further by 17 points when a set of historical empire controls are included. Under Column 6, the coefficient value of -0.198 still suggests that a 1,000 year earlier transition to agriculture decreases the GDP per capita by about 20 percent. This main result suggests that the timing of agriculture during the Neolithic period has a negative influence on the current economic standing in a region, independent of the Neolithic biogeography, subsequent empire influences, as well as access to the Atlantic Ocean (AJR 2005), the region's latitude, and communist rule.

Table 1 also includes a battery of geographical and biogeographical controls. In particular, we use variables capturing the fraction of different vegetation types in the regions 10,000 years ago, as shown in Figure 7. We also use variables capturing the region's historical belonging to various empires, as well as access to the Atlantic. Our results suggest that a higher GDP per capita is strongly associated with territorially smaller regions, with an icy climate in prehistory, and with a location inside the historical borders of the Roman empire. On the other hand, income levels have a significant negative relationship with a *Semi-desert* vegetation and an inclusion in the former Byzantine or Ottoman empires.

The negative and significant relationship between income levels and agricultural transitions dates is however not robust to including country fixed effects in Column 7. Hence, we cannot rule out that variation between countries is driving the regional results in Columns 1-6. In order to investigate this issue in more detail, we conduct the following analysis in two ways. First, we run an in-depth analysis of within-state variation by focusing only on one country - Italy - for reasons explained below. Second, we carry out an extensive cross-country analysis to explore the reduced-form relationship further and to analyze the channels through which the timing of agricultural adoption influenced modern outcomes at the country level.

3.3.2 Italy

Italy provides a suitable setting for which the above hypothesis can be tested. Its geographical location on an axis from southeast to northwest gives it the same spatial orientation

²⁴Please see Appendix 4 for further details about the variables included in the analysis.

as the direction of the historical spread of agriculture across the continent, as shown in Figure 6. The country is geographically placed in the middle of the agricultural spread and in the Mediterranean region, made up the core area of the Roman Empire, and has a rich set of 78 archaeological sites to infer local diffusion of agriculture. Furthermore, the country is divided into 134 different regions, 107 of which we have income data for comparison. These regions have also been the focus of institutional and cultural research for their varying institutional performance despite close proximity to each other and despite belonging to the same country for about 150 years.²⁵ The broad contours of the country's history since the Neolithic were presented in Section 2.

The maps in Figures 9-10 show the average dates of transition to agriculture and average income levels per capita, respectively. The southern regions adopted agriculture early on, while northern regions adopted agriculture later, an observation which is consistent with the pattern of diffusion in the rest of the European continent. In particular, the north-central regions of Italy were late to adopt and are now the wealthiest areas of the country. Visual inspection suggests that there is a strong negative correlation between date of transition in Figure 9 and current income per capita in Figure 10.

Figures 8-9

Table 2 presents a set of regression results which again shows a consistent finding of higher income related to later adopting regions. The results remain significant even after controlling for the Neolithic biogeography. Note also that the result is not driven by a simple north-south difference; *Latitude* is positive and significant as expected in the table but its inclusion only affects the magnitude of the estimate for *Average time since agricultural transition*, not its level of significance.

Table 2

3.3.3 Cross-country analysis

The main results for the cross-country analysis are shown in Table 3. The sample includes 64 Western countries in Europe, Middle East, North Africa, and Southwestern Asia that belonged to the Western core of agricultural diffusion. The cross-country sample thus contains more than twice as many countries as in the cross-regional analysis. Appendix 6 provides descriptive statistics for the included variables.

²⁵See for instance Banfield (1958) and Putnam (1993). Banfield (1958) studies the effect of culture on the success of institutions in these regions. The author finds "familial amorality" as the dominant ethos in Montegrano in Southern Italy: "Maximize the material, short-run advantage of the nuclear family; assume that all others will do otherwise." The result of such cultural values, according to Banfield, is the main cause for the backwardness in Southern Italy.

Following Banfield, Putnam (1993) refers to the absence of "civic virtue," or the character of the citizens showing "interest in public issues and devotion to public causes" (Walzer, 1992), as the main determinant for the lack of institutional performance in the southern regions of Italy. Importantly, the author traces the differences of institutional performances in South and Northern Italy back to the year 1100, arguing that Northern Italy's merchant ruling class with horizontal social networks and active social involvement led to better institutional performance than the South, a region marked by a history of autocratic rulers.

Table 3

As is clear from the table, *Average time since agricultural transition* in the Western core has consistently a negative and significant impact on log income per capita in 2005. Like in the previous tables, we also include a number of geographical control variables such as country area, the percent of arable land, and the average altitude of the country. Interestingly, *Log Arable land* is negative and significant in Columns 2-4, but not in the other columns.

Obviously, the countries in our Western sample have been strongly affected by other historical events apart from their transition to Neolithic agriculture. Starting in Column 3, we try to account for some of these other influences by including variables proxying for the influence of Atlantic trade (*Atlantic coastline to area-ratio*), the impact of being part of the Roman, Byzantine, and Ottoman empires (measured as the fraction of a country's territory within each empire at the time of their maximum extension), and whether the country was a previous Warsaw pact, East European country or a former Soviet republic. In the full Western sample, former Roman countries appear to have higher GDP and former communist countries have a substantially lower GDP.

When the standard set of controls (used in tables below) is employed as in Column 4, time since agricultural transition is still negative and significant. The conditional scatter plot for this regression is shown in Figure 10. The point estimate (-0.64) indicates that a 1,000-year earlier transition to agriculture would have implied a 64 percent lower GDP per capita. The numbers imply that if a country close to the mean time since transition such as Italy had experienced the transition to agriculture in 6,300 BCE instead of in the actual year 5,300 BCE, their GDP per capita in 2005 would have been 6,979 \$US instead of 19,386 \$US. The economic significance is thus also quite strong.

Figure 10

A potential objection to using the full Western sample is that it includes a quite heterogenous group of countries, mixing European states with North African and Middle Eastern countries. In Columns 5 and 6, we therefore restrict our sample to 40 European countries. Within Europe, the former communist dummy is very significant, as expected, but so is time since agricultural transition. In Columns 7 and 8, we restrict the sample even further to only include 31 countries that had more than 50 percent of its territory within the Roman empire in year 200 CE. These countries shared a similar institutional and cultural context during a very formative period of Western history. The precision of the estimates for our main explanatory variable is even better in this sample.

In Table 4, we check the robustness of our results in a number of ways. We start by using two alternative measures of time since agricultural transition. First, we include *Time since agricultural transition* from Putterman (2006) which so far has been the main variable used in research for measuring time since the agricultural transition in cross-country studies. This variable is also negative and significant at the 10 percent-level in

Column 1 but not in Column 2 when control variables are included. Second, instead of taking the average value of transition to agriculture within countries, we use the earliest evidence of Neolithic agriculture in a country from the Pinhasi et al (2005) data.²⁶ The estimates for this variable are negative and significant in Columns 3 and 4. Hence, the main tendency in the results do not seem to be driven by the particular choice of proxy for time since the agricultural transition.

Table 4

In Columns 5-6, we exclude all countries in the sample that do not have at least one of the 765 site observations from Pinhasi et al (2005) within their borders. In this way, we restrict the sample to country observations with a greater precision in the measurement of the date of agricultural transition. Reassuringly, in this smaller sample of 44 countries, the t -values for the negative estimates of *Average time since agricultural transition* are very high.

In Column 7, we use the whole sample of available Western countries again and introduce the standard control variables from the recent study by Ashraf and Galor (2012): *Log Arable Land*, *Log Latitude*, and *Log Suitability for Agriculture*. The latter variable was originally developed by Michalopoulos (2012) and is calculated as a country average from geospatial data on grid cell level on soil and climate suitability for agriculture. *Log Land Suitability for Agriculture* is never significant in columns 7-9 and even changes sign. Also *Log Latitude* changes sign and although *Average time since agricultural transition* inevitably is positively correlated with latitude, the former variable is consistently negative and significant at the 10-percent level in columns 7-9.

In columns 8-9, we also include the fraction of a country's territory covered by different vegetation types 10,000 years ago. Although we recognize that biogeography to an important extent influenced the timing of the agricultural transition, we believe it is still an informative exercise to assess the influence of the timing of transition when holding vegetation types constant. For instance, we can see from Figure 7 that whereas current Turkey and Spain shared a similar biogeography (Dry and Wooded Steppe), Spain made the transition almost 2000 years later (9,323 and 7,381 years ago respectively). In Column 8, only four of these biogeographical variables are significant at a lower level than 10 percent but none remain so in Column 9.²⁷

When the whole set of 17 geographical, biogeographical and historical control variables are included as in Column 9, we see that only *Log Latitude* is still positive and moderately significant. Even in this extremely challenging horse race, the coefficient for *Average time since agricultural transition* remains negative and significant at the 10-percent level. Given these results, we find it very unlikely that our main explanatory variable is mainly

²⁶See Appendix 6 for the descriptive statistics regarding this variable. Compared to the *Average date of transition*, the cross-country mean level of *Earliest date of transition* is 835 years higher.

²⁷Note that the estimates for vegetation variables that are never significant in the regressions are not displayed in the table.

capturing land quality characteristics. If these geographical variables have a long-run impact on economic development, this impact appears to run through the timing of the Neolithic.

When did this reversal happen in the Western world? There are at least two strands in the literature arguing for a great divergence happening in the Western world after 1500 CE. Acemoglu et al (2005b) demonstrate that Atlantic trading nations, benefitting from the newly opened colonial trade, surged ahead of other countries and regions in Europe after 1500. The second and very significant shift was the Industrial Revolution, starting around 1750, which even further contributed to the economic and technological dominance of Britain and other north European countries (Mokyr, 1990; Acemoglu and Robinson, 2012). A key question in our analysis is thus if the reversal since the Neolithic was visible already by 1500?

For the Malthusian era, it is widely accepted that population density is a good indicator for the level of economic development in a country (Ashraf and Galor, 2011). In Table 5, Columns 1-3, we use population density in years 1, 1000 and 1500 CE as dependent variables. In year 1, the reversal does not seem to be in place since the estimate for *Average time since agricultural transition* is positive. In 1000 CE, the estimate is negative but insignificant. However, by 1500, the reversal is evident since time since agricultural transition in that year has turned negative.

Table 5

In Columns 4-6, we instead use *Log GDP per capita* from the same time periods as the dependent variables. The sample is now limited to only 21-24 countries and the data on historical income levels is once again taken from Ashraf and Galor (2012). A quite similar pattern emerges in these regressions. The time since agricultural transition even has a positive and significant influence on income in year 1000 CE, whereas the reversal is in full play by 1500 CE in Column 6. Interestingly, the same dynamic of a reversal by 1500 CE appears in Columns 7-8 where the dependent variable is an indicator for the average level of technological sophistication, taken from Comin et al (2010).

The results in Table 5 strongly suggests that the historical heritage from the Neolithic turned from being an asset to Western countries' levels of development as late as 1000 CE, to being a drag only 500 years later, and from then on until today. In Table 6, we investigate the time period 1000-1500 CE further by using the population and GDP per capita growth rates as the dependent variables. As expected, *Average time since agricultural transition* has a statistically significant negative influence on both population and GD per capita growth rates during the period. Since the initial levels of population density and income levels are included in Columns 2 and 4, this is not a simple convergence effect.

Table 6

In figure 11, we show the bivariate association between GDP growth and time since agricultural transition from the specification in Table 6, Column 3. The fit among these 21 countries is rather high with a R^2 of 0.52. Not surprisingly, Renaissance Italy and Belgium are outliers with superior growth rates. In the upper left corner are the North European countries and in the lower right, the early civilizations with weak growth. The point estimate of -0.0347 in Column 3 implies that a 1000 year earlier transition to agriculture is associated with an annual growth rate that is 0.0347 percentage units lower. This might seem like a small effect but during this medieval period, when the mean annual growth rate in our sample was a modest 0.069 percent, the economic significance was not negligible.

Figure 11

We do not interpret these results as evidence against the critical roles played by Atlantic trade, the Reformation, and the Industrial Revolution. Undoubtedly, these fundamental processes contributed very importantly to the great divergence that made Britain and its northern followers so much richer than the Mediterranean and Middle Eastern countries. What we do suggest, however, is that the process of reversing fortunes in the Western world seems to have followed an older trajectory rooted in the Neolithic which has previously not been recognized and which seems to have become manifest already during the Medieval period. We leave it for future research to investigate further why the reversal happened in 1000-1500 CE and not in some other period.

In Table 7, lastly, we analyze the influence of *Average time since agricultural transition* on our intermediate variable; historical and current levels of institutional quality. If our hypothesis is correct, we should observe that by 1500 CE, time since the Neolithic should already have a negative influence on democratic and private property-related institutions. In Row 1, the dependent institutional variable is *Executive constraints* in 1500 CE, taken from Acemoglu et al (2005b), and believed to capture to what extent governments were constrained from expropriating private property. As predicted, *Average time since agricultural transition* has a negative impact on *Executive constraints* in 1500, meaning that later adopting countries had stronger institutions already by this time.

Table 7

In Rows 2-3, we include *State antiquity index* 1500-1950 from Putterman's (2010) data set as an indicator of the level of statehood during the Modern Era. A recurring argument in the literature is that European states strengthened power over their territories in the Modern Era, which in turn created a foundation for later economic development. Columns 2-3 show that countries that more recently transitioned into agriculture also experienced the emergence of stronger states in the post-1500 period.

Columns 4-9 have contemporary institutions as the dependent variable. These variables arguably captures the essence of what our model defines as extractive institutions; the level of rent seeking in society (*Corruption in 2010*), income inequality (*Gini coefficient*

in 2000), and the level of democracy/autocracy (*Democracy in 2010*).²⁸ Given the path dependency of many institutional indicators, we also expect that the current levels should be correlated with historical levels, although we unfortunately do not have comparable historical measures readily available to test this argument.

As we see from the table, countries that made the agricultural transition early tend to have relatively more corruption, be strongly autocratic, and have a substantial income inequality. This does not change when control variables are included. A potential objection to this analysis is that the institutional variables used above mainly capture the formal rules or compliance to rules at a specific and recent point in time. For instance, the scores for *Democracy in 2010* are obtained from the Polity data set where scores can sometimes change drastically from year to year for a specific country. In a companion paper (Paik and Olsson, 2012), we specifically investigate the impact of the transition to agriculture on informal institutions and cultural norms that are likely to change in a much slower fashion. Our results show for instance that norms towards obedience are also more prevalent in regions that transitioned early, in line with our model.

4 External validity and an extended model

Is this model then only applicable to the Western core or have there been similar reversals elsewhere, as suggested by Figure 1? Outside Europe, the colonial era has been regarded as central for understanding the comparative development of countries. Acemoglu et al (2002) observe a reversal of fortune among former colonies in the sense that countries that had a high population density and a high urbanization rate in 1500 CE are relatively poor now. Like Sokoloff and Engerman (2000), Acemoglu et al (2002) emphasize the importance of differential colonial strategies for understanding this outcome: In regions that were already wealthy and had a dense population, colonizers installed extractive institutions involving massive plunder of mineral riches and forced labor, whereas Westerners settled themselves and established strong property rights in less densely populated colonies.

Clearly, it can easily be argued that the higher population density and wealth in certain former colonies was actually due to an earlier transition to agriculture. Acemoglu et al (2002, p 248) compare for instance the cases of Bolivia and Argentina. According to their estimates, Bolivia was seven times as densely populated as Argentina in 1500, whereas Argentina is a lot richer today. However, the main reason for this substantial difference in population density in pre-Columbian times is the very different agricultural histories of the two countries. Western Bolivia was part of the Andean highland civilization that made the transition to agriculture around 2000 BCE, based on the cultivation of squash, beans, potato, and avocado (Bellwood, 2005). The dominant city of Tiwanaku hosted between 15,000-30,000 people already in 600 CE (Kolata, 1993). Argentina, on the other hand, was peripheral to the major early civilizations and the largely nomadic tribes in the

²⁸Note that higher values imply *more* inequality in the *Gini coefficient*-variable, whereas higher values imply less corruption and autocracy in the *Corruption*- and *Democracy*-variables.

area only developed primitive agriculture. In pre-Columbian times, no urban settlement hosted more than a few thousand people.

Hariri (2012) likewise argues and demonstrates empirically that regions outside Europe that had a long history of agriculture and of statehood tended to provide a stronger resistance to the colonial powers when they first appeared after 1492. Some of the oldest civilizations, like China and Ethiopia, were never colonized at all. Unfortunately, this also meant that their highly autocratic institutions were resistant to Western ideas of democracy and inclusive institutions that were transplanted to many countries with weaker indigenous state formations (like Australia and Argentina). In this way, early agriculture again implied a curse to long-run development.

In this paper, we have focused on establishing a causal relationship for the Western core where we also have a rich archaeological data set to base our analysis on. A similar data set as Pinhasi et al (2005) does not exist for other parts of the world, as far as we know. Hence, we cannot undertake identical studies outside Western Eurasia with the same level of confidence. In addition, Eurasia consists of countries with almost entirely indigenous populations. Samples obtained from populations of anthropological interests have been in place before the great diasporas started in the 15th and 16th centuries. Since population admixtures became the norm after this period, especially in the Americas, it is imperative to take further precautions and look at a continent where such admixture is minimized. As supporting evidence, Putterman and Weil (2010) find that along with almost all of Africa and Asia, Europe is a continent of countries with almost entirely indigenous populations. In contrast, countries of like Australia, New Zealand and Canada have populations that are overwhelmingly of European origin, and some others (Central American and Andean countries) have both large Amerindian and substantial European-descended populations.

As in Figure 1, it is possible to use the dates provided by Putterman (2006) in order to get an idea of what the relationship between agricultural transition and current levels of income has been elsewhere. From a theoretical point of view, there are strong reasons to believe that the same pattern of an early transition to agriculture, followed by autocratic rule, rent seeking, inequality, technological backwardness, and ultimately stagnant economic development has also prevailed within other agricultural core areas.

In Figure 12, we look at the unconditional correlation between log GDP per capita in 2005 and Putterman's measure of agricultural transition among 41 countries in Sub-Saharan Africa. All these countries are part of the Sub-Saharan zone where agriculture spread mainly from an early core in the Sahel (Diamond, 1997; Bellwood, 2005). As the figure shows, there is a robust and surprisingly strong negative relationship. Northeast African states like Sudan (SDN) and Ethiopia (ETH) are among the countries that made the transition first and are very poor today, whereas latecomers such as Mauritius (MUS) and Botswana (BWA) are a lot richer. In Mauritius, agriculture did not appear until 362 years ago, according to Putterman's (2006) estimates. Ethiopia, on the other hand, is one of the oldest persistent statehoods in the world and is yet one of the poorest countries on earth.

Figure 12

The pattern in Central and East Asia is described by Figure 13. The simple relationship is clearly negative and significant at the 10-percent level.²⁹ China (CHN) was the first country to adopt agriculture and is somewhat richer than predicted by the model, whereas Japan (JPN) and Singapore (SGP) are late adopters that are relatively rich in an Asian comparison.

Figure 13

In the Americas, any analysis of a relationship between transition to agriculture and current income levels is extremely complicated due to the demographic shift that happened there since 1500 CE. It is a well-known fact that disease and hardship caused a very large fraction of the native Indian population to become extinct and be replaced by European immigrants and slaves from West Africa. Hence, we refrain from drawing any conclusions on the basis of the American case.

In Figure 1, we combine the regression predictions for the relationship between Putterman's (2006) *Time since agricultural transition* and *Log GDP per capita in 2005* from Figures 2, 12, and 13. The graph shows the positive fitted relationship for the whole sample as well as the negative fitted relationships for the Western, Sub-Saharan African, and East Asian subsamples. Although one should be careful about overinterpreting these bivariate associations, the pattern does seem to support our hypothesis regarding the links between agricultural transition and current levels of development.

In line with the Diamond-model as tested in Hibbs and Olsson (2004), Olsson and Hibbs (2005), and Putterman and Weil (2010), the average Western country has a higher GDP per capita than the average country within other agricultural core regions. As indicated by the figure, a country on the middle of the Western regression line made a transition about 7,000 BP and has a log of GDP per capita of about 8.6 (5,430 \$US). An equivalent mid-range country in East Asia made the transition somewhat later, by about 6,500 BP, and has a much lower log GDP per capita at about 7.5 (1,810 \$US). The equivalent numbers for Sub-Saharan Africa are roughly 2,600 BP and a log of GDP at 6.24 (515 \$US). We argue that these large continental differences in average levels of development can be well explained by the advantages of a superior biogeography and geography and an earlier transition to agriculture and civilization in the Western core, as argued by Diamond (1997). However, *within* the Western core, the relationship is clearly negative, as discussed above.³⁰

The figure provides a way of reconciling the Jared Diamond-hypothesis with the institutional reversal-hypothesis outlined in this analysis. To a great extent, the positive relationship for the whole sample is driven by the successive negative relationships for the

²⁹Clearly, a negative convex curve would have given a stronger fit to the data points in the graph.

³⁰It is noteworthy that almost all Western countries had already made the transition when the first regions in Sub-Saharan Africa did.

Western, East Asian and Sub-Saharan African cores. Although the evidence from East Asia and Sub-Saharan Africa are clearly inconclusive at this stage, they are consistent with the basic pattern demonstrated for our Western sample. We believe that the relationships that emerge from Figure 1 might serve as the basis for a new hypothesis regarding the long-run impact of early agriculture.

5 Conclusions

In this paper, we argue that whereas countries that made the transition to agriculture early tend to be relatively rich in a worldwide comparison, there is a reversal of fortune within the agricultural core regions in the sense that early adopting countries tend to be poorer today than the countries in the periphery of the core. Our model suggests that the reason for this reversal is that countries and regions that made the transition to agriculture early tended to develop autocratic, unstable states early in history, characterized by rent seeking, inequality, and technological inertia, while later adopting regions had more democratic forms of government, less rent seeking, and a greater social equality.

In the empirical section, we demonstrate that there is a strong negative association between time since transition to agriculture and current income levels in regressions featuring 1,371 European regions, in a study of 107 Italian regions, as well as in a cross-country analysis of Western countries. We also show that time since agricultural transition is associated with early statehood, high corruption, autocratic forms of government, and great inequality. Importantly, the economic, institutional, and technological reversal appears to have been in place already in 1500 CE, i.e. before Western colonization and industrialization. Hence, the very large income differences that emerged during the last 500 years seem to be partly rooted in development trajectories dating back to the Neolithic.

Our analysis ends with a brief investigation of the external validity of our hypothesis outside the Western core. Preliminary findings from Sub-Saharan Africa and East Asia, as well as our interpretation of the existing literature, strongly suggest a positive association between time since agricultural transition and current income on a worldwide basis, combined with a negative association within core areas. The findings also warrant a more careful analysis in the future of the links between agricultural transition and long-run economic development outside the Western core.

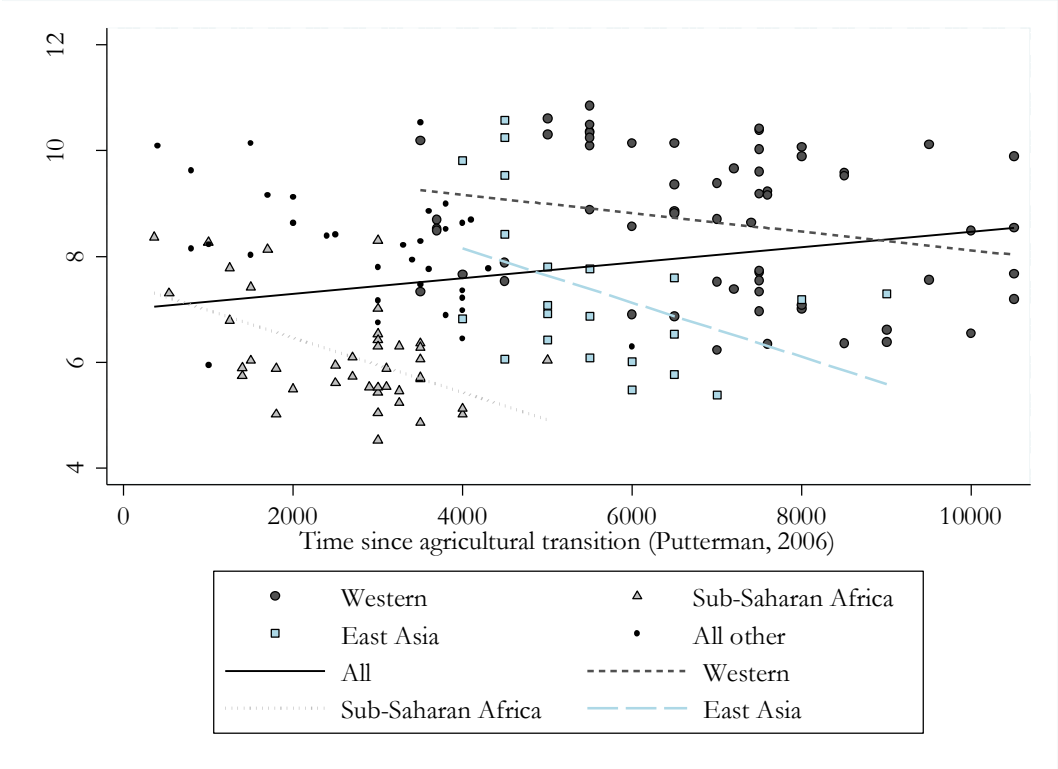
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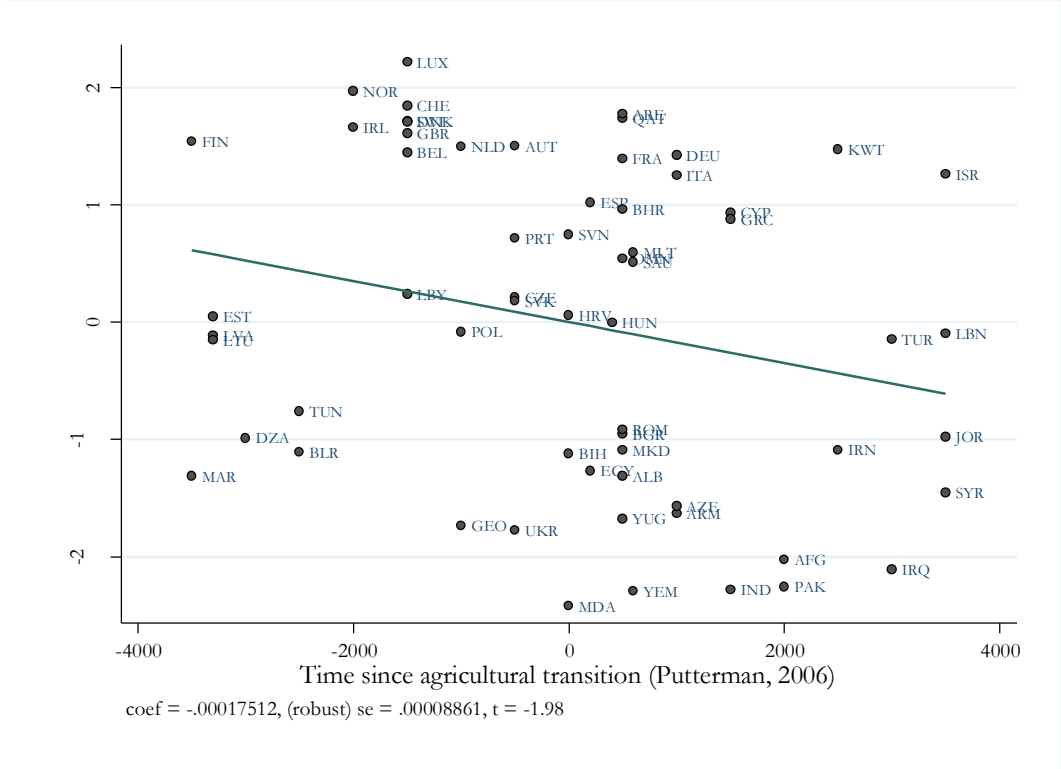
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Figure 1: Relationship between log GDP per capita in 2005 and time since agricultural transition in total sample and within the Western, Sub-Saharan African, and East Asian cores.



Note: The figure combines four fitted lines for separate OLS regressions using the full sample of observations (N=158), the Western sample (N=62), the East Asian sample (N=22), and the Sub-Saharan African sample (N=41). See figures 2, 12, and 13 for parameter estimates and other information about the separate regressions. The color of each country indicates whether it belongs to the Western, East Asian, Sub-Saharan African, or Other category. *Time since agricultural transition* is taken from Putterman (2006).

Figure 2: Relationship between log GDP per capita in 2005 and time since agricultural transition among 62 Western countries.



Note: The figure shows the added-variable plot for the unconditional relationship between *Log GDP per capita in 2005* and *Time since agricultural transition (Putterman, 2006)*. N=62, R²=0.056, p-value < 0.053. OLS estimates using robust standard errors. Each country is identified by a three-letter isocode. *Time since agricultural transition* is taken from Putterman (2006). Western countries are all countries in Europe, North Africa, and Middle East, plus Armenia, Azerbaijan, Georgia, India, and Iran.

Figure 3: Our model

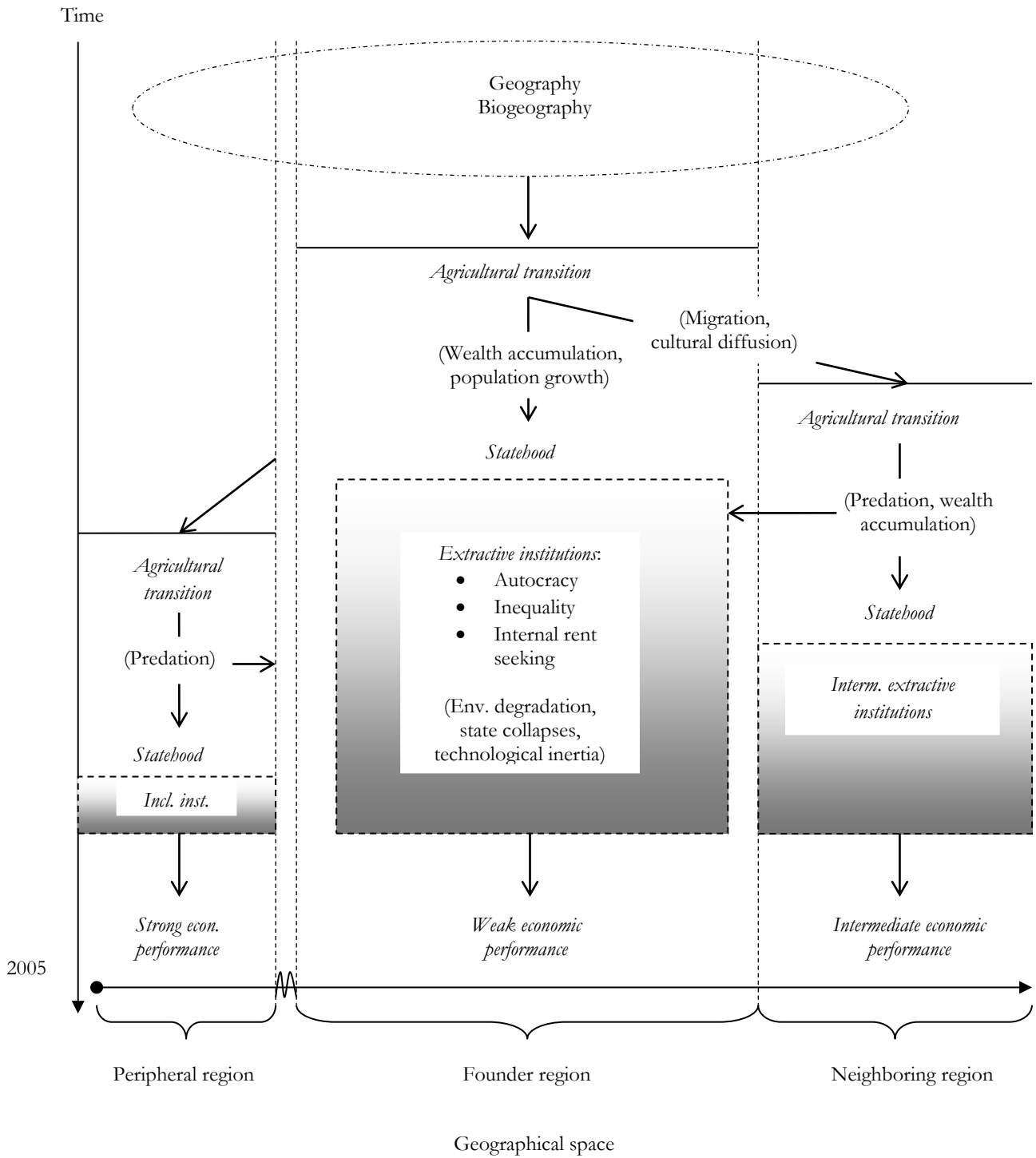
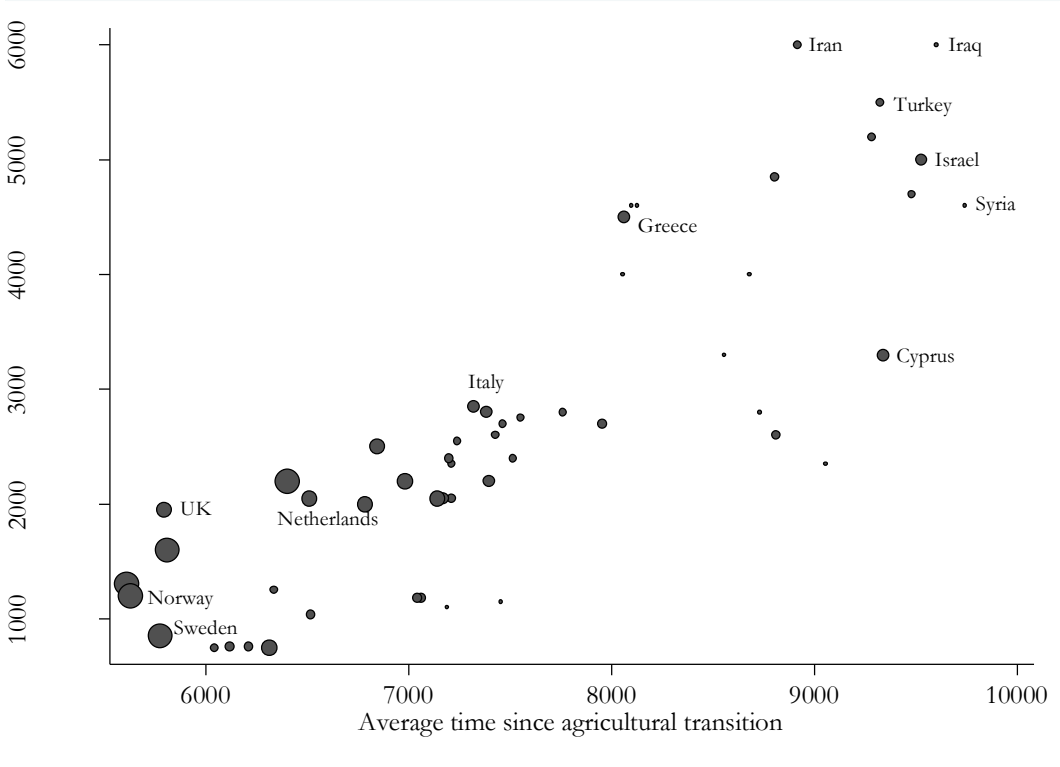


Figure 4: Scatter plot showing time since first state formation and average time since agricultural transition for 52 Western countries with markers weighted by GDP per capita in 2005



Note: N=52. Each circle represents a country and the size of each marker is determined by its level of GDP per capita in 2005, ranging from <1500 USD (smallest markers) to >29000 USD (largest markers). Average time since agricultural transition uses a measure constructed from Pinhasi et al (2005). Time since first state formation is taken from Borcan et al (2012). Western countries include all countries in Europe, North Africa, and Middle East, plus Armenia, Azerbaijan, Georgia, India, and Iran.

Figure 5: Neolithic sites and the spread of agriculture in Italy

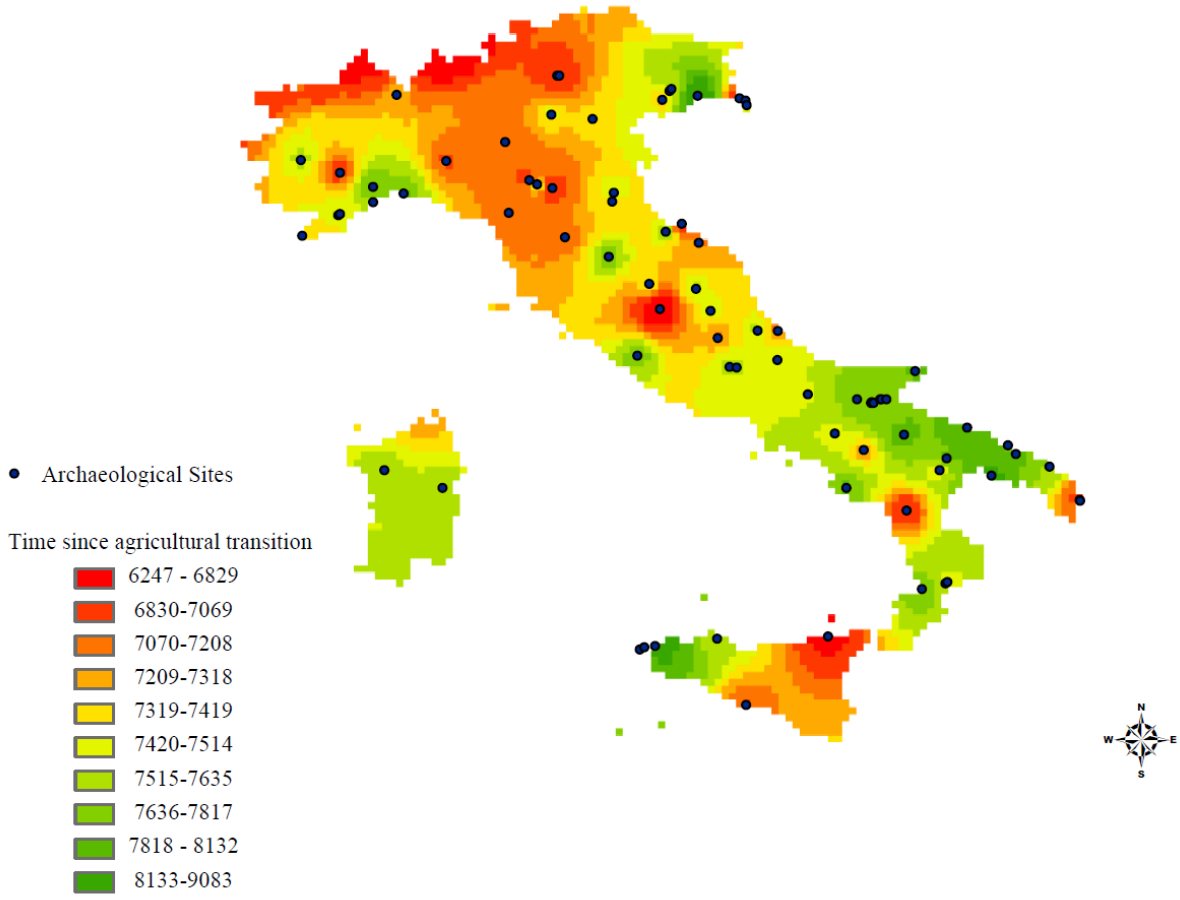


Figure 6: Neolithic sites and spread of agriculture in the Western core

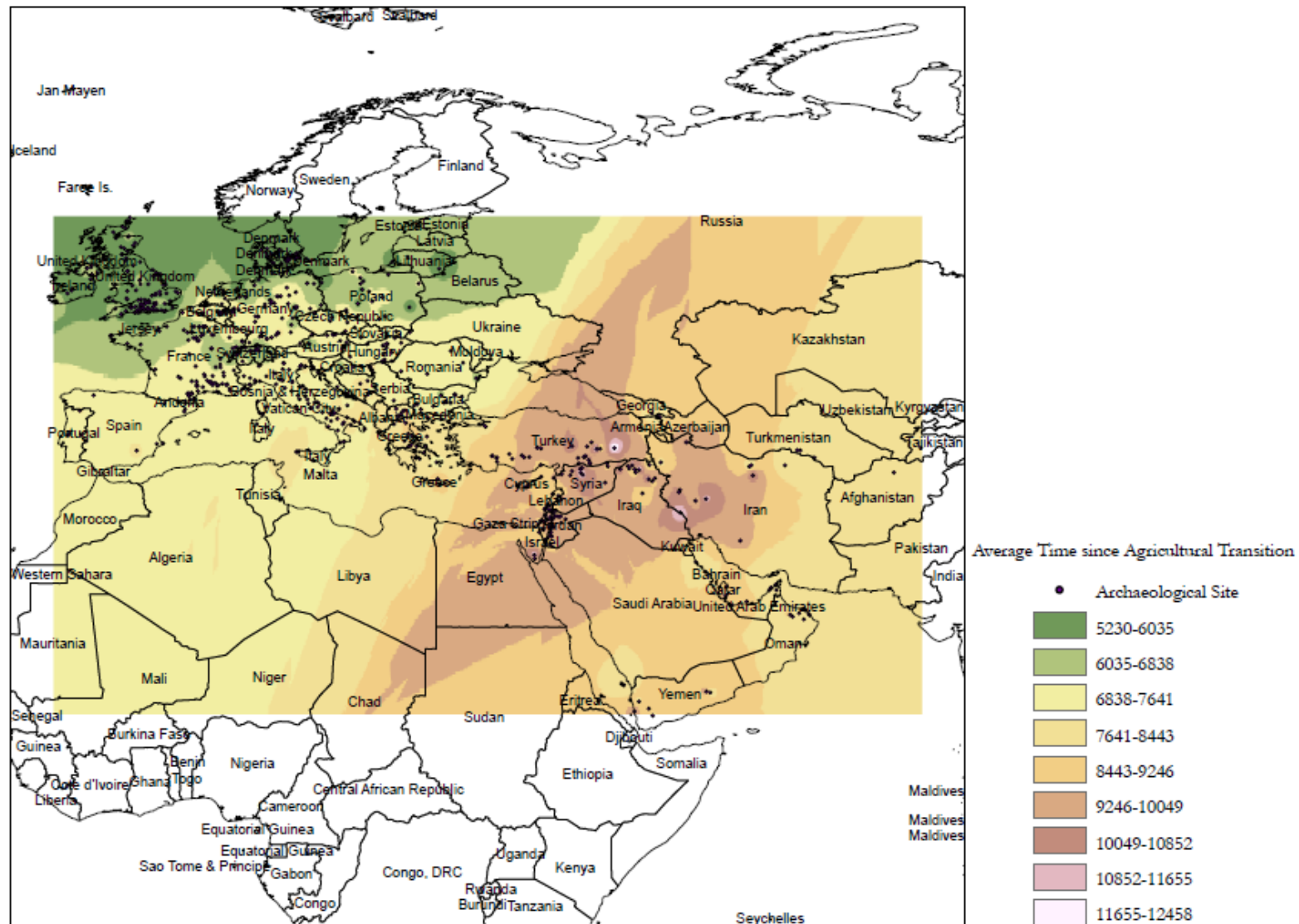


Figure 7: Biogeography in the Western core 10,000 years ago

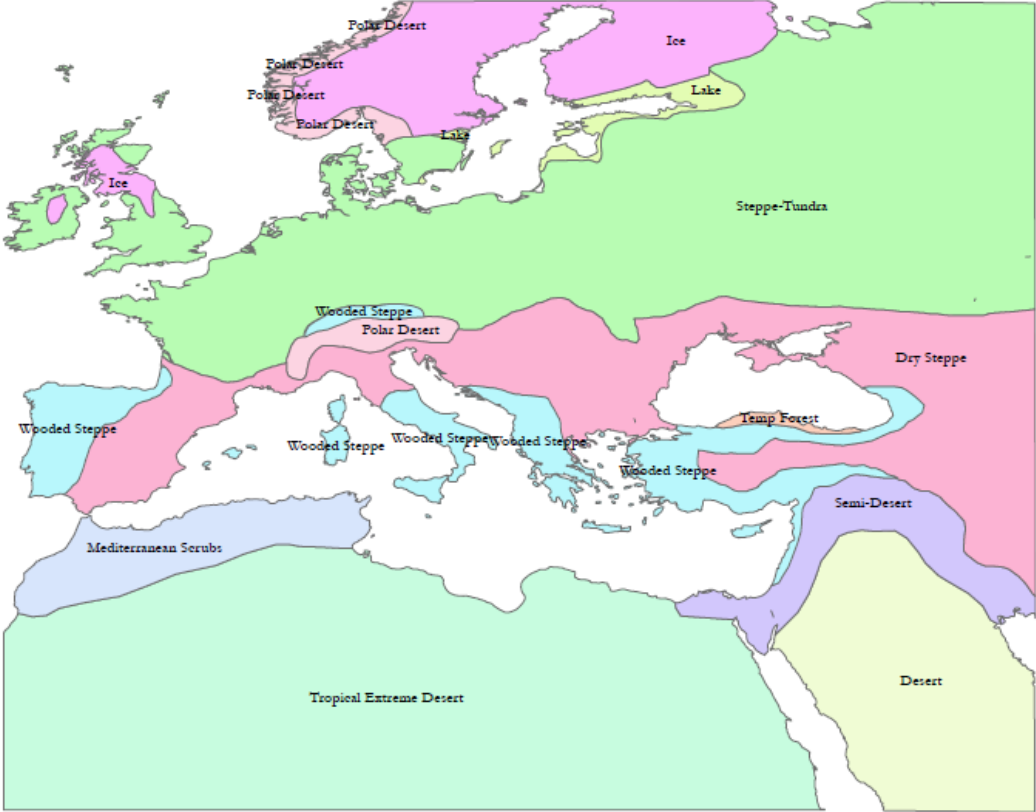


Figure 8: Average time since agricultural transition among Italian regions

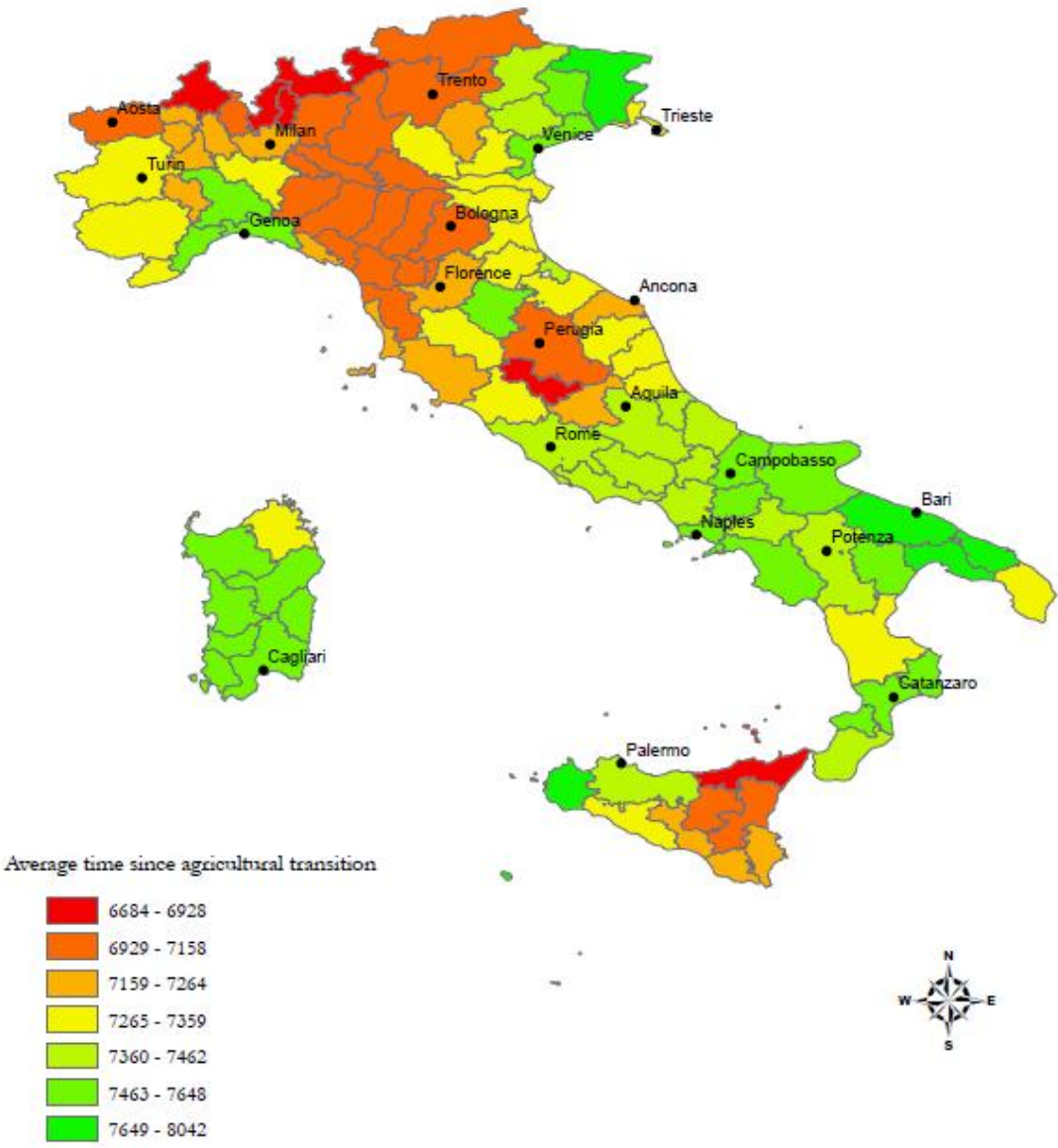


Figure 9: Average GDP per capita 1997-2008 among Italian regions

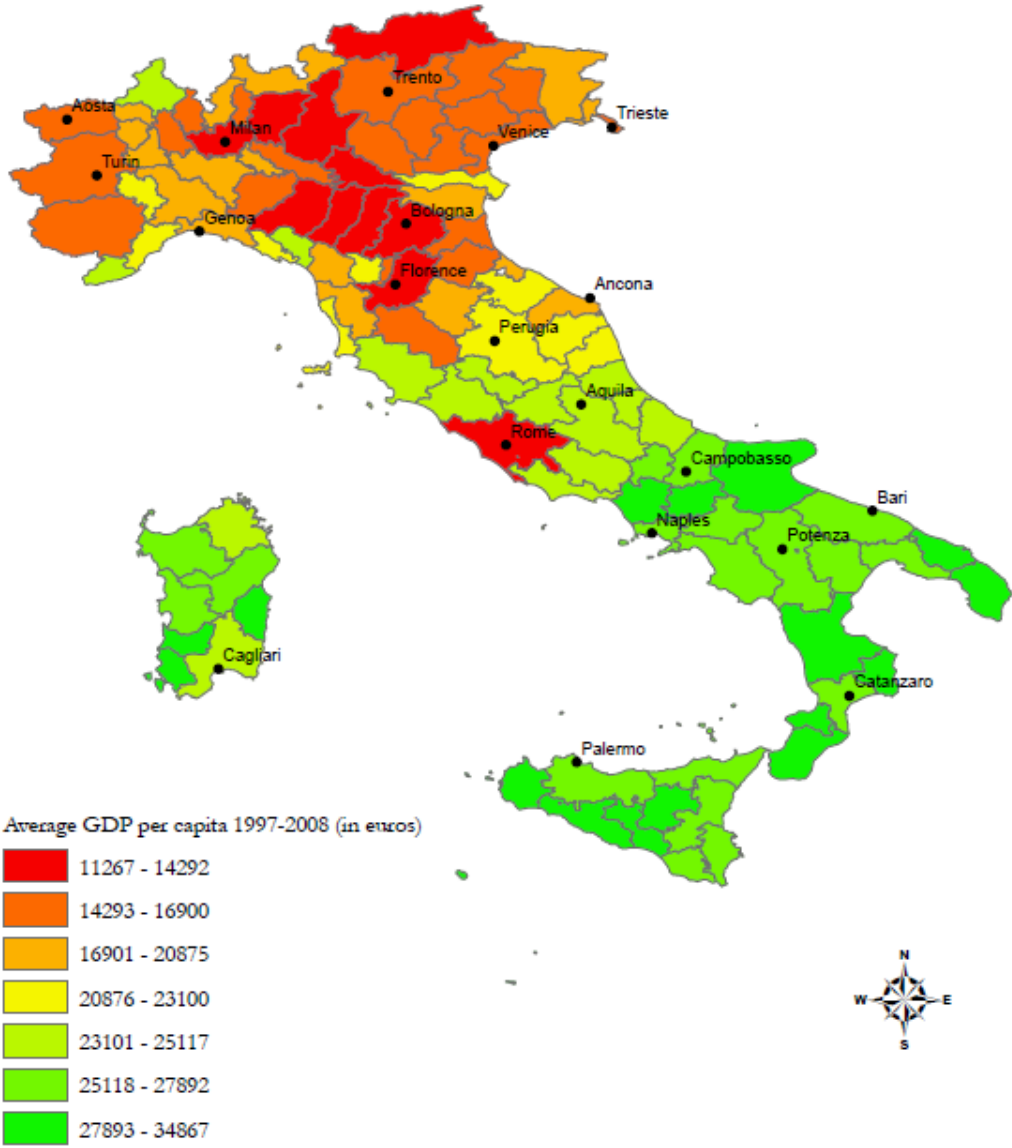
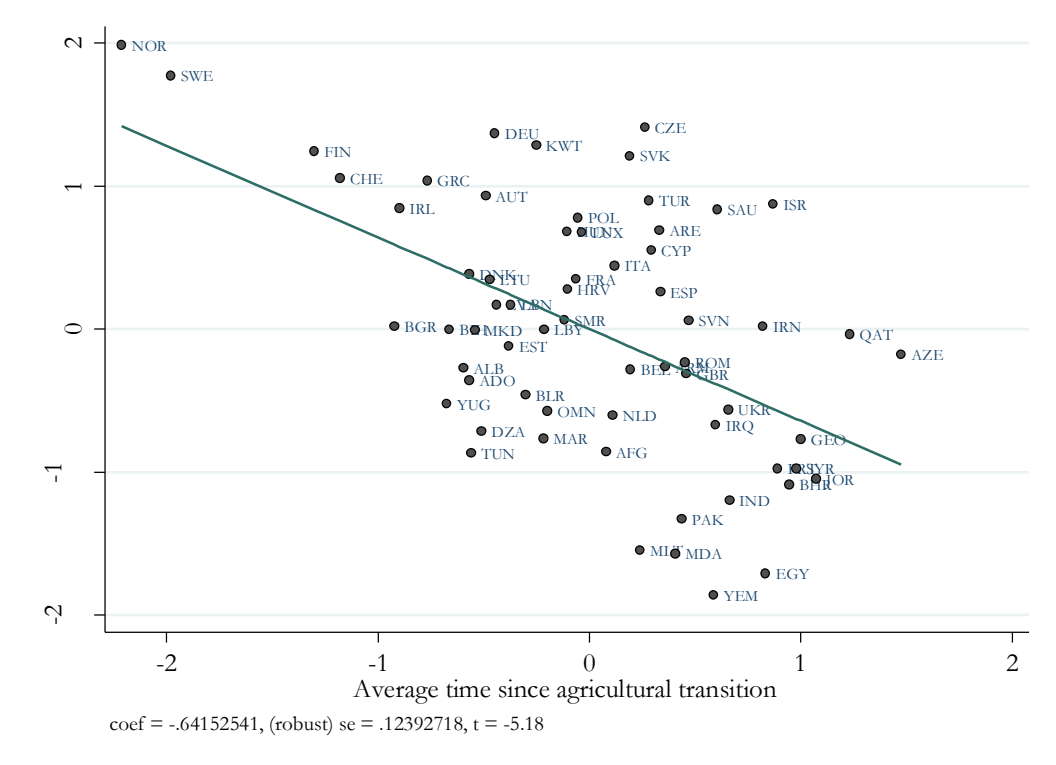
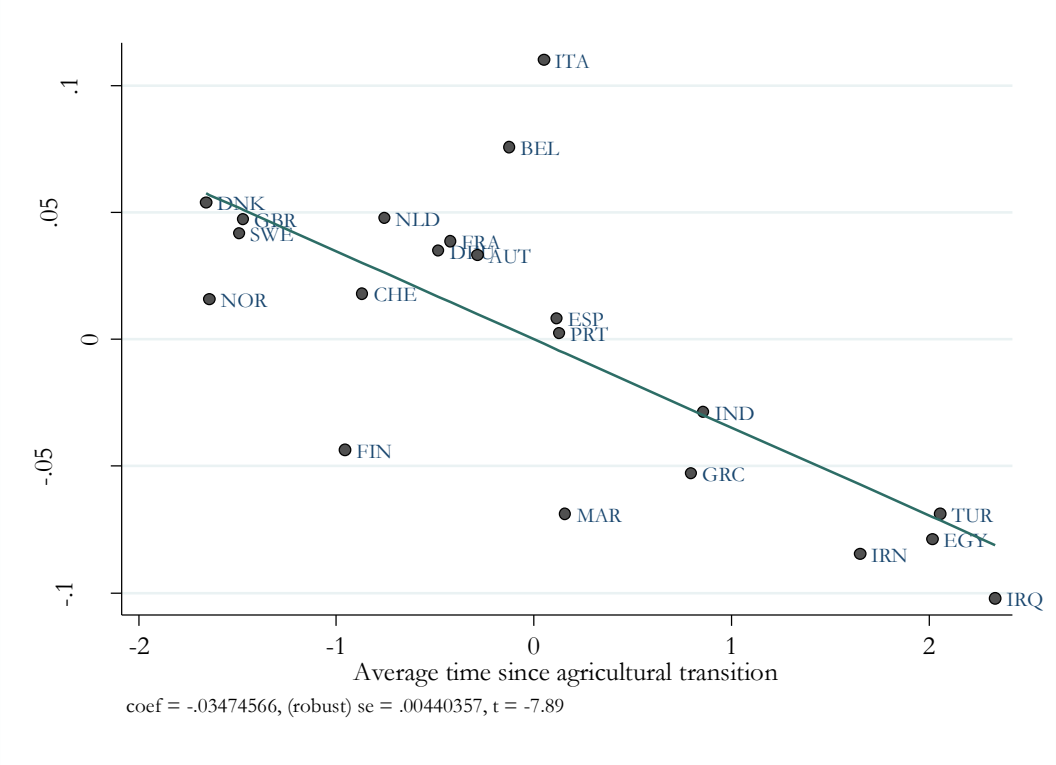


Figure 10: Conditional relationship between log GDP per capita in 2005 and average time since agricultural transition among 64 Western countries



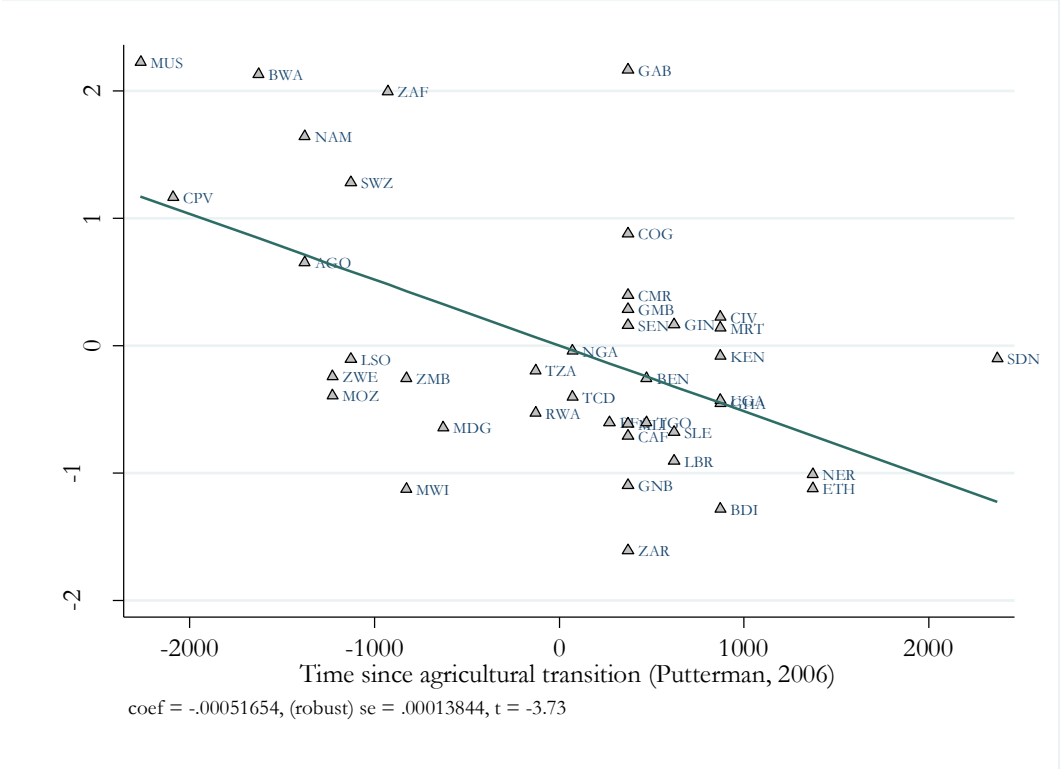
Note: The figure shows the added-variable plot for the conditional relationship between *Log GDP per capita in 2005* and *Average time since agricultural transition* from the regression specification in table 1, column 4.

Figure 11: Relationship between the annual growth rate of GDP per capita 1000-1500 CE and average time since agricultural transition among 21 Western countries



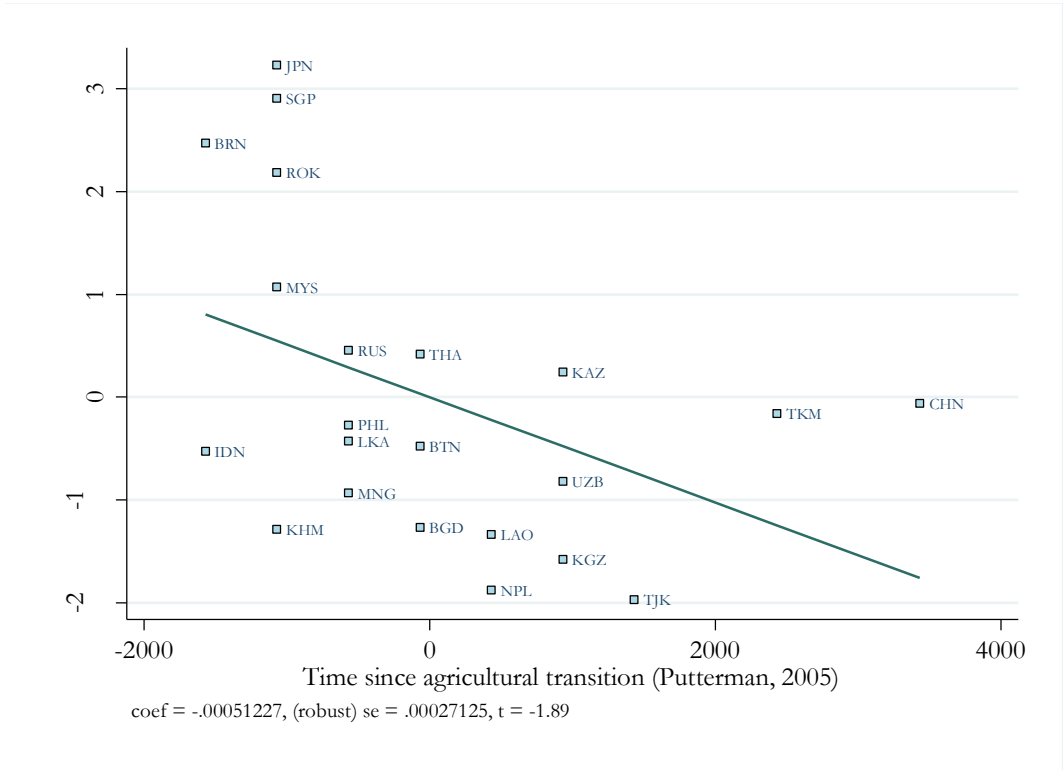
Note: The figure shows the added-variable plot for the unconditional relationship between *Percent growth of GDP per capita 1000-1500 CE* and *Average time since agricultural transition (in 1000 CE)* from the regression specification in table 6, column 3.

Figure 12: Relationship between log GDP per capita in 2005 and time since agricultural transition among 41 Sub-Saharan African countries.



Note: The figure shows the unconditional bivariate relationship between *Time since agricultural transition* and *Log GDP per capita in 2005*. N=41, R²=0.281, p-value < 0.001. OLS estimate using robust standard errors. Each country is identified by a three-letter isocode. *Time since agricultural transition* is taken from Putterman (2006).

Figure 13: Relationship between log GDP per capita in 2005 and time since agricultural transition among 22 Central and East Asian countries.



Note: The figure shows the unconditional bivariate relationship between *Time since agricultural transition* and *Log GDP per capita in 2005*. N=22, R²=0.186, p-value = 0.074. OLS estimates using robust standard errors. Each country is identified by a three-letter isocode. *Time since agricultural transition* is taken from Putterman (2006).

Table 1: Relationship between time since agricultural transition and GDP per capita among 1,371 European NUTS-3 regions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Log Average GDP per capita 1997-2008						
Average time since agricultural transition	-0.484*** (0.0210)	-0.473*** (0.032)	-0.379*** (0.036)	-0.147*** (0.033)	-0.121*** (0.034)	-0.198*** (0.027)	-0.066 (0.060)
Log Region Area		-0.277*** (0.015)	-0.240*** (0.014)	-0.203*** (0.013)	-0.207*** (0.013)	-0.112*** (0.009)	-0.120*** (0.032)
Altitude		0.096 (0.073)	-0.177** (0.079)	-0.219*** (0.064)	-0.213*** (0.065)	-0.405*** (0.057)	-0.166 (0.104)
Latitude		-0.019*** (0.006)	-0.057*** (0.009)	-0.031*** (0.009)	-0.031*** (0.009)	-0.005 (0.006)	0.012 (0.021)
Steppe Tundra, 10000 Yrs Ago			0.004 (0.003)	0.003 (0.003)	0.003 (0.003)	0.000 (0.002)	0.001 (0.002)
Ice, 10000 Yrs Ago			0.008*** (0.003)	0.009*** (0.003)	0.008*** (0.003)	0.001 (0.002)	0.002 (0.002)
Polar Desert, 10000 Yrs Ago			0.011*** (0.003)	0.008** (0.003)	0.008** (0.003)	0.008*** (0.002)	0.005* (0.003)
Semi Desert, 10000 Yrs Ago			-0.010*** (0.004)	-0.007** (0.004)	-0.008** (0.004)	-0.011*** (0.002)	-0.003 (0.003)
Dry Steppe, 10000 Yrs Ago			-0.003 (0.003)	-0.001 (0.003)	-0.002 (0.003)	0.000 (0.002)	0.002 (0.002)
Wooded Steppe, 10000 Yrs Ago			0.001 (0.003)	0.002 (0.003)	0.002 (0.003)	0.001 (0.002)	0.002 (0.002)
Temperate Forest, 10000 Yrs Ago			-0.009** (0.004)	-0.004 (0.004)	-0.005 (0.004)	-0.009*** (0.002)	-0.001 (0.002)
Ottoman Empire (dummy)				-0.870*** (0.070)	-0.873*** (0.071)	-0.313*** (0.080)	-0.180** (0.078)
Roman Empire (dummy)				0.335*** (0.034)	0.321*** (0.035)	0.153*** (0.027)	0.223*** (0.051)
Byzantine Empire (dummy)				-0.207*** (0.074)	-0.214*** (0.076)	-0.421*** (0.082)	0.091 (0.192)
Atlantic Ocean (dummy)					0.152*** (0.048)	-0.134*** (0.034)	-0.005 (0.053)
Warsaw Pact or Soviet Republic (dummy)						-1.251*** (0.038)	
Country Fixed Effects	No	No	No	No	No	No	Yes
Constant	12.99*** (0.147)	15.836*** (0.496)	16.553*** (0.799)	13.350*** (0.779)	13.262*** (0.791)	12.368*** (0.533)	10.151*** (1.130)
Observations	1,371	1,371	1,370	1,370	1,370	1,370	1,370
Countries	30	30	30	30	30	30	30
R-squared	0.234	0.408	0.486	0.611	0.613	0.812	0.903

Note: The estimator is OLS in all specifications. The sample is all Western regions with available data. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 2: Relationship between time since agricultural transition and GDP per capita among 107 Italian NUTS3-regions

	(1)	(2)	(3)	(4)	(5)
Dependent variable: Log Average GDP per capita 1997-2008					
Average time since agricultural transition	-0.565*** (0.106)	-0.251*** (0.062)	-0.187*** (0.052)	-0.173*** (0.055)	-0.173*** (0.055)
Log Region Area		0.065*** (0.024)	0.073*** (0.023)	0.070*** (0.023)	0.070*** (0.023)
Altitude		-0.132*** (0.037)	-0.058 (0.045)	-0.061 (0.044)	-0.061 (0.044)
Latitude		0.088*** (0.005)	0.064*** (0.010)	0.062*** (0.010)	0.062*** (0.010)
Polar Desert, 10000 yrs ago			0.084 (0.075)	0.096 (0.075)	0.096 (0.075)
Dry steppe, 10000 yrs ago			0.178*** (0.054)	0.179*** (0.054)	0.179*** (0.054)
Byzantine Empire (dummy)				-0.045 (0.048)	-0.045 (0.048)
Constant	14.09*** (0.785)	7.573*** (0.572)	7.929*** (0.606)	7.927*** (0.597)	7.927*** (0.597)
Observations	107	107	107	107	107
R-squared	0.208	0.802	0.826	0.827	0.827

Note: The estimator is OLS in all specifications. The sample is all Italian regions with available data. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Relationship between time since agricultural transition and GDP per capita in 2005 among Western, European, and former Roman countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable: Log GDP per capita in 2005							
Sample	Western			Europe			Roman empire	
Average time since agricultural transition	-0.492*** (0.133)	-0.573*** (0.131)	-0.434*** (0.151)	-0.642*** (0.124)	-0.459** (0.203)	-0.441** (0.210)	-0.560** (0.212)	-0.645*** (0.186)
Log Country area		-0.207*** (0.050)	-0.056 (0.064)	-0.098 (0.061)		-0.025 (0.056)		-0.117* (0.067)
Log Arable land		-0.415*** (0.105)	-0.507*** (0.124)	-0.366*** (0.110)		-0.208 (0.193)		0.061 (0.238)
Log Altitude		-0.196* (0.117)	-0.456*** (0.125)	-0.400*** (0.129)		-0.028 (0.135)		0.027 (0.232)
Atlantic coastline to area-ratio			17.217 (10.903)	-2.075 (7.775)		-6.053 (7.181)		-5.787 (9.964)
Roman empire (fraction of area)			1.598*** (0.364)	1.219*** (0.336)		0.334 (0.460)		
Byzantine empire (fraction of area)			0.541 (0.460)	0.201 (0.397)		-0.418 (0.313)		0.000 (0.295)
Ottoman empire (fraction of area)			-1.302*** (0.483)	-0.384 (0.477)				
Warsaw pact or Soviet republic (dummy)				-1.129*** (0.267)		-1.770*** (0.241)		-1.794*** (0.274)
Constant	12.435*** (0.984)	14.836*** (1.171)	12.503*** (1.394)	14.379*** (1.083)	12.313*** (1.389)	13.595*** (1.194)	13.184*** (1.615)	14.775*** (1.591)
Observations	64	64	64	64	40	40	31	31
R-squared	0.16	0.44	0.62	0.70	0.10	0.81	0.19	0.72

Note: The estimator is OLS in all specifications. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The sample of Western countries includes all countries specified as Western in the text. The sample of countries from the Roman empire includes all countries in which more than 50 percent of its territory was within the Roman empire in 200 AD.

Table 4: Robustness analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Dependent variable: Log GDP per capita in 2005								
Sample	Western				Site obs>0		Western		
Time since agricultural transition (Putterman, 2006)	-0.175*	-0.123							
	(0.089)	(0.093)							
Earliest date of transition (Pinhasi et al, 2005)			-0.285***	-0.247**					
			(0.088)	(0.104)					
Average time since agricultural transition					-0.510***	-0.534***	-0.469**	-0.516*	-0.469*
					(0.134)	(0.147)	(0.198)	(0.277)	(0.233)
Log Arable land		-0.259**		-0.302***		-0.284**	-0.632***	-0.329	-0.285
		(0.105)		(0.104)		(0.114)	(0.223)	(0.371)	(0.299)
Log Latitude							1.733**	-0.312	2.091*
							(0.777)	(1.227)	(1.033)
Log Land Suitability for Agriculture							0.078	-0.048	-0.298
							(0.188)	(0.274)	(0.281)
Steppe (fraction 10000 yrs ago)								2.205*	1.328
								(1.213)	(0.961)
Polar desert (fraction 10000 yrs ago)								3.959***	0.704
								(0.878)	(1.069)
Ice (fraction 10000 yrs ago)								3.430***	-0.048
								(1.228)	(1.119)
Wooded steppe (fraction 10000 yrs ago)								2.405*	0.975
								(1.236)	(1.021)
Log Country Area & Log Altitude controls	No	Yes	No	Yes	No	Yes	No	No	No
Insignificant biogeographical controls	No	No	No	No	No	No	No	Yes	Yes
Historical controls	No	No	No	No	No	No	No	No	Yes
Constant	9.868***	10.622***	11.090***	12.013***	12.872***	14.300***	7.429*	12.731**	4.069
	(0.640)	(1.199)	(0.769)	(1.068)	(0.988)	(1.325)	(4.252)	(6.173)	(5.270)
Observations	62	62	60	60	44	44	55	52	52
R-squared	0.06	0.28	0.11	0.33	0.23	0.47	0.41	0.57	0.80

Note: The estimator is OLS in all specifications. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The sample of Western countries includes all countries specified as Western in the text. The sample *Site obs>0* includes all countries that have at least one site observation in Pinhasi et al's (2005) data set. *Insignificant biographical controls* includes the following variables measuring the fraction of a country's area that was covered by different types of biogeography in 10,000 BCE: *Desert*,

Tropical extreme, Semi-desert, Dry steppe, and Mediterranean. Historical controls include Atlantic coastline to area-ratio and the fractions of countries in Roman empire, Byzantine empire, and Ottoman empire, as well as a dummy for Warsaw pact or Soviet republic.

Table 5: Historical evolution of relationships between average time since agricultural transition and population density, GDP per capita, and levels of technology among Western countries.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Log Population density in:			Log GDP per capita in:			Technology level in:	
Average time since agricultural transition in:	1 CE	1000 CE	1500 CE	1 CE	1000 CE	1500 CE	1 CE	1500 CE
- 1 CE	0.215 (0.142)			0.088*** (0.014)			0.027** (0.013)	
- 1000 CE		-0.001 (0.125)			0.106*** (0.020)			
- 1500 CE			-0.231* (0.137)			-0.056*** (0.024)		-0.043*** (0.013)
Constant	-0.164 (0.814)	1.328 (0.850)	3.375*** (1.015)	5.689*** (0.074)	5.441*** (0.109)	6.813*** (0.169)	0.769*** (0.083)	1.113*** (0.088)
Observations	54	60	61	24	21	22	49	38
R-squared	0.04	0.00	0.04	0.37	0.71	0.09	0.05	0.15

Note: The estimator is OLS in all specifications. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The sample is always all Western countries with available data.

Table 6: Average time since agricultural transition and percentage growth rates of population and GDP per capita, 1000-1500 CE, among Western countries.

	(1)	(2)	(3)	(4)	(5)
	Percent population growth, 1000-1500 CE		Dependent variable: Percent growth of GDP per capita, 1000-1500 CE		
Average time since agricultural transition in 1000 CE	-0.0571*** (0.011)	-0.0571*** (0.000)	-0.0347*** (0.004)	-0.0309*** (0.009)	-0.0313** (0.011)
Log Population density in 1000 CE		-0.0003 (0.009)			
Log GDP per capita in 1000 CE				-0.0360 (0.074)	
Log Latitude					0.0220 (0.078)
Constant	0.4719*** (0.068)	0.4723*** (0.068)	0.2864*** (0.031)	0.4826 (0.404)	0.1819 (0.359)
Observations	60	60	21	21	21
R-squared	0.36	0.36	0.52	0.53	0.52

Note: The estimator is OLS in all specifications. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The sample is always all Western countries with available data.

Table 7: Influence of time since agricultural transition on institutions among Western countries.

	Dependent variables:	OLS point estimate for <i>Average time since agricultural transition in:</i>		Constant	Controls	Obs.	R ²
		1500 CE	2000 CE				
(1)	Executive constraints in 1500 CE	-0.262** (0.116)		3.380*** (0.766)	No	24	0.09
(2)	State antiquity index, 1500-1950 CE	-0.044* (0.023)		0.983*** (0.164)	No	51	0.07
(3)		-0.061** (0.025)		0.780*** (0.257)	Yes	51	0.62
(4)	Corruption in 2010 CE		-0.536*** (0.101)	4.410*** (0.779)	No	62	0.32
(5)				-0.599*** (0.117)	5.421*** (1.032)	Yes	62
(6)	Democracy in 2010 CE		-3.359*** (0.696)	29.996*** (4.966)	No	57	0.30
(7)				-3.843*** (0.749)	30.874*** (6.465)	Yes	57
(8)	Gini coefficient in 2000 CE		2.414*** (0.609)	14.947*** (4.496)	No	42	0.26
(9)				3.210*** (0.729)	7.111 (6.568)	Yes	42

Note: The estimator is OLS in all specifications. The dependent variables in each regression are shown in the first column to the left. The control variables are *Log Country area*, *Log Arable land*, *Log altitude*, *Atlantic coastline to area-ratio*, *Roman empire*, *Byzantine empire*, *Ottoman empire*, and *Warsaw pact or Soviet Republic*. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The sample is always all Western countries with available data.

Appendices (online only)

Appendix 1: Comparative country analysis

In order to illustrate the logic of our model further, we will in this section make a more detailed comparative country analysis, using Iraq and Sweden as examples. Iraq and Sweden are two extreme observations in Figure 4. Iraq was one of the very earliest countries to experience sedentary agriculture and statehood and is currently one of the poorest and institutionally least developed countries in the western world. For Sweden, the situation is right the opposite. Our analysis aims to demonstrate that Iraq's long history has been characterized by extractive institutions in the form of autocratic, unstable state formations, a weak rule of law, a persistent social and economic inequality, and intense rent seeking, whereas Sweden's late transition to agriculture and much shorter history is characterized by more stable and broadly inclusive governments, an egalitarian and democratic society, and an absence of major internal or external struggles over the distribution of resources.

Iraq

The northern parts of current Iraq, as well as the eastern parts on both sides of the Iranian border, were part of the Fertile Crescent where the very earliest signs of domesticated plants and animals in the world have been found. In Neolithic times, the area was characterized by open wood and grasslands and hosted a large number of heavy-seeded wild grasses including the wild progenitors of wheat and barley. After a temporary downturn in temperature levels (referred to as the Younger Dryas), evidence of domesticated plants started to appear after 9500 BCE in Syrian sites such as Abu Hureyra and soon spread to the whole region (Diamond, 1997; Bellwood, 2005). Animals such as goats and pigs were domesticated somewhat later, presumably on the flanks of the Zagros Mountains (Smith, 1995; Diamond, 1997). A few thousand years later, they would be complemented with cattle and horses.

One of the oldest archaeological sites in northern Iraq is Qermez Dere, with an agricultural settlement from about 9000 BCE (Pinhasi et al, 2005). One of the most notable findings on this site was three circular, underground chambers filled with tons of soil, supported by heavy plastered stone pillars and containing six buried jawless skulls. Even more impressive monuments have been found in other parts of the Fertile Crescent, such as a cluster of spacious underground chambers with pillars, each weighing 8 tons or more in Göbekli Tepe, and the massive walls and nearly 8 meter high defensive tower of Jericho, both from about 9000 BCE (Morris, 2010). Clearly, monuments like these were the result of closely coordinated work efforts by a village community.

Similar findings from neighboring sites from the same period provide a picture of a sedentary population, living in tight village settlements with houses in uniform style, separate community buildings, shrines and sometimes defensive fortifications, and a worshipping of ancestors manifested in the keeping of plastered skulls, presumably of ancestors. Several instances of headless burials could potentially be interpreted as human sacrifice.

Some of the largest settlements, such as Abu Hureyra in Syria, hosted around 5000 people already by 8000 BCE (Bellwood, 2005). Houses with own storerooms and kitchens would soon emerge. Together with the almost obsessive reverence of ancestors, these social changes indicate a society with important public goods but also one where private property started to matter and where land was inherited from one generation to the next (Morris, 2010). As we know from the work of Mulder et al (2009), such a pattern of inheritance in agricultural communities typically leads to the emergence of income inequality and a hierarchical society.

The heartland of historical Mesopotamia, i.e. the land between Euphrates and Tigris, was not settled by farmers until about 5000 BCE. Despite the rivers, the area was generally drier than in the grasslands of the nearby Fertile Crescent, further to the east. Productive farming could still be carried out with the use of irrigation technology that diverted water from the flooding rivers. This technique required substantial collective activities such as the construction of canal regulators, digging out and dredging canals and reservoirs, and digging earthen dykes that protected fields from flooding water. In order to be efficient, the structure of the irrigation system had to be planned and work carefully coordinated. A failure at any link in this highly sensitive system might have disastrous consequences for the village.¹ Workers further had to be fed and provided with effective tools and the structure of fields and cultivation had to be carefully planned (Postgate, 1995).

All these characteristics of the new production technology implied pressures towards creating a strong centralized power. In the rural villages, irrigation management was coordinated by an official referred to as *gugallum* (Postgate, 1995, p 178). It is certainly straightforward to think of this kind of social organization as being the driver of the further development towards more centralized power in the villages which eventually resulted in full-blown city-states. The famous *hydraulic hypothesis* of Wittfogel (1957) proposes that the nature of water management in Mesopotamia, Egypt, and China was responsible for the rise of highly centralized states in these regions.² Exactly how causality worked between collective water management and centralized rule in Mesopotamia remains to be established, but the association is in any case clear.

A climate downturn around 3800 BCE with even less rain and less reliable flooding of the rivers, put a great strain on the already fragile ecological system of Mesopotamia. It has been suggested that this downturn provided a further impetus towards a more efficient organization and use of resources (Morris, 2010). Only the cities that succeeded in this endeavour survived and most likely experienced an inflow of people from collapsed communities.³ One of the oldest cities in the area was Eridu where the earliest settlement dates back to 5400 BCE. Archaeological excavations have revealed that the city hosted a

¹The failure of any individual to regulate the flow of water might for instance lead to the flooding of the fields of a whole village.

²The hypothesis has been criticized on many grounds, for instance that the major Chinese efforts at centralized water management were made after the rise of centralized rule.

³Yoffee (1995) even refers to this sudden urbanization process as a "demographic implosion" which resulted in a relative depopulation of the countryside.

succession of temple structures, built on top of each other, with the earliest small shrine dating to 5000 BCE (Postgate, 1995).

During this period, Uruk emerged as a leader among the growing cities in the area and soon became very influential culturally, not only in Mesopotamia but also in neighboring lands. Around 3500 BCE, the first statehood arose. This event is generally viewed as the onset of what is usually referred to as *civilization*. The Sumerians in Uruk invented cuneiform writing around 3300 BCE, inscribed on clay tablets, and used bronze on a large scale by 3000 BCE. The massive temple area was clearly the home of a very powerful "priest-king", managing a temple economy that controlled substantial areas of agricultural land as well as farm labor to work its fields. The clay tablets that have been recovered often record temple production quotas. A highly specialized labor force worked in the temples apart from the priests, including accountants, guards, water-carriers, weavers, boatmen, barbers, and musicians, as well as regular slaves (Postgate, 1995). The temple most likely also organized the long-distance trade that brought foreign luxury goods to Mesopotamia and contributed to the more efficient mining of metals like bronze and copper. Humble citizens presented regular offerings to the gods (and food rations to the temple staff) and were often sent to war on neighboring city-states in large military campaigns. The city of Uruk is believed to have covered around 400 hectares with a 9 km town wall (Postgate, 1995) and presumably hosted around 20,000 individuals, packed into carefully planned mud brick dwellings (Morris, 2010).

Uruk's eminence in Mesopotamia ended early in the 3rd millennium BCE for unclear reasons but their power had anyway always been more cultural than political. The southern part of Mesopotamia remained for several centuries a land united by a common Sumerian culture but where rivalling city-states often fought each other and remained largely independent. In this sense, Mesopotamia after Uruk was more similar to the highly fractionalized pre-Hellenic Greek system of city states than to neighboring Egypt, which was led by a single ruler. Sargon of Akkad was the first Mesopotamian ruler to unite the whole area under one reign around 2350 BCE, but the Akkadian domination turned out to be short-lived. By 2200, both the Egyptian and the Mesopotamian states collapsed and foreign rulers (Gutians) assumed power in the Sumerian heartland.

This was perhaps the first of many state collapses in which invading peoples from neighboring areas played an important role. By 2030, the domination of the highly bureaucratic regime in Ur was ended by invading Amorites from Iran. The Old Babylonian empire that emerged after Ur was in turn conquered by yet another eastern people, the Kassites, in 1595. An even greater disaster for the Western core would happen around 1200 BCE when more or less all the established states of the period collapsed, including Egypt, the Mitanni and Hittite empires, and the Mycaenean Greek state. In Mesopotamia, Assyria initially could expand but soon fell into the general decline. The city of Babylon was sacked by Elamites from Iran.

Exactly what happened during this Dark Age has much debated and explanations range from natural disasters to massive migrations. The outcome was basically the same every-

where; burned and destroyed cities, depopulation, a protracted break in written records, collapse of long-distance trade, and an abandonment of agricultural land (Morris, 2010). Not until the brief rise of the neo-Assyrian empire around 750 BCE would the current territory of Iraq be under a single ruler again, and by this time the political and technological leadership of the western world had shifted westwards towards the Mediterranean.

In 539 BCE, the Persians under Cyrus II plundered Babylon and initiated a period of more than a thousand years when Mesopotamia was completely under the domination of foreign powers; most often under Persian rule but also briefly under the Seleucid, Roman and Sassanid empires (see figure 6). Almost all of the major autocratic empires of the Mediterranean seemed to want to conquer Mesopotamia during some part of their expansion. The time of independent city-states was long gone.⁴

The long era of Arab Muslim rule started in 638 CE when the Sassanids were defeated. A mass immigration of Arabs took place in this period. The following centuries witnessed a revival of social development and the newly founded capital of the Abbasid caliphate, Baghdad, became a center of the Muslim intellectual world. The caliphate reached a peak the period 750-800 CE in terms of the extension of statehood and it is believed that the city hosted nearly a million people.

However, once again, a foreign aggressor would invade Mesopotamia, as had happened so many times before. The Mongols lay Baghdad under siege in 1258 and eventually conquered and looted the city and murdered a large share of its population. Some sources claim that at least 100,000 people, perhaps much more than so, were slaughtered and palaces and libraries were destroyed. The Mongol destruction initiated a new period of depopulation and agricultural decline, perhaps due to irreparable damages to the sensitive irrigation system in the area. The sacking of Baghdad was a major blow not only to Arab civilization in Iraq but also to the Muslim world as a whole.

From 1533, the territory of modern Iraq would fall under the domination of yet another foreign power, the Ottomans, who would rule the area more or less effectively until 1918. During this period, Iraq was divided into three provinces (*vilayets*) - Mosul, Baghdad, and Basra - a division which would play an important role since then. At its peak, the Ottoman empire was the largest in the western world since Rome. The Ottomans put the Iraqi provinces under direct rule shortly after their conquest, but during the protracted disintegration of the Ottoman empire after its peak around 1600, local rulers would frequently struggle for power against each other and against foreign powers. The British gradually asserted their influence during the 19th century in the area. When the Ottoman empire collapsed after the World War I, Britain administered Iraq on a mandate from the League of Nations until Iraqi independence in 1932.

Independence did not create political stability in Iraq. Frequent power struggles and a new intervention by Great Britain during World War II followed, and military coups took place both in 1958 and in 1968. The latter brought the Baath-party of Saddam Hussein to power. Iraq established closer ties to the Soviet union and oil started to generate

⁴The rest of the section relies on Britannica (2012) for general dates and facts.

substantial revenues to the government. After 1980, three successive wars in the Gulf area (the Iran-Iraq war, 1980-1988, and the Persian Gulf Wars in 1991 and 2003) would however lead to an economic deterioration of the country and to the dissolution of Saddam Hussein's regime. From 2003 to 2011, the country was occupied by yet another foreign power on Mesopotamian soil; the United States.

In summary, we believe the Iraqi example has the following key components in relation to our model: It describes an area that was one of the first in the world to develop sedentary agriculture by 9000 BCE and statehood and civilization already by 3500 BCE. Although Mesopotamia started off with fairly independent city-states, government was highly autocratic, inequality was high and wealth was highly concentrated in temples and palaces. The rich Mesopotamian cities soon became the object of predation by numerous neighboring tribes and foreign armies with subsequent state collapses. By medieval times, the polities in the Iraqi territories were clearly stagnant. Throughout the 20th century, internal and external rent seeking have been the norm. Although a kind of parliamentary democracy is now in place, Iraq as of 2012 is by many regarded as one of the failed states of the world.

Sweden

At about the same time that a full-blown civilization with a socially stratified state, codified writing, massive public monuments, and a centralized "palace economy", administered by bureaucrats, was emerging in Mesopotamia (i.e. middle 4th millennium BCE), the first small farming communities established themselves along the coasts of what is now Sweden, employing the agricultural food package from the Fertile Crescent; wheat, barley, pigs, goats, and cattle. Recent evidence strongly indicate that it was migrants from southern parts that introduced agriculture and that these migrants later blended with the local hunter-gatherer population (Skoglund et al, 2012). There are clear links from this early farming culture with other communities in northern Europe at the time.⁵

Unlike the riverine type of farming practiced in Mesopotamia, agriculture in Sweden was always rain fed, implying a weaker need for a centralized organization of the economy. As elsewhere in the Atlantic parts of Northern Europe, the construction of megalithic tombs were a common feature of early farming communities, suggesting an increased reverence for the dead and an emerging organization for the provision of public goods. Copper was used by these early farmers but the metal was not widespread and presumably imported. Bronze was not widely used until about 1500 BCE, a change which most likely revolutionized warfare and social organization. During the latter part of the period, very large burial mounds suggest an increase in social stratification although not beyond tribal level (Welinder, 2009).

The use of iron became widespread in Sweden around 500 BCE. The Scandinavian countries did not become part of the Roman empire but were nonetheless affected by

⁵The culture is referred to as TRB and shares many features with the so called "Ertebölle" culture of Denmark from the same period (Bellwood, 2005).

developments on the continent. In particular, the collapse of the Western Roman empire in the 5th century CE and the massive migrations during the period, resulted in a period of social unrest in Sweden, manifested in the construction of multiple defensive fortifications.

By 550 CE, a more peaceful period referred to as "Vendel" started in Sweden when tribal chiefs in various parts of the country could establish rule over extended regions and were buried in impressive burial mounds. The greater concentration of wealth was due to a centralized control over iron mining and the establishment of trading centers which greatly increased imports and exports. The chiefs controlled forces of mounted elite warriors with costly weaponry, offered pagan ceremonies in wooden halls, and oversaw the production of jewelry in gold (Welinder, 2009). Primitive writing in the form of runes were carved into stone.

In the latter part of the 700s, the trading post Birka was founded in Lake Mälaren by a local unidentified chief and quickly emerged into the first urban settlement of Sweden. However, even at its peak, the size of the population still did not exceed 1000 individuals. Traded goods from many parts of the world have been excavated, including Arabic countries. Christian missionaries appeared in the town in the 830s but failed to establish Christendom in the area.

By 800 CE, Sweden was still very much a periphery in the Western world; culturally, economically and politically. However, population growth had been rapid since the great migrations ended and local chiefs had accumulated the power to equip troops with expensive weaponry and horses and to build long ships that were capable of making long sea voyages. In 793, a fleet of such ships reached the monastery of Lindisfarne in Northern England, which was subsequently looted and the local population terrorized. This attack is usually regarded as marking the beginning of the Viking Age in the Scandinavian countries.

The Viking attacks on the more developed parts of Europe that started around 800 basically followed the same pattern as so many other attacks by primitive peoples on more advanced core regions. The wealthy cities of Mesopotamia were overrun by neighboring tribes who had adopted the basic military technology of the center but were still not integrated into its urban civilization. In the same manner, the Vikings looted numerous towns and monasteries in Atlantic Europe, around the Baltic Sea, as well as in the Mediterranean. Vikings formed new kingdoms in England and Normandy, settled Iceland and Greenland, served as mercenaries to the emperor in Constantinople, and even formed a temporary colony on New Foundland. Eventually, the Vikings outside Scandinavia blended with the local populations, settled down and were Christianized.

When Viking energy subsided in the 11th century, there were kingdoms and states in Norway and Denmark but still not in Sweden. The two core areas, Svealand around Lake Mälaren and Götaland in the southwest, were not easily united and were divided by deep forests. The country was eventually Christianized by 1100 and not until around 1150 was the country united under a king. From this period onwards, Sweden is considered to have had a government above tribal level but with a very weak state and a king who had

to struggle to maintain jurisdiction over local chiefs and independent bishops. Not until the era of Birger Jarl, a strongman from Götaland whose son inherited the throne, was the Swedish state consolidated around 1250, almost five thousand years after the initial emergence of agriculture.

As can be seen in figure 6, the date 1250 also marks the time when Sweden overtook Iraq in terms of strength of statehood. In 1258, Iraq was overrun by yet another foreign people, the Mongols, an event which ended the golden era of Arab culture in the region. In peripheral Sweden, in contrast, no foreign peoples ever sought to invade the sparsely populated and culturally backward country, lacking proper cities and fertile farming lands. Traders from the German towns by the Baltic Sea dominated economic life in Sweden throughout the Middle Ages but were never interested in the land as such. As elsewhere in Europe, feudalism was the main economic organization of the countryside, but peasants were generally a lot more independent than in for instance Eastern Europe. In 1393, Sweden entered a union with its more powerful neighbor Denmark which would remain until 1523, when the founder of the modern Swedish state, Gustav Wasa, defeated the Danes, renegotiated debts with the German trading towns, suppressed local rebellions, and finally established Sweden as a fully sovereign state.

In the early 17th century, Sweden adopted Protestantism and rose in the Thirty Years' War (1618-1648) to become a major military power in northern Europe, mainly due to its superior organization of taxation and military service. Once again, Swedish armies pillaged continental Europe and contributed to the long decline of the Holy German Empire. Also Poland was badly ravaged during the rule of the constantly campaigning Charles X. New territories were conquered from Denmark in the south and substantial amounts of war booty enriched a nobility from which most of the military commanders had been recruited. Inspired by the autocratic rule of Louis XIV in France, the Swedish kings Charles XI and Charles XII ruled without taking much advice from parliament. After the decisive Swedish defeat against Russia in 1709, Sweden's period as a north European superpower was effectively over.

When Charles XII died in 1718, a new era started when the king had to cede substantial powers to the parliament. Not even the attempts by Gustav III to restore autocratic rule were successful and the king was even murdered in 1792. Sweden was clearly not characterized by social equality in the modern sense during this period, but the farming population was relatively free and protected by law. After its involvement in the Napoleonic wars in the early 1800s, Sweden adopted a principle of neutrality and has not been engaged in any war since.

Free from military threats domestically and campaigns abroad, the country entered a road towards an even stronger parliament and a widened suffrage. A massive emigration of poor Swedish peasants to the United States in the decades after 1850, eased a growing problem of overpopulation in the countryside. During the strong social tensions after World War I, which swept away the old regimes in so many European countries, universal suffrage of all men and women was introduced in 1921 and the Social Democratic Party

was allowed to dominate Swedish politics from 1932 onwards. Since the country was spared war damages in World War II due to its neutrality, the speed of industrialization picked up even further when the demand for Swedish goods surged. Extensive social reforms and progressive taxation turned Sweden into one of the most equal societies in Europe. Not even the very serious economic crisis of the early 1990s altered the general trend of rising prosperity.

By 2012, Sweden is one of the richest and least corrupt countries in the world and has the strongest public finances in the European Union.⁶ Like in the neighboring Scandinavian countries, there are no signs of social unrest, even in the wake of the financial crisis.

In summary, Sweden's late transition to agriculture and to statehood, in combination with its geographical peripherality and relatively unproductive farming lands, implied that the country was not a natural target of predation by neighboring peoples or by rent seeking local lords. Wealth was relatively evenly distributed through most of history and not even the attempts by the militarily powerful kings of the 1600s succeeded in permanently establishing autocratic rule. Due to the great degree of social cohesion, the social reforms after World War II could be peacefully installed without alienating capitalists and the upper classes. In so many ways, Sweden's history was the direct opposite of that of Iraq.

Additional references:

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⁶In 2005, real GDP per capita was almost 45 times higher in Sweden than in Iraq (\$31,271 versus \$690).

Appendix 2: Inverse Distance Weighted Interpolation

The first step of calculating the average adoption date for a given region is interpolating observed points of archaeological sites. For each cell S_0 on the map, the formula used in interpolation is as follows (Johnston-2003):

$$\hat{Y}(S_0) = \sum_{i=1}^N \lambda_i Y(S_i)$$

where:

$\hat{Y}(S_0)$ is the predicted adoption date for location S_0 .

N is the number of measured sample points surrounding the prediction location that will be used in the prediction. Here N is set to 15.

λ_i are the weights assigned to each measured point.

$Y(S_i)$ is the observed value at the location S_i , one of the known archaeological sites.

The formula to determine the weights is the following:

$$\lambda_i = d_{i0}^{-p} / \sum_{i=1}^N d_{i0}^{-p}$$

$$\sum_{i=1}^N \lambda_i = 1$$

The power parameter p , which is determined by minimizing the root-mean-square prediction error (RMSPE), is 2.⁷

In determining the adoption date of a given area, the paper assumes that the archaeological site closest to the area gives best information on the approximate date of agricultural adoption, given the cost of travelling from one place to another and the similarity of landscape of adjacent areas. That is, IDW considers proximity to each area to be the most important factor in estimating adoption dates. IDW method is used to obtain the average adoption date for each subnational unit of analysis, which is simply the average of all the estimated adoption date of location cells within that subnational unit. IDW assumes that the surface is driven by the local variation, which can be captured through the neighborhood. This method is part of the deterministic techniques to create a surface of adoption dates. Another class of interpolation techniques, often known as kriging, uses geostatistical properties. Kriging relies on autocorrelation as a function of distance and assumes that the data comes from a stationary stochastic process. Given the terrain variation and boundaries, however, the spread of agricultural adoption does not appear to satisfy this assumption. Pinhasi (2005) finds that for Eurasia the agricultural adoption date in an area can be well approximated as a linear function of the distance from

⁷Each observed point is removed and compared to the predicted value for that location. The RMSPE is the summary statistic of the error of the prediction surface. The Geostatistical Analyst in ArcGIS tries several different powers for IDW to identify the power that produces the minimum RMSPE.

the origin in the Fertile Crescent. The correlation between IDW and kriging estimates nevertheless remain very high (0.9729) and have little impact on the final result.

Appendix 3: Vegetation Maps

The vegetation maps are the result of a compilation of information of many experts of the Quaternary Environments Network (QEN). Adams-Faure (1997) address explicitly the endogeneity issue arising from a map of palaeovegetation backed up by previous assumptions about human subsistence, and assert that the maps are predominantly based on non-archaeological sources. These include foremost the use of plant fossil data (non-domesticated at the advent of the Neolithic Revolution), the most direct source of information on past vegetation. Given that there are still large enough gaps in the pollen and macrofossil record across regions, however, other sources are used as well to supplement the picture from plant fossils. Proxy indicators of past vegetation cover and structure include animal fossils, which give a rough indicator of the ecology of an area in the past. Adams-Faure (1997) also argue that sedimentological processes depend on vegetation cover, either in the area where the sediment is being deposited or the area from which it is being eroded; certain types of sediments therefore may be used to support plant fossil data in more accurately describing the type of vegetation. Furthermore, the authors use the standard palaeoenvironmental assumption of the past existence of a monsoon belt, embedded in the drawing of the map. To a lesser extent, the trends predicted by general circulation models (GCMs), which examine the effects of the presence of lower sea levels, cold seas and massive ice sheets in the past, are used to describe spatial patterns and vegetation boundaries as well. For further discussions on the use of general circulation models, see Adams-Faure (1997). Finally, the authors use biogeographical clues based on the present day distributions of flora and fauna, as a reference to what may have existed back during the Neolithic period. However, this approach is only used as a way to back up or dispute patterns suggested on the basis of palaeoenvironmental evidence, not as a primary source of ideas and opinions.

The Soil Quality Ranking of Vegetation Types in Europe and the Middle East:

HIGHEST

Wooded Steppe

Mediterranean Scrubs

Temperate forest, Lake

Dry Steppe and Semi desert

Steppe-Tundra

Desert

Polar Desert, Ice

Tropical Extreme Desert

LOWEST

Appendix 4-6

Table A4: Summary statistics and sources of variables used in the cross-regional study

Variables	N	Mean	SD	Min	Max	Source
<i>Dependent variable</i>						
Log Average GDP per capita 1997-2008 (in €)	1,371	9.580	0.846	6.802	11.83	Eurostat (2012)
<i>Independent variables</i>						
Average time since agricultural transition (in 1000 yrs from 2000 CE)	1,371	7.055	0.847	5.243	11.32	Own assessment based on Pinhasi et al (2005)
Log Region area (km 2)	1,371	7.382	1.384	2.962	10.58	Own assessment
Altitude (km)	1,371	0.348	0.363	-0.003	2.328	Own assessment
Latitude	1,371	47.97	5.169	35.05	59.77	Own assessment
Steppe Tundra, 10000 Yrs Ago (percent of area)	1,370	59.92	48.11	0	100	Own assessment
Ice, 10000 Yrs Ago (percent of area)	1,370	2.049	13.28	0	100	Own assessment
Polar Desert, 10000 Yrs Ago (percent of area)	1,370	2.779	14.61	0	100	Own assessment
Semi Desert, 10000 Yrs Ago (percent of area)	1,370	0.559	6.648	0	100	Own assessment
Dry Steppe, 10000 Yrs Ago (percent of area)	1,370	17.39	36.20	0	100	Own assessment
Wooded Steppe, 10000 Yrs Ago (percent of area)	1,370	16.20	35.43	0	100	Own assessment
Temperate Forest, 10000 Yrs Ago (percent of area)	1,370	0.437	5.683	0	100	Own assessment
Ottoman Empire (dummy=1 if region part of empire in 1600 CE)	1,371	0.155	0.362	0	1	Own assessment based on Euratlas (2012)
Roman Empire (dummy=1 if region part of empire in 200 CE)	1,371	0.670	0.471	0	1	Own assessment based on Euratlas (2012)
Byzantine Empire (dummy=1 if region part of empire in 500 CE)	1,371	0.129	0.335	0	1	Own assessment based on Euratlas (2012)
Atlantic Ocean (dummy=1 if region located by Atlantic ocean)	1,371	0.116	0.320	0	1	Own assessment
Warsaw pact or Former Soviet republic (dummy=1 if region part of the above before 1989)	1,371	0.175	0.380	0	1	Own assessment

Table A5: Summary statistics and sources of variables for the regions in Italy

Variables	N	Mean	SD	Min	Max	Source
<i>Dependent variables</i>						
Log average GDP per capita 1997-2008 (in €)	107	9.928	0.275	9.330	10.459	Eurostat (2012)
<i>Independent variables</i>						
Average time since agricultural transition (in 1000 yrs from 2000 CE)	107	7.363	0.222	6.734	8.092	Own assessment
Log Region area	107	7.774	0.632	5.347	8.910	Own assessment
Altitude	107	0.456	0.370	0.003	2.099	Own assessment
Latitude	107	42.82	2.690	36.908	46.697	Own assessment
Polar desert, 10000 yrs ago (fraction of area)	107	0.116	0.273	0.000	1.000	Own assessment
Dry steppe, 10000 yrs ago (fraction of area)	107	0.434	0.462	0.000	1.000	Own assessment
Wooded Steppe, 10000 yrs ago (fraction of area)	107	0.450	0.494	0.000	1.000	Own assessment
Byzantine empire (dummy)	107	0.065	0.248	0.000	1.000	Own assessment based on Euratlas (2012)

Table A6: Summary statistics and sources of variables for the cross-country analysis

Variables	N	Mean	SD	Min	Max	Source
<i>Dependent variables</i>						
Log GDP per capita in 2005 (constant 2000 USD)	64	8.688	1.369	6.224	10.859	World Development Indicators (WDI)
Log Population density in 1 CE	54	1.024	1.266	-1.481	3.170	Ashraf and Galor (2012)
Log Population density in 1000 CE	60	1.318	1.136	-1.258	3.442	Ashraf and Galor (2012)
Log Population density in 1500 CE	61	1.733	1.296	-1.258	4.135	Ashraf and Galor (2012)
Log GDP per capita in 1 CE	24	6.158	0.169	5.991	6.696	Ashraf and Galor (2012)
Log GDP per capita in 1000 CE	21	6.105	0.155	5.991	6.477	Ashraf and Galor (2012)
Log GDP per capita in 1500 CE	22	6.440	0.229	6.064	7.003	Ashraf and Galor (2012)
Technology level in 1 CE (average)	49	0.914	0.137	0.7	1	Comin et al (2010)
Technology level in 1500 CE (average)	38	0.819	0.124	0.408	1	Comin et al (2010)
Percent growth of population, 1000-1500 CE	60	0.092	0.106	-0.139	0.233	Own assessment based on Ashraf and Galor (2012)
Percent growth of GDP per capita, 1000-1500 CE	21	0.069	0.059	-0.033	0.179	Own assessment based on Ashraf and Galor (2012)
Executive constraints in 1500 CE	24	1.708	0.751	1	3	Acemoglu et al (2005b)
State antiquity index, 1500-1950 CE	51	0.678	0.183	0.417	1	Putterman (2010)
Corruption in 2010	62	0.335	1.062	-1.621	2.374	Worldwide Governance Indicators 2012
Democracy in 2010 (Polity2)	57	4.404	7.178	-10	10	Polity data set
Gini coefficient in 2000	42	32.402	4.906	24.44	44.1	WDI
<i>Independent variables</i>						
Average time since agricultural transition (in 1000 yrs from 2000 CE)	64	7.611	1.100	5.608	9.743	Own assessment based on Pinhasi et al (2005)
Log Country area (km ²)	64	4.501	2.131	-2.797	8.098	
Log Arable land (percent)	64	2.575	1.250	-2.106	4.028	WDI
Log Altitude	64	-1.117	1.032	-4.198	0.588	
Atlantic coastline to area-ratio	64	0.0023	0.0079	0	0.051	Acemoglu et al (2005b)
Roman Empire (fraction of country part of empire in 200 CE)	64	0.469	0.455	0	1	Own assessment based on EurAtlas (2012)
Byzantine Empire (fraction of country part of empire in 500 CE)	64	0.174	0.357	0	1	Own assessment based on EurAtlas (2012)
Ottoman Empire (fraction of country part of empire in 1600 CE)	64	0.267	0.383	0	1	Own assessment based on EurAtlas (2012)
Warsaw pact or Former Soviet republic (dummy=1 if country part of the above before 1989)	64	0.328	0.473	0	1	Own assessment
Time since agricultural transition (in 1000 yrs)	62	7.003	1.850	3.5	10.5	Putterman (2006)
Earliest date of transition (in 1000 yrs)	60	8.446	1.593	5.673	12.408	Own assessment based on Pinhasi et al (2005)
Log Latitude	64	3.700	0.271	2.734	4.097	Own assessment
Log Land suitability for agriculture	55	-1.478	1.631	-5.799	-0.045	Ashraf and Galor (2012)
Steppe Tundra, 10000 Yrs Ago (fraction of area)	59	0.266	0.400	0	1	Own assessment
Polar Desert, 10000 Yrs Ago (fraction of area)	59	0.032	0.110	0	0.497	Own assessment
Ice, 10000 Yrs Ago (fraction of area)	59	0.035	0.131	0	0.663	Own assessment
Wooded Steppe, 10000 Yrs Ago (fraction of area)	59	0.151	0.297	0	1	Own assessment