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Article

Increased Affluence Explains the Emergence of Ascetic Wisdoms and Moralizing Religions

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Summary

Background: Between roughly 500 BCE and 300 BCE, three distinct regions, the Yangtze and Yellow River Valleys, the Eastern Mediterranean, and the Ganges Valley, saw the emergence of highly similar religious traditions with an unprecedented emphasis on self-discipline and asceticism and with "otherworldly," often moralizing, doctrines, including Buddhism, Jainism, Brahmanism, Daoism, Second Temple Judaism, and Stoicism, with later offshoots, such as Christianity, Manichaeism, and Islam. This cultural convergence, often called the "Axial Age," presents a puzzle: why did this emerge at the same time as distinct moralizing religions, with highly similar features in different civilizations? The puzzle may be solved by quantitative historical evidence that demonstrates an exceptional uptake in energy capture (a proxy for general prosperity) just before the Axial Age in these three regions.
Results: Statistical modeling confirms that economic development, not political complexity or population size, accounts for the timing of the Axial Age.
Conclusions: We discussed several possible causal pathways, including the development of literacy and urban life, and put forward the idea, inspired by life history theory, that absolute affluence would have impacted human motivation and reward systems, nudging people away from short-term strategies (resource acquisition and coercive interactions) and promoting long-term strategies (self-control techniques and cooperative interactions).

Introduction

The term "Axial Age" was coined in 1947 by the German philosopher Karl Jaspers to describe the concomitant emergence of a range of doctrines that eventually lead to the emergence of world religions. Jaspers argued that this period was pivotal in the sense that the questions that people ask today about the way they should live their lives and the answers they get from today's religions and philosophies were all invented at that time. "Man, as we know him today, came into being" wrote Jaspers [1].

Indeed, to most people, believers and nonbelievers alike, it seems obvious that religion is on the side of the spiritual rather than the material world and that it fosters self-discipline and selflessness rather than license and greed. However, such spiritual and moral concerns are recent in human history [1, 2]. In hunter-gatherer societies, early chiefdoms, and archaic states, religions focused on performing rituals, offering sacrifices, and respecting taboos in order to ward off misfortune and ensure prosperity [3, 4]. By contrast, between roughly 500 BCE and 300 BCE, new doctrines appeared in three places in Eurasia (the Yellow and Yangzi rivers, the Ganga Valley, and the eastern part of the Mediterranean; see Figure 1). These doctrines all emphasized the value of "personal transcendence" [5], that is, the notion that human existence has a purpose, distinct from material success, that lies in a moral existence and in the control of one's own material desires, through moderation (in food, sex, ambition, etc.), asceticism (fasting, abstinence, detachment), and compassion (helping, suffering with others). This higher purpose is reflected in the constitution of the universe itself (e.g., through *karma* or *logos*). Beyond this material world lies another reality in which human existence acquires a new meaning. In this other reality, humans are not just bodies anymore. They are endowed with a soul and can survive the death of their bodily incarnation. Most importantly, in this other reality, individuals pursuing material success are doomed. Only moderation and moral behavior guarantee salvation [2].

The emergence of spiritual and moralizing religions is well documented, occurring over a short period, between the fifth century BCE and the third century BCE (some of them became culturally dominant a few centuries later). In the Ganges Valley, Buddhism, Samkhya, Ajivikism, and Jainism appeared in the Magadha and Kosama kingdoms in the late fifth century BCE [6, 7], although ascetic movements were probably present already. These movements spread rapidly to the rest of India under the Mauryan Empire (ca. 320–185 BCE). Vedism, in turn influenced by these spiritual movements, underwent a massive transformation, integrating asceticism and karma in the new Brahmanic orthodoxy [6, 8, 9].

In the Mediterranean, self-discipline and ascetic doctrines, combined with a moral outlook, appeared in Greek city-states in the late fifth century BCE [10, 11], with precursors in Orphism and Pythagoreanism [12]. This spiritual trend grew stronger and spread outside continental Greece in the fourth century, developing into the Hellenistic movements known as Stoicism, Epicureanism, Skepticism, and Cynicism. Beliefs that the gods and the universe were on the side of the moral good [9, 13] and that good behaviors would be rewarded in the afterlife (see, for instance, Plato's *Republic* and Pindar's *Odes*) [9, 14] emerged during the same period. Although these ideas were still marginal in the fifth century BCE, literary works such as Virgil's *Aeneid* and Plutarch's *On Superstitions* suggest that they had become mainstream among elite Romans by 100 CE [15, 16].

In China, although the *Daodejing* and the *Zhuangzi* are now recognized as late compilations, recent studies have traced the beginning of self-discipline doctrines go back to the fourth century BCE [17–20], the same time Confucius started his moral teaching. Similarly, the belief in divine punishment

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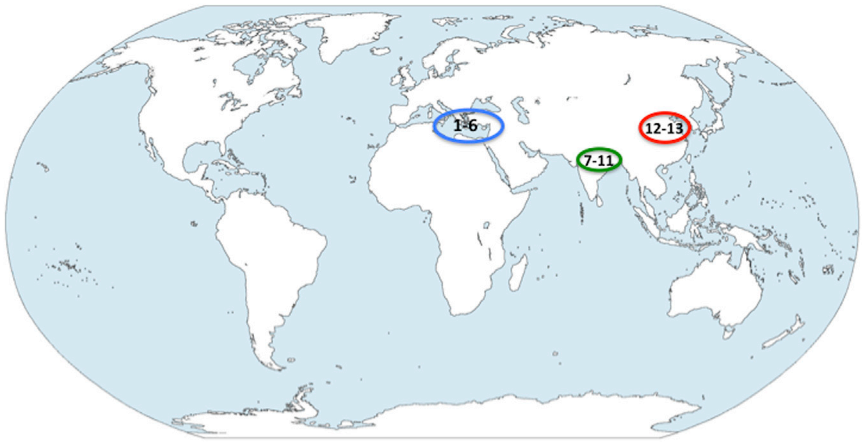

Figure 1. Map of Axial Religions and Movements
Some Axial Age religions and spiritual movements: 1, Pythagoreanism; 2, Orphism; 3, Platonism; 4, Stoicism; 5, Epicureanism; 6, Second-Temple Judaism; 7, Ajivika; 8, Samkhya; 9, Buddhism; 10, Jainism; 11, Hinduism; 12, Taoism; 13, Confucianism.

(through the celestial bureaucracy), previously thought to have come from Buddhism between the first and third centuries CE, may have appeared before the Han empire [21]. The rising popularity of Lao Zi in the late Han empire and the appearance of Daoist mass movements such as the Celestial Masters confirm the gradual influence of ascetic and spiritual ideologies early in the Common Era.

These processes raise the following question: why did these similar movements emerge simultaneously? These innovative religious movements could not have resulted from the emergence of large-scale state polities (Sumerian, Egyptian, Mayan, Inca, and Zhou empires), many of which had priestly organized religions but lacked this focus on asceticism and morality. The puzzle may be solved by recent advances in evolutionary psychology that suggest that absolute affluence has predictable effects on human motivation and reward systems [22–24], moving individuals away from “fast life” strategies (resource acquisition and coercive interactions) and toward “slow life” strategies (self-control techniques and cooperative interactions) typically found in axial movements. In line with this idea, quantitative studies reveal a sharp increase in energy capture (a reliable proxy for affluence [5]; see Figure 2) occurring at the same time in three distinct regions of Eurasia (the Yellow and Yangzi rivers, the Ganga Valley, and the eastern part of the Mediterranean). At the end of the first millennium BCE, these regions reached an economic level (>20,000 kcal/capita/day) that greatly surpassed the economic level of previous societies, from 4,000 kcal for hunter-gatherer societies to 15,000 kcal for archaic large-scale civilizations like Egypt or Sumer [5].

In this paper, we sought to formally test for a potential link between the emergence of axial religions and the affluence of the societies in which they emerged. We computed the extent to which different social variables were associated with the emergence of axial religions. Specifically, we developed and compared stochastic models (formally, an inhomogeneous Poisson process) in which the probability of the emergence rate during a given time period depends on the value of one factor. This can be viewed as one special form of logistic regression (classically used to assess the classification power of one of several explaining factors) that simply takes into account the duration between successive data points. All models were divided into the following two subsets: (1) models based on variables indexing the level of affluence, which were referred to as affluence proxy models, and (2) models based on factors reflecting political success, which were referred to as political complexity proxy models. We used classical Bayesian methods to select the model under which the observed data are most likely to occur. The Akaike information criterion (AIC) measures those likelihoods and allows comparison between political complexity proxy models, affluence proxy models, and a null model (homogeneous Poisson, i.e., zero-factor model).

Results

First, all four political complexity proxy models failed to account for the emergence of axial religions better than the null model, except for the state population model, which outperformed it by a small margin (Figure 3A). In contrast, five out of the six affluence proxy models accounted for the occurrence of Axial Age religions significantly better than the null model and the state population model. Overall, the main city population model and the energy capture model were the most likely according to the data, with a differential AIC value of 8. In other words, whereas political complexity models fail to explain the data (i.e., they did not perform better than the null model), the affluence parameters are 4,900 and 3,200 times more likely to be true than the null model.

In the maximum-likelihood energy capture model, there was a sharp transition around 20,000 kcal/capita/day, before which there was virtually a null probability of appearance of axial religion and after which there was a high probability of appearance within a few centuries (Figure 3B), confirming predictions from our first qualitative approach. On the contrary, maximum-likelihood models for any political complexity proxy displayed much weaker modulation of probability of appearance by the associated factor.

Second, because one of the political success proxies (state population) provided a (slightly) better-than-chance account of the data, we wanted to know whether that predictive power of state population, with respect to appearance of axial religions, was complimentary to or absorbed in the predictive power of affluence proxies. To that end, we coupled state population and energy capture (the best predicting proxy for affluence) to build a two-factor model in which appearance rate was dependent on the joint values of those two variables. There was still less evidence for the two-factor model than for the single energy capture model (Figure 4), suggesting that knowing state population did not add any predictive power to knowing energy capture. We found the same trend when using the second-best predicting proxy for affluence (main city population). This confirms that whereas affluence proxies provide very good indicators for the emergence of axial religions, political success proxies do not.

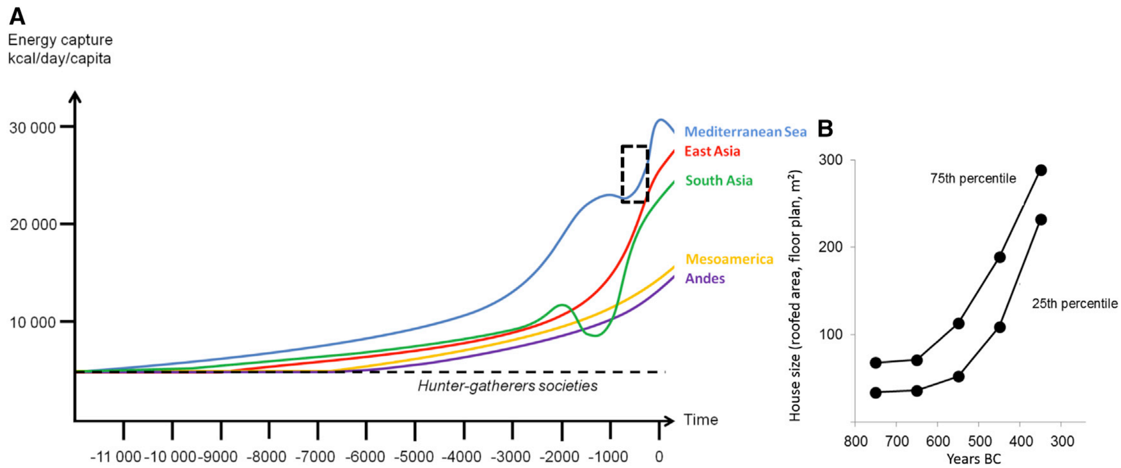

Figure 2. Evolution of Energy Capture since the Neolithic Revolution

(A) Evolution of energy capture in the five most-intensive agricultural zones from 11,000 BCE to 0 CE. The dotted line represents the level of energy capture in hunter-gatherers societies. The dotted square represents the evolution of energy capture during the period represented in (B).

(B) Evolution of Greek house size, a proxy for energy capture, adapted from [24].

Discussion

The results support our initial hypothesis that economic development rather than political complexity explains the emergence of axial religions. This is congruent with the qualitative description of some religious historians, who, following Jaspers, noted that Axial Age movements did not appear in the largest archaic states (i.e., Assyria, Babylon, Egypt, Persia) but rather in smaller prosperous polities, such as the Greek city-states, the richest Mahājanapada, and the most developed of the Chinese warring states.

Before discussing the possible interpretations of this analysis, it is important to note that more data would be needed to adequately test the robustness of this conclusion. The proxies we used for affluence and political complexity remain very crude, and we hope that better data will become available in the near future. It is all the more important that the data used in this analysis probably lead to an underestimation of the role of material prosperity. First, we used a very crude measure of urbanization (size of the main city) that greatly underestimates the astonishing rates of urbanization of Greece, China, and India during the Axial Age [25, 26]. Second, absolute energy capture does not take into account the distribution of resources within a given society (e.g., the Gini index). Because the small Greek *poleis*, for instance, were considerably more egalitarian than the great empires of Egypt or Persia, it can be assumed that the energy capture available to the upper middle class in Greece (within the axial movements emerged) was probably much greater than what was available to the corresponding class in Persia or Egypt. Finally, the lack of reliable and extensive archaeological data precluded the inclusion of many non-Eurasian empires (Hawaii, Yoruba, Kongo, etc.) as well as many preaxial ancient empires (Phoenicia, Nubia, etc.) that would have provided additional independent cases for comparing economic and political factors. Given what we know about the absence of spiritual and moral religions in all of these societies [1–4], their inclusion in the sample would greatly strengthen our model.

Although our analysis suggests that the Axial Age may be the product of an increase in standard of living in the most affluent societies of antiquity, it leaves open the question of the proximate mechanisms by which affluence leads to the emergence of new kinds of religions. One possibility, originally proposed by Jaspers [1], is that axial religions resulted from the emergence of a new class of scholars or priests who had the resource and the time to elaborate more abstract religions. Additionally, economic prosperity could have changed religions through the development of literacy and schooling, giving rise to more educated believers.

Although this hypothesis explains the clear increase in cognitive sophistication in religious doctrines during the Axial Age, it does not account for their specific content (rising importance of morality and spirituality) and the practice they are associated with (generosity, asceticism). In particular, it does not account for why the new upper class would have been particularly attracted by the condemnation of earthly pleasures, food, luxury, or social status.

Another possibility is that affluence may have promoted a new way of life through the emergence of more cosmopolitan, open, and diverse societies in which generosity, universality, and self-control became more attractive. This alternative fits very well with the importance of main city population in our model, a proxy for the development of urban life, and with the social recruitment of the axial movement among the better off.

Finally, the effect of affluence on religion could be understood in terms of life history theory [2], specifically focusing on the contrast between a "fast" strategy, with short-term investment of resources (e.g., early reproduction, more offspring, and less nurturing), and a "slow" strategy, with opposite characteristics [23, 27]. Shifts of strategies are known to be triggered by environmental cues, such as the harshness or unpredictability of environments; they result in lower or higher degree of cooperation [22, 24, 28] and in investment in the self [29], a phenomenon originally described by Maslow in his "pyramid of needs" model [30, 31].

In this life history perspective, a massive increase in prosperity and certainty during the Axial Age may have triggered a drastic change in strategies, shifting motivations away from materialistic goals (acquiring more wealth, higher social status) [23] and short-term aggressive strategies ("an eye for an eye") [24], typical of fast life strategies, toward long-term

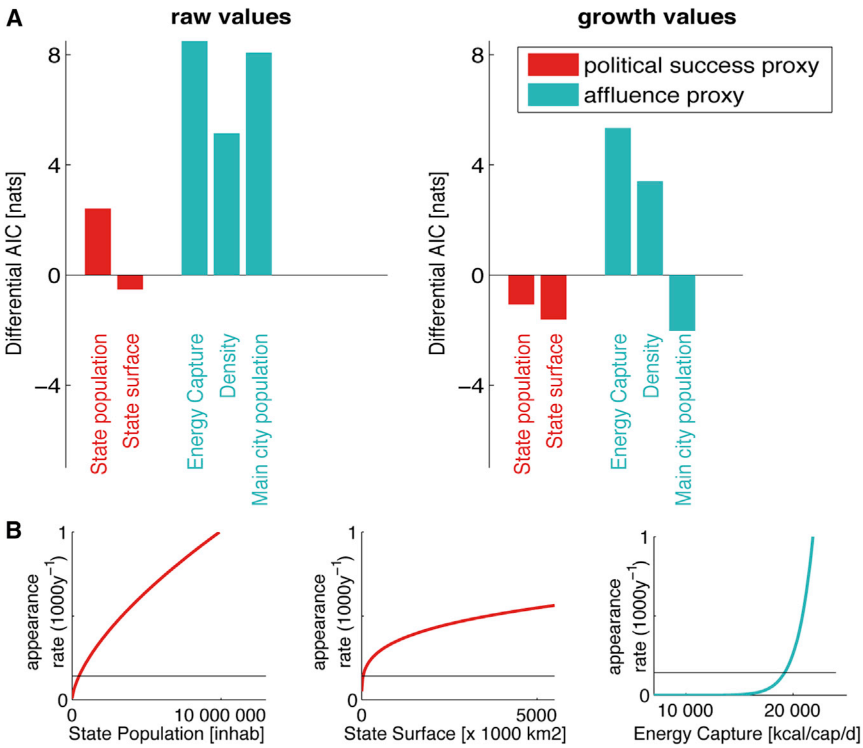

Figure 3. Comparison of Differential AICcs for Single-Factor Models

(A) Comparison of all single-factor models for the emergence of axial movements. The left panel uses raw variables as factor; the right panel uses their growth over time. Orange bars represent political success proxies; green bars depict affluence proxies. Differential AIC (equal to the difference between the null model AIC and the single-factor model) indexes the support for each model from the data: higher values indicate larger support.

(B) Appearance rate as a function of state population (left), state surface (center), and energy capture (right) in each of the corresponding maximum-likelihood models (see Supplemental Information for more information). Energy capture model shows a very sharp transition around 20,000 kcal/capita/day from lower values, where appearance is very likely, to higher values, where appearance is very unlikely, showing that energy capture provides a strong predictor for the appearance of axial religion. By contrast, for both state population and state surface, over most of the range of values, the appearance rate remains in an intermediate region where appearance is moderately likely, indicating that these two variables provide poor predictors for the appearance of axial religions.

investment in reciprocation ("do unto others...") and in self-development (variously described as the "good life" or "self-actualization" in Maslow's original theory). This shift in priorities progressively would have impacted religious and intellectual traditions through a transmission bias, in favor of doctrines and institutions that coincided with the new values [2, 4, 32]. In a nutshell, at some point in the middle of the first millennium BCE, old "ritual" religions emphasizing short-term strategies would have been supplanted by new "spiritual" religions that emphasized long-term strategies through asceticism and self-control techniques.

In this perspective, it would be relevant to investigate whether axial societies also exhibited other characteristics specific to slow strategies, such as a high parental investment or long-term monogamy [33]. Another possible area of investigation could be to study parallel phenomena later in history where more detailed historical series are available. A case in point is the concomitant emergence in medieval Europe of ascetic and moralizing movements both inside the church (e.g., the Franciscans, the Dominicans, the Beguines, etc.) and outside the church (e.g., the Humiliati, the Waldesians, or the Cathars) [34].

Experimental Procedures

We used energy capture as a proxy for affluence but also relied on more classical, albeit indirect, proxies for affluence, such as population density, population growth, and the population of the main city: population density is a proxy for economic development that allows more inhabitants in a given area, population growth requires increased survival rates and thus is correlated with economic prosperity, and main city population is a proxy for urbanization, another good indicator of economic prosperity.

We used state population and state surface as a proxy for political complexity of the main state of the area of interest. These variables, commonly mentioned in the historical literature, assess large-scale cultural changes. It has been generally assumed in classical scholarship of religion that there was a connection between social structure and the contents of religious doctrines. More recently, some authors have argued that moral religions emerged because they were indispensable to ensuring large-scale cooperation in large-scale societies [5].

As all historical models predict that world religions only appear in complex societies, we only considered the eight most advanced areas of antiquity (Egypt, Mesopotamia, Greece, Anatolia, India, China, Mesoamerica, and the Andes). Using Morris's work [5], we created time series for energy capture in Greece, Egypt, Mesopotamia, Anatolia, and China. We reconstructed changes in energy capture in India, Mesoamerica, and the Andes using the same parameters (see Supplemental Information available online). We used evidence from political geography for state size and state

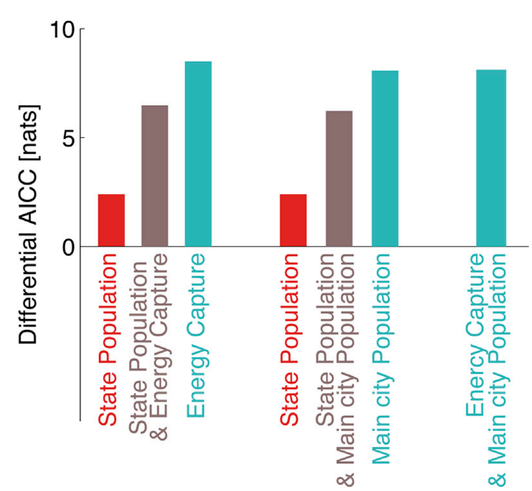

Figure 4. Comparison of Differential AICcs for Double-Factor Models

Comparison of differential AICcs for single-factor models (state population and energy capture state population) with differential AICcs for two-factors models, showing (1) that coupling any of the two best-predicting proxies for affluence with state population did not improve evidence for the model and (2) that coupling the two best-predicting proxies for affluence did not improve the affluence model.

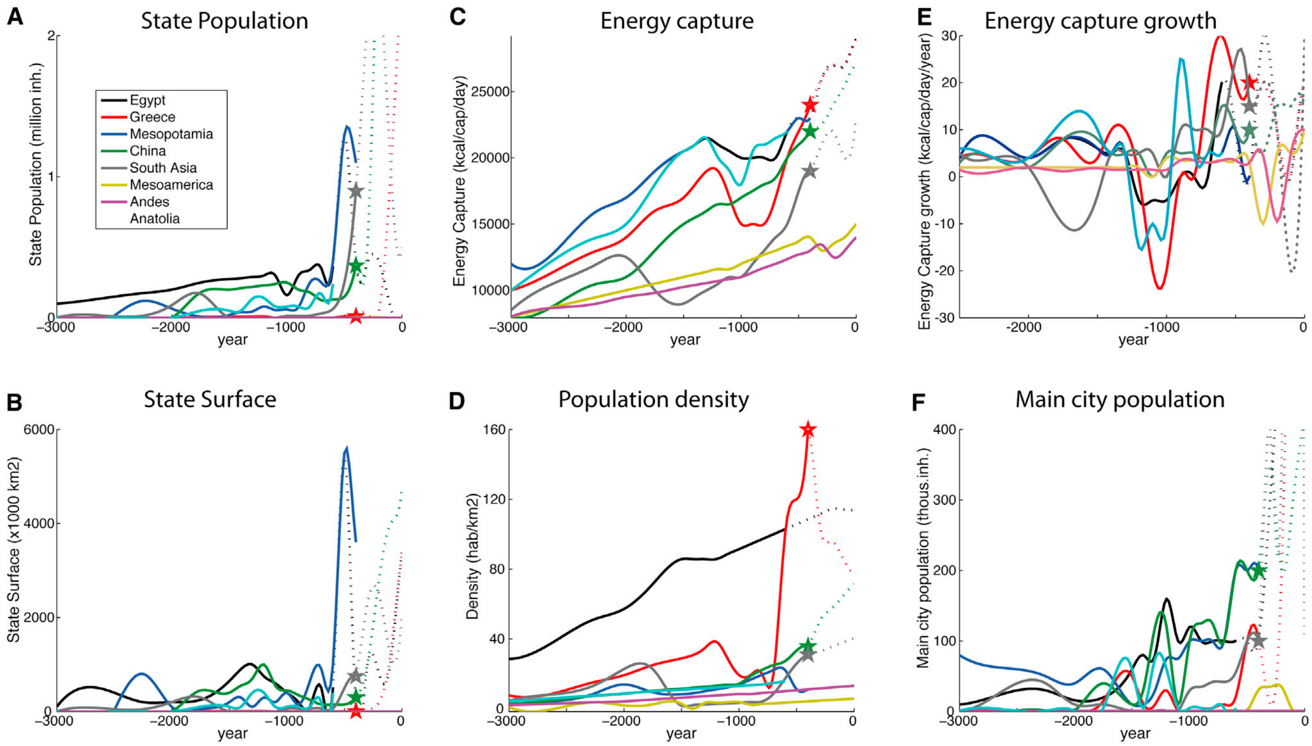

Figure 5. Evolution of Environmental Variables

(A–F) Evolution of each environmental variable, per century and per area of interest, and the emergence of axial movements (stars) at 400 BC.

population [35, 36] and evidence from historical demography for population growth, main city population and density [37, 38].

We used the standard list of axial movements described in the literature. One problem with cross-cultural studies is that cultural phenomena are often not independent from each other (because, for instance, they have all been in contact with Christian missionaries), and their comparisons may produce spurious correlations [39]. To avoid this case of "Galton's problem," we considered only one data point per cultural area (e.g., all Greek sects counted as only one axial case) and excluded one cultural area—Israel—for which cultural independence could not be proven (due notably to the influence of Egypt, Mesopotamia, and Hellenistic Greece throughout its history). Finally, we could not include Zoroastrianism due the lack of reliable historical dating of the movement (estimates typically range from 1500 BCE to 600 BCE).

Although our data set comprised only eight independent cultural regions (three of which hosted the emergence of axial religions), the very long temporal depth of the time series (e.g., more than 3,000 years in the case of Egypt and Mesopotamia) allowed us to robustly survey the ecological factors favoring the emergence of axial religions. Thus, whereas cross-cultural studies of religions usually compare multiple societies taken at a single point in time, we used data from a few regions over a long time interval.

Historical data were thus available for eight distinct areas of interest (Egypt, Greece, Mesopotamia, Anatolia, China, India, Mesoamerica, and the Andes) from 3000 BCE to 0 CE, in intervals of one to five centuries, and consisted of time series for six different factors: energy capture, population, density, state population, state surface, and main city population (see Figure 5). Although the absolute level of affluence seems crucial, its dynamics could also play a role (i.e., stagnation or decline may interact with absolute level of affluence). We thus extended our analysis by adding single-factor models based on the growth rate of each parameter rather than on its absolute value. We computed the rate of growth for these factors (excluding the first data point in each region) simply defined for time series x_i as $(x_i - x_{i-1})/(t_i - t_{i-1})$, where t_i is the date corresponding to the data points. Note that once axial religions appear they may coexist with nonaxial practices (as was the case in the remote provinces of the Roman Empire after the conversion of Constantine). We thus studied the dependence between various factors and the appearance of spiritual religions, not the existence of such religions.

All of the models are stochastic models (Poisson processes) whereby, in each region and at each time step, spiritual religions have a certain probability of appearing based on some emergence rate. The form of that emergence rate depends on the model.

(1) In the null model (or homogeneous Poisson model), the rate is constant over time (i.e., the appearance of spiritual religions does not rely on any factor): $\lambda(t_i) = \alpha$. This model is used as a control model.
(2) In single-factor models, the rate depends upon one factor, e.g., energy capture. The dependence is taken to be of the general form $\lambda(t_i) = \alpha x_i^{\beta}$, where x_i is the value of the factor at the corresponding time and α and β are some unknown parameters to be estimated. Growth parameters can take negative values that are inconsistent with the rate formula above, so for those parameters, we used instead $\lambda(t_i) = \alpha(x_i - x_{min})^{\beta}$.
(3) In two-factor models, the rate depends upon two factors, e.g., energy capture and state population. The general form now writes as $\lambda(t_i) = \alpha x_i^{\beta} y_i^{\gamma}$, where x_i and y_i are the two factors and α, β, and γ are the unknown parameters.

Maximum-likelihood parameters in each type of model can be estimated using gradient descent on the log likelihood (LLH) of data. They can also be determined analytically by searching for sets of parameters where the LLH gradient vanishes, yielding the following:

(1) For the null model, $\hat{\alpha} = n_{trans}/\sum_i dt_i$, where n_{trans} is the number of transitions in the data set and dt_i is the duration of time step I (in other words, the estimated rate is simply equal to the number of observed transitions divided by the overall durations of observations combined with the overall regions of observations).
(2) For single-factor models,

$$n_{trans} \sum_i dt_i \log(x_i) x_i^{\hat{\beta}} = \sum_i dt_i x_i^{\hat{\beta}} \sum_{i \in trans} \log(x_i)$$

$$\hat{\alpha} = \frac{n_{trans}}{\sum_i dt_i x_i^{\hat{\beta}}}.$$

(3) For two-factor models,

$$\hat{\alpha}\sum_i dt_i \log(x_i) x_i^{\hat{\beta}} y_i^{\hat{\gamma}} = \sum_{i \in trans} \log(x_i)$$

$$\hat{\alpha}\sum_i dt_i \log(y_i) x_i^{\hat{\beta}} y_i^{\hat{\gamma}} = \sum_{i \in trans} \log(y)$$

$$\hat{\alpha} = \frac{n_{trans}}{\sum_i dt_i x_i^{\hat{\beta}} y_i^{\hat{\gamma}}} .$$

Models were compared using the corrected AIC (AICc, which corrects the maximum a posteriori LLH (LLH_{max}) for the number of estimated parameters:

$$AICc = -2LLH_{max} + 2k + \frac{2k(k+1)}{N-k-1} ,$$

where k is the number of parameters in the model (from 0 to 2) and N is the number of data points. The model with the lowest AICc is the most likely (a model can be said to capture data significantly better than another one if its AICc score is at least 3–4 bits lower than the other). Here, we used differential AIC, i.e., the difference between AICc for the null model and AICc for the model under consideration. A higher-differential AIC thus means a more-likely model.

Supplemental Information

Supplemental Information includes Supplemental Experimental Procedures and one figure and can be found with this article online at http://dx.doi.org/10.1016/j.cub.2014.10.063.

Author Contributions

N.B. proposed the hypothesis, designed the study, and produced the time series. I.M. provided the time series for energy capture. A.H. built the model and ran the analysis. All the authors wrote the paper.

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Supplemental Information

Increased Affluence Explains the Emergence of Ascetic Wisdoms and Moralizing Religions

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Supplemental figures

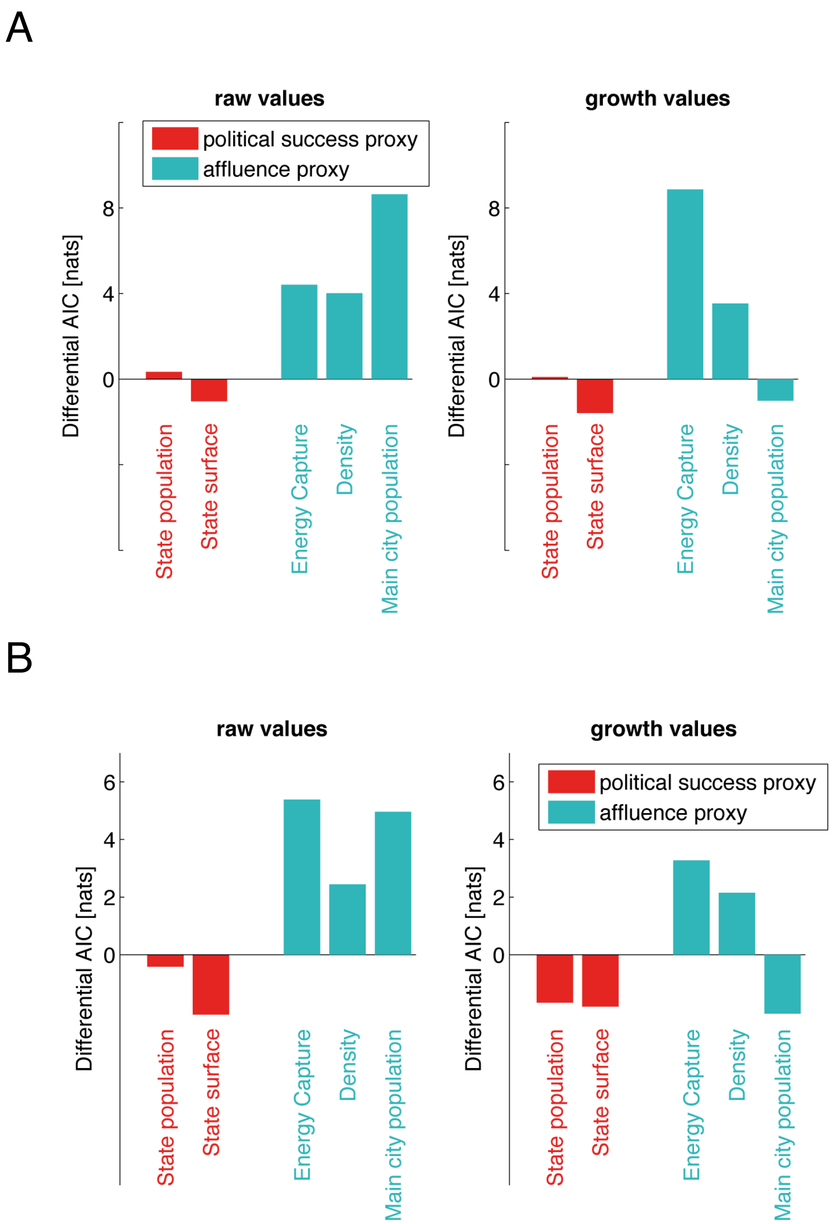

Figure S1, Related to Figure 3: (A) Control for an Early Date of Axial Movements (500 BCE). (B) Control with Tribal Areas Excluded

Supplemental Procedures

1. Dependent variable

The dependent variable in this model is the emergence of axial movements in a particular area of interest. There is little disagreement about the identity of the movements that are considered 'axial' [S1, S2, S3]. Indeed, 'Axiality' is usually considered as an atheoretical characteristic as it mostly refer to the fact that a particular movement lead to a world religion. In other words, 'axiality' is a based on the cultural success, and is agnostic about the cause of this success.

We thus used the standard list that comprises Greece (Pythegoreanism, Socratism, etc.), Israel (Judaism), Persia (Zoroastrianism), India (Buddhism, Hinduism, Jainism) and China (Taoism, Confucianism). Two areas of interest were excluded for methodological reasons:

Independence of the data points: To avoid Galton's problem of non-independent data, we excluded Judaism. Indeed, the Hebrews were rarely politically independent (they were controlled at some time by Egypt, the Mesopotamian states and the Hellenistic kingdoms), and they were very much under the cultural influence of Egypt, Greece and Mesopotamian. For this reason, we cannot include it in a model assessing the likelihood of independent emergence of axial religions.

Similarly, we excluded all areas that were culturally dependent from another one due to political conquest. Thus, we excluded Mesopotamia, Egypt and Anatolia after Alexander's conquests (300 BC onward) as these three areas becomes heavily influenced by the Greek culture (foundation of new cities, Greek emigration, adoption of the Greek language by the elites, etc.). Due to this cultural influence, it is impossible to assess whether any subsequent emergence of an axial religion (e.g. Hellenic Judaism, Manicheism) is truly independent.

Lack of data: In line with the contemporary characterizations of the axial religion, we did not include Zoroastrianism in the list [S1]. First, the case of Zoroastrianism is problematic for methodological reasons as the dating as well as the actual content of Zoroastrianism remains unclear. As Bellah [S1] writes for instance: "*everything about Zoroaster (including his dates which vary according to different authorities from the middle of the second millennium to the middle of the first), Zoroastrianism (including the contents and dating of Zoroastrian scriptures), and the degree to which and the way in which Zoroastrianism was institutionalized in Achaemenid Persia, is in dispute due to enormous problems with very limited sources*."

It is worth noting that, aside from methodological problems, modern scholarship suggests that Zoroastrianism was not an axial religion [S4, S5, S6, S7]. While Zoroastrianism was originally in Jaspers' list, it was not very well studied at the time Jaspers published his idea, and Jaspers included it partly because it looked like a world religion due to its geographic extension. But the influence of Zoroastrianism now appears to be only the consequence of the extension of the Persian Empire, and not of a specific cultural success like other axial religions. Indeed, Zoroastrianism always remained an ethnic religion, and never experience proselytism, unlike all other axial age religions. Modern scholarship confirms that there is nothing 'axial' in Zoroastrianism. In particular, there is no asceticism, no renouncers, no spiritual exercises, no conversions. The only axial aspects of Zoroastrianism appeared much later, in the medieval period, after a thousand years of Greek, Christian and Muslim influence.

Dating of axial religions: As there are some debates surrounding the actual emergence of some spiritual religions (e.g. the birth of Gautama or the dating of the *Daodejing*), we ran a subsequent analysis with an early estimate (500 BCE). No significantly change was observed (see Figure [S1]).

2. Independent variables

2.1 Proxies for affluence

Energy capture: Measures of energy capture originate with Cook's work that pointed to an increase from about 5,000 kcal/cap/day for prehistoric hunters through 12,000 for early farmers to 26,000 for advanced farmers, 77,000 for early industrialists, and 230,000 in modern industrial societies [S8, S9]. Comparative anthropology, energetics, and archaeology now allow us to improve on Cook's estimates. Excavated skeletons, food remains, tools, metallurgy, agricultural practices, houses and their contents, monuments, and shipwrecks can all serve as indicators of energy capture. These can be compared with chemical traces of industrial pollution in ice cores and bogs and, when available, ancient written evidence on wages and consumption. All these sources can be combined to provide us with a detailed picture. Margins of error might reach 10%, but are unlikely to exceed 20% in such estimates [S8].

The estimate of energy capture for Egypt, Mesopotamia, Greece, Anatolia and China were extracted from Ian Morris's published database [S8] These quantitative studies reveal a sharp increase in energy capture occurring at the same time in three distinct regions of Eurasia (Yellow-Yangzi rivers, Ganga valley, Eastern part of the Mediterranean). At the end of the first millennium BCE these regions reached an economic level (>20,000 kcal/capita/day) that greatly surpassed those of previous societies – from 4,000kcal for hunter-gatherer societies to 15,000kcal for archaic large-scale civilizations like Egypt or Sumer.

More specifically, while the Mediterranean world, until about 1000 BCE, was a periphery to a more developed, richer Middle East [S10], cheap maritime transport turned the region into a trade highway [S11]. Greek living standards caught up with middle-eastern level of about 23,000 kcal/cap/day by 500 BCE, and then surpassed it (see Figure 2, main article). By 400 BCE, unskilled Athenian workers were earning some of the highest wages known in pre-modern times [S12]. By 300 BCE, Italy had also caught up, being the richest region on earth, at around 31,000 kcal/cap/day. By 1CE, Rome had annexed Iberia and Gaul, with the economic core remaining in Italy.

China, though lagging behind western Eurasia (e.g. in metal use), saw a similar upward trend. Brick houses replaced thatched huts, farmers adopted draft animals and high-yield rice, transportation improved dramatically [S13]. Energy consumption rose from about 17,000 kcal/cap/day in 1000 BCE to 27,000 in 1 BCE. Excavations at Sanyangzhuang, flooded by the Yellow River in 11 CE, revealed standards of living broadly comparable to those of Roman sites like Pompeii [S14].

We completed Morris' database for the oldest periods for Greece (before 1800 BC) by positing a similar pattern of growth (i.e. accelerate growth rate over time) as the other Mediterranean societies at the same level of energy capture. For instance, the study of housing shows a replacement of curvilinear single-room by multi-room rectilinear houses, first in the Western core (Egypt, Syria, Israel, Palestine, Irak) at the beginning of the 1st Millennium BCE, followed by a similar replacement in Greece by 750 BCE (complete by 500 BCE), and in Southern Italy by 600 BCE.

For South Asia, Mesoamerica and the Andes, we built new estimates based on the same criteria used by Morris, especially metallurgy, agricultural practices and building materials. In South Asia, farmers in the Indus Valley (in modern Pakistan) began using bronze and building cities soon after 3000 BCE, roughly 500 years after farmers in West Asia but nearly 1,000 before those in East Asia. By 2000 BCE, city-dwellers of the Harappan culture were consuming about 12,500 kcal/cap/day, but a massive and poorly understood urban collapse around 1900 BCE cut this by about 25%. It took 1,000 years for South Asian economies to regain the energy capture level of 2000 BCE [S15]. By 900 BCE the urban core had had shifted to the Gangesa Valley in what is now northern India [S16]. These cities enjoyed an economic boom after 700 BCE, and the emergence of ever merging into larger and larger kingdoms until the Mauryan Empire united them all around 300 BCE [S17]. At that point, energy capture had reached about 21,000 kcal/cap/day, not far behind contemporary East Asia (22,500 kcal/cap/day or the East Mediterranean (26,000 kcal/cap/day).

By contrast, the New World, for instance, had almost no draft animals and only very little metallurgy [S16]. Experiments with copper smelting, had begun in the Andes by 1000 BCE, but the conquistadores arriving in the 1520s CE found that stone was still the dominant material for tools and weapons. Around 1000 BCE, large civilizations, like the Olmec in Mesoamerica and Chavín de Huántar in the northern Andes, were in many ways comparable with those of Mesopotamia around 3000 BCE or China around 1800 BCE, with energy capture levels no higher than a 11,000-12,000 kcal/cap/day range [S18, S19]. By the end of the 1st millennium BCE, energy capture in Teotihuacán and the Moche culture were still below 15,000 kcal/cap/day [S20, S21]. This is roughly equivalent to the Old World's archaic states, like Egypt around 2500 BCE or China's Central Plain under the Shang around 1500 BCE, far from Axial Age levels.

Population density: Population data at different geographical scales were extracted from McEvedy and Jones [S22], a dataset still commonly used by social scientists, as it fares well in comparison of more recent evaluations, see e.g. [S23] for Greece. Although one may want to supplement this database with more recent data, we avoided this in order to preserve the benefit of using a consistent source for statistical modeling. Indeed, where new data are available, they are still very much debated, see e.g. [S24] about Roman population. As McEvedy and Johnson's potential errors all result from the same estimation principles (maximal density supported by agriculture at each stage of technical development, comparison with modern data, etc.), they likely go in the same direction and should not invalidate comparative conclusions. As McEvedy & Johnson use modern borders, we aggregated the population of modern countries when necessary (e.g. in the case of the Neo-Assyrian empire at its peak in the 8th century BCE, we included Irak, Egypt, Israel, Palestine, Jordan, Armenia, Lebanon, Syria, Kuwait and the southeastern corner of Turkey). Although McEvedy & Johnson do not provide any estimate of the distribution of population within the modern borders of a given country, the actual distribution of ancient populations (massively grouped in a few river valleys) suggests that the margins of error remain relatively low.

While arable land do not change much throughout the history of Ancient Egypt, it increases a lot during the Axial Age in India and China. Not taking into account the variation of arable land would artificially inflate the rate of density growth during the Axial Age and bias the analysis in favor of our hypothesis. We thus took into account the variation of arable land in Antiquity as reported by McEvedy and Johnson.

Population of the capital: We used comprehensive datasets by Chandler [S25] and Modelski [S26] to estimate the size of the capital of the largest political entity in a given area of interest. These estimates of city population are mostly based on the size of archaeological sites, sometimes corrected by historical documents. Because the estimate depends heavily on assumptions made by each scientist about the density of each city within its walls, it is preferable to stick to one database, even though other estimates are sometimes available, see e.g. Morris [S27] concerning classical Athens. When Chandler and Modelski depart from each other, we used the more recent Modelski. In areas where there is no record of any city over 10.000 inhabitants (which is Chandler and Modelski's criteria for Antiquity), we posited a standard political center of one thousand inhabitants for complex chiefdoms, and five thousands for simple states (A subsequent analysis shows that removing all the data points where a State is absent does not change the result significantly. See Figure [S1]).

2.2 Proxies for political success

State size: We used Taagepera's classic work [S28, S29, S30] on the size of kingdoms and empires. Taagepera used a variety of historical atlases to measure the variation of the major political entities (all >0.3 million km²) from 3000 BCE to 600 CE – for methods, see [S29]. Although historical chronicles are often imprecise, especially for archaic empires, the margins of error are pretty low, and most of the time below 10%. We completed this with two comprehensive online historical atlases, Geacron [S31] and the Atlas of World History [S32], for the few cases not included in Taagepera's database. For each area of interest, we always selected the largest polity (for instance Babylonia in 1750 BC, but Assyria in 1500 BC for Mesopotamia). Note that this probably biases the analysis in favor of the political complexity theory, against our own hypothesis, because it likely overestimates political complexity in a given area of interest. In the case of archaic city states, which flourished at a time where money was unknown and transportation costly, we postulated that each city was economically independent. We thus used the city population combined with local density to estimate the area controlled by the city. Again, note that this method, which probably underestimates the size of city states, biases the analysis against our hypothesis since it underplays the size of the states before the emergence of axial religions.

State population: State population was obtained by dividing the total population of the area by the percentage of this area covered by the largest polity. For instance, in 5th century India, where it is commonly estimated that the Maghada Kingdom covers a third of the Ganges Valley, we divided McEvedy and Johnson's estimate (15m people) by a third of the area estimated by Taagepera (500,000 km²). In the case of city-states, we equated state population with capital population.

2.3 Areas not included

To better test our hypothesis, we considered including other non-Eurasian societies such as Polynesia before 1700 CE (Hawaii, Tonga), Gulf of Guinea before 1500 CE (Benin, Yoruba, etc.), the Kongo Valley before 1500 CE (Kongo), the Interlacustrine African area before 1800 CE (Rwanda, Burundi) and Central Africa before 1800 CE (Luba, Luanda). Given their population densities and their agricultural practices, it is unlikely that any of these societies probably ever reached the 12,000 kcal/cap/year threshold of early farmers. Combined with what we know about the absence of spiritual and moral religions in all these societies, their inclusion in the sample would have greatly strengthened our model. However, the lack of reliable and extensive archaeological evidence made their inclusion unwise. Similarly, population and city size estimates are scarce for more ancient polities such as the Phoenician, Nubian, Yemenite and Hebrew kingdoms.

Since we required all parameters at a given time for a given society to compare different models, we chose not to include them.

2.4 Proxies not included

We considered using a range of proxies to estimate affluence and political complexity. For affluence, urbanization rate would have been an ideal candidate, see e.g. (*44, 45*) for the medieval and modern periods. Yet, reliable estimated urbanization rates are only available for the Greek city states and the Roman Empire [S24, S33]. For the other areas, only the largest cities are documented, often with little precision. We thus dropped this proxy. Note, however, that if urbanization is considered as a proxy for affluence (because it reflects how many urban people the peasant population can sustain and hence its productivity) then the very high urbanization rates of classical Greece and the Roman Empire, unknown until economic boom of the 12th-13th centuries, clearly suggest a link between affluence and axial age movements.

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