Did Religion Initiate the Neolithic Revolution and Later Facilitate the Creation of Ancient States?

By Mukesh Eswaran*

Vancouver School of Economics

University of British Columbia

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ABSTRACT

Drawing on the novel hypothesis of archaeologist Jacques Cauvin on the origins of the Neolithic Revolution based on evidence, this paper explores the plausibility of religion initiating the Neolithic transition from hunting and gathering to agriculture. I cast religion as a club good that is bolstered by rituals (for which there is ample evidence from the period of Neolithic incipience), and supply a model that attempts to identify why the hypothesis is very plausible on economic grounds. The core mechanism of the model is that religion facilitates the public good investments needed for agriculture. The theory also provides reasons for believing that religion may have further aided these agricultural societies to create ancient states in order to solve the collective action problem inherent in large-scale investments like irrigation.

Key Words: Neolithic Revolution, agricultural investment, religion, state formation

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*Email: mukesh.eswaran@ubc.ca

1. Introduction

It is generally accepted that the transition from hunting and gathering to agriculture some 10,000 -12,000 years before the present has been one of the most momentous changes in human history for it has wrought profound consequences in its wake. It increased the supply of food, facilitated the division of labor, increased populations dramatically, introduced social hierarchies and inequalities, created urban societies, enabled the industrial revolution and generally increased the per capita output to historically unprecedented levels [Diamond (1997)].[1] What we call "civilized" life as opposed to primitive life is ultimately tied to this 'Neolithic Revolution', as it has been called [Childe (1951)]. The reasons offered for the transition to agriculture are many—climate change, overpopulation, food scarcity, technical change, among others. These theories, which are now part of the received wisdom, have been proposed mostly by non-economists to my knowledge, Bowles and Choi (2019) being a notable exception. My purpose in this essay is to explore within the framework of an economic model the possible role of religion in facilitating the transition to agriculture and permanent settlements.

I take my cue from archaeologist Jacques Cauvin (2000/1994), who argued that the Neolithic Revolution was due to cognitive changes entailing symbolism. Based on artifacts unearthed by archaeology in the Near East, he inferred that there was in humans a shift in the perception of the order of things, hinting at the divine origins of humans (with references to mother-goddesses and bull gods). This imbued humans at the time with a sense of agency that resulted in substantive changes in social relations and in the belief that they could manage nature to produce food. Gauging from the timing (obtained from carbon dating) of the artwork and figurines left by humans living at the time, Cauvin argued that their symbolic vision preceded the introduction of agriculture. Subsequent research by archaeologists has found some support for Cauvin's theory, though there is also evidence for the standard views on the Neolithic Revolution [Zeder (2011)].

A core feature of primitive religion is the importance of rituals [Hayden (1987), Rappaport (1999)]. Archaeological remains provide ample evidence of extensive rituals involving large groups around 10,000 years before the present. The effects of rituals on the performers has been

[1] Hibbs and Olsson (2004) and Olsson and Hibbs (2005) in an endogenous growth model that accounts for the transition from hunter-gatherers show that a head-start in this transition has discernible positive effects on income even today.

well-studied in contemporary settings, but there are several studies offering reasons why rituals were crucial in prehistoric religions. One of the effects of ritual performances, which were done collectively, is the generation of solidarity or prosocial behavior [Hayden (1987, 2003)]. Since rituals were performed around 10,000 to 12,000 years ago even involving intergroup bands of hunter-gatherers, the activity created solidarity across groups (and, of course, within groups). This had evolutionary advantages pertaining to survival in prehistoric times. In fact, in the developing countries of today, cultivation of connections across geographical space is seen as beneficial for minimizing risk in adverse circumstances stemming from climatic and environmental uncertainties. But, very importantly, rituals are acknowledged today to also produce social cohesion and solidarity [Kavanaugh et al (2020)].

Rituals and their *collective* performance is an important part of contemporary studies in religion. Since Iannaccone (1992, 1994) proposed his novel idea that religion is a club good, it is well-recognized in economics that religious rituals are a public good for the group of practitioners.[2] This essay draws on the club good aspect of religion and further incorporates the prosocial behavior and religious commitments that rituals induce. I then set up a model to study how primitive religion could have spurred the Neolithic transition from hunting and gathering to agriculture.

Strictly speaking, the transition from hunting and gathering to agriculture did not occur in a single step. It was preceded by an intermediate stage in which humans settled into a sedentary life but still lived by foraging and some hunting [Simmons (2011), Dow and Reed (2015)]. In this paper, I examine how religion could have led sedentary foragers to settled agriculture, that is, to the domestication of plants and animals for food.

Drawing on and adapting Eswaran (2023), I posit individual preferences over three goods: food (here privately produced), a cultural good, and private leisure. The cultural good represents an aggregate of all the activities that are jointly produced by a primitive group's members, which contribute to the group's culture. Religion is incorporated as one cultural component of many public goods that are important for a band's wellbeing. In addition to this, the theory models the fact that viable agriculture requires considerable public good effort for activities such as clearing

[2] See Iyer (2016) for a review of the idea of religion as a club good.

forests, building wells, irrigation channels, etc. This investment increases the total factor productivity of the land of everyone in the group, and hence it has a public good nature. Within this framework, I ask what the effects would be of viewing agricultural investment during the Neolithic transition as being somewhat imbued with a religious purpose.[3] The model's results suggest that religion positively affects investment in agriculture. The mere fact that agricultural investment is viewed as a religious activity to some extent enables it to do "double duty": it contributes to raising total factor productivity of agriculture and it also contributes to the collective cultural good. This releases resources by economizing on other inputs contributing to the cultural good and allowing a reallocation to agricultural investment. This is one avenue in the model through which religious groups are seen to outperform secular groups in agricultural investment.

Next, in the same model, I explore how the group solidarity that religious beliefs are known to generate affect the group's public investment in agriculture. The results show that prosocial behavior attenuates the moral hazard in teams that is much-emphasized in neoclassical economics. Individuals recognize that their contribution to agricultural investment benefits not only themselves but also all others in the group about whom they care. This is a second avenue through which religion positively impinges on agricultural investment. The model thus supplies two different routes through which Neolithic religion enhanced the public effort needed to transition to agriculture. Thus, my theory suggests that economics offers plausible reasons in support the hypothesis of Cauvin (1994/2000), Cauvin (2000), that religion instigated the Neolithic Revolution.

The paper then moves on to answer the question of whether the religion stemming from Neolithic roots could have aided the creation of ancient states. Agriculture existed for millennia before the earliest states were created, which was around 4,000 BCE [Scott (2017)]. Large scale agriculture requiring massive irrigation seems to have been responsible for many of these early states. Large-scale agricultural investment calls for considerable coordination and cooperation, which is best done via a state, as shown in the recent empirical work of Allen, Bertazzini, and

[3] This exercise also provides the microeconomic mechanisms of how religiosity impinges on actions other than by merely positing religious preferences that directly affect allocations.

Heldrig (2023). My paper shows how religion would have facilitated the formation of these early states by enabling the implementation of large-scale irrigation projects.

The next section offers a brief overview of the empirical literature, almost exclusively from disciplines other than economics, that lends support for the hypothesis that religion may be implicated in initiating the Neolithic Revolution. Section 3 presents a model that explores whether economics offers a plausible support for the hypothesis. Section 4 investigates the possible role of Neolithic religion in the formation of the earliest states. Section 5 offers some concluding remarks.

2. The Case for Religion's Role in the Origin of Agriculture

There are many theories of the origins of agriculture, which is deemed to have originated around 10,000 - 12,000 years before the present in the Near East and a few other regions in the world. The Near East is the best studied region and I shall restrict myself to this geographical area.[4] The shift was from sedentary foraging to agriculture. Bar-Yosef and Belfer-Cohen (1991, p. 190) claim that the shift from the Natufian (sedentary foragers) to the early Neolithic (farmers) in the Levant occurred in the short time span between 10,500 - 10,300 and 10,100 years before the present. Childe (1951), who coined the term "Neolithic Revolution", proposed that agriculture started when humans settled down on fertile land near in the vicinity of oases. Richerson et al (2001) have argued that it was climate change that made agriculture possible. Others like Boserup (1965) and Binford (1968) have suggested that population pressures led to agriculture. Bowles and Choi (2019) gave an economic rationale and argued that it was the move to private property that was responsible. Yet others like Bender (1978) and Hayden (1990) have put forward the view that social and cultural factors were responsible for agriculture.[5] Bar-Yosef (1989) in an archeological overview of earliest attempts in agriculture in the Levant (Near East) points out that the record also shows failures. Among the possible reasons, he suggests failure to achieve the needed level of social cohesion as one.

[4] Archaeologists refer to regions near the east of the Mediterranean Sea as the Near East. It generally comprises the Levant, Anatolia, Mesopotamia, and Egypt.

[5] As noted in the Introduction, the transition from hunting and gathering to farming did not occur as a single discrete change, though it is often thought of as such for conceptual purposes. In reality there was a gradual shift to sedentism, and the complete switch to agriculture as a way of life took millennia to evolve [see Kelly (1992), Dow and Reed (2015)].

Jacques Cauvin (2000/1994) proposed a novel paradigm in his book *The Birth of the Gods and the Origins of Agriculture*. He argued that the Neolithic Revolution in the Fertile Crescent in the Near East was preceded by dramatic cognitive innovations in symbolism and religious ideas. In particular, he pointed to artwork and figurines of a mother goddess as a symbol of fertility and a bull as a symbol of male dominance and power, and the mother goddess giving birth to the bull-god. This perception of the birth of divinity in humans imbued them with a sense of agency [Cauvin (2000/1994, 2000), Hodder (2001)]. These cognitive changes occurred before plant and animals were domesticated in the Near East. In Cauvin's view, the vision of humans dominating nature as a cultural change led to the domestication of plants and animals. This occurred, he argued, around 9,000 BC, at a time of abundance and not scarcity. In other words, the driver of the Neolithic Revolution was not environmental or economic but a shift in symbolic vision, religion, and rituals. Agriculture spread from the original site to others in the Near East through the diffusion of culture. The archaeological record seems to be consistent with Cauvin's theory, at least in broad outlines though not in all the details [Zeder (2011)]. However, it seems to be generally agreed by archaeologists and anthropologists that religion cannot be seen as the exclusive driver of the Neolithic Revolution; various other factors—ecological, economic, and demographic—probably also contributed.

Religions in the Neolithic era and before were quite different from those of the major established religions of today. Hayden (2003), draws attention to a distinction made by other anthropologists between "book" religions and "traditional" religions. The former are the major established religions of today, for which the teachings are contained in scriptures that are read by the adherents. The traditional religions, by contrast, are *experiential*; spirituality is a matter of directly experiencing what is revealed in ecstatic states and mystical revelations. Prehistoric religions fell in this latter category. The fundamental belief that underlies this view is the existence of a vital force or spirit that is manifest (immanent) in this universe, in contrast to some other-worldly religions of today which posit a transcendent reality entirely apart from this world. Prehistoric religions had a very strong emotional element in them [Hayden (1987), Rappaport (1999)]. Their goal was to seek to establish direct contact with the immanent force/spirit. This was done through numerous rituals—like dancing, feasting, etc. Shamans were virtually universal practitioners of traditional religions, especially among hunter-gatherers who constitute 99.5% of our human history (see Hayden (2003) for an exhaustive account of shamans).

Whitehouse and Hodder (2010) (and Whitehouse in his publications with several coauthors) also make a distinction similar to "book" and "traditional" religions. Roughly, they allude to the former as "doctrinal" and the latter as "imagistic" modes of religiosity. The imagistic ones involve low-frequency, high emotional-impact events that leave a lasting impression on the participants. The doctrinal ones are high frequency events that have low impact, are more uniform and discursive. The major religions of today would certainly fall into the doctrinal category.

Even the established religions of today, it must be noted, have at their core the mystical experiences of their founders.[6] It is only later that these experiences are interpreted, conceptualized, written down, systematized, and made rigid. Most practitioners of contemporary religions follow these written-down versions of the interpretations of the experiences of the founders. Thus, today's religions arguably lack the vitality that inform traditional religions, where what is sought in religious activity are direct encounters with reality. Experiential encounters of what is perceived as reality have an immediacy that is absent in the receipt of second-hand information. Therefore, the lives of those with experiential knowledge tend to be transformed by what was experienced. Their lives tend to be strongly colored, if not driven, by the perceived reality in these experiences. As Eliade (1959, p. 12) put it, "[F]or primitives as for man of all premodern societies, the *sacred* is equivalent to a *power*, and, in the last analysis, to *reality*" (emphasis in the original).

When the perception of unity across people is experienced in an ecstatic state of consciousness, it inevitably will have an effect on their perceptions of the real world even after the ecstasy has passed. As a result, the inner world can have profound effects on the perceived external world. The hallmark of mystical experience is that the reality perceived contradicts the separative perceptions of the egoistic self, and ecstatic experience presumably does the same to some extent. In that case, ecstatic experiences would blur the distinction between self and others and, therefore generates a sense of bonding across people. Social bonding is recognized by anthropologists and biologists to have conferred a quintessential benefit on survival in evolution in the hunter-gatherer stage of our evolution [Hayden (1987, 2003)].

[6] Lewis-Williams and Pearce (2005) note the well-known fact that ecstatic experiences and altered states of consciousness are present in all religions. For a classic treatment of the subject in western religions, see the work of Underhill (1911). See Eswaran (2024) for a discussion on this.

The role of rituals in religion cannot be overemphasized; they are part of all the religions we observe. In an illuminating view on this, Radcliffe-Brown (1952, esp. Ch. VIII) points out that rituals do not evolve from religious beliefs. Rather, rituals come first and religious beliefs come later as ways of justifying the rituals. The performance of rituals derives from a need for actions, which themselves symbolically embody deeply-felt emotions. The effects on the society or cult do not depend on the veracity of the beliefs but on the repeated performance of the rituals. One of the important functions of rituals is to regulate the behavior of individuals so that they are not anarchic in nature but, rather, converge on behavior driven by commonly acknowledged emotions. In other words, rituals cement a society and religion derives its efficacy from it. Rituals promote cooperation and coordination of activities. The social bonding that results from the performance of rituals is well understood in the fields of sociology, anthropology, and evolutionary psychology [e.g. Durkheim (1965/1915), Whitehouse and Lanman (2014), Sosis and Alcorta (2003), Winkelman (2009), Watson-Jones and Legare (2016)].

In the 1990s, an archaeological discovery dramatically changed the views of scholars on the organizational skills of hunter-gatherers and the origin of religion. This was the discovery of the Gopekli-Tepe in south-east Turkey by Schmidt (2000). This structure, which is estimated to have been built between 11,600 to 10,200 years before the present, is deemed by archaeological experts to be the world's oldest temple and comprises circles of massive stone pillars surrounding two massive obelisks. The size and weight of these pillars are too large for individual bands of hunter-gatherers to have moved them on this site, for these bands typically comprised around 150 individuals on average [Dunbar (1992)]. There is no evidence of settlements at or in the vicinity of Gopekli-Tepe and the conclusion that was drawn is that several hunter-gatherer groups had to collaborate in the building of this gigantic structures.

The prevalent hypothesis is that Gopekli-Tepe was the location of frequent rendezvous of several hunter-gatherer groups. The evidence from animal bones in the vicinity and hints of beer production at the location has led researchers to suggest that it was a location of rituals and feasting, and possibly drinking [Dietrich (2012), Dietrich and Dietrich (2019)].[7] As discussed above, the common performance of rituals leads to a cementing of bonds across people, which naturally leads to other-regarding preferences (see Ruffle and Sosis (2007) for contemporary

[7] For a contrary view, see Banning (2011).

evidence on the effects of collective rituals in one setting). Some scholars see in Gopekli-Tepe the beginnings of religion [Ozalp (2019)]. The importance of rituals in this context is that religion facilitates coordination and cooperation on large projects.[8] In the light of this, it is perhaps not an accident that the region around Gopekli-Tepe saw settled agriculture merely 500 years later.

Evidence of Neolithic religiosity is most certainly not restricted to the Gobekli Tepe. Whitehouse and Hodder (2010) find archaeological evidence for modes of religiosity at Çatalhöyük, central Turkey, during the period 7,400-6,000 BC, which is one of the best known Neolithic sites in Anatolia and the Middle East. From the point of view of agriculture, however, the Çatalhöyük was well after agriculture had originated. They found evidence of climactic rituals involving the infliction of "physical pain and participation in psychological disturbing acts", collective possession and mystery cults. This imagistic mode of religiosity is more or less localized because this requires participation. They also found here what they surmise is evidence of the later emergence of the doctrinal model of religiosity patterns of uniformity and hierarchical structure.

Irrigation in Mesopotamia, where agriculture first originated, was deeply imbued with religious sentiments. Gruber (1948) describes the numerous tablets and inscriptions found near the canals hat were built in Mesopotamia at around 2900 BCE that invoke the gods. He says, "From the importance given the construction of this early canal in this essentially religious inscription, it may be inferred that such construction was not only a secular necessity, but a religious accomplishment as well." (p. 73) And again "The stele of Ur-Nammu illustrates quite vividly the idea that the irrigation canals and, particularly, their effect on the productivity of the land were god-given and god-inspired. This same stele, as well as all the others, indicates too that the ruler was merely carrying out the wishes of the gods in constructing his canals." (p. 75) Even secular activities were tied to religion. Gruber (1948, p. 75) says, "The particular emphasis on land as property and the necessity for continued productivity may explain the ruler's secular interest in the maintenance of the canals, both as means of irrigation and land delimitation, an interest which was always and inevitably linked to his religious duties in this respect." It must be noted that large-scale irrigation comes at a later stage in the development of Neolithic agriculture than at the stage of its incipience.

[8] A recent summary of the literature on religion and prosociality is Tsang et al (2021).

There is some contemporary evidence, too, that religion aids agricultural investment. Decker et al (2014) studied this for the Great Plains region of the U.S. at the turn of the 20th century. They found that counties with higher concentrations of religious people exhibited higher growth rates in land-improvement investments. Th authors attribute this to the higher levels of social capital associated with religious counties. More generally, based on experimental and interview evidence from Catholicism and Islam, Warner et al (2015) find religious communities provide club and public goods through their theological beliefs.

The hypothesis of Cauvin (2000/1994) would also explain why humans gave up hunting and gathering and settled into a sedentary agricultural life in spite of its many drawbacks, though it undoubtedly had obvious advantages. Agriculture was accompanied by soil erosion, disease hazards like epidemics, and general health problems associated with a more sedentary lifestyle. Even the brain size of humans, as measured by the cranial capacity, declined after the adoption of agriculture [Gowdy (2021, Ch. 4)]. [9] An ideological change could plausibly have helped the adoption of agriculture by downplaying these disadvantages. Abbo et al (2022, p. 93) claim, "Cauvin emphasized that ideology preceded economy; since food production was an antithesis of the hunter-gatherers' ethos, without the ideological-perceptual developments that allowed hunter-gatherers to change their attitude towards nature and the world, the Agricultural Revolution could not have transpired."

The archaeological excavations offer more than suggestive evidence for the implication of primitive forms of religion in the emergence of agriculture. Could this be consistent with an economic model that incorporates a role for religion in the Neolithic Revolution? That is a question investigated in the next section.

3. The Model

In this section, I offer a model of how religion plausibly could have jump-started the development of Neolithic agriculture. The model here borrows some aspects from Eswaran (2023), though the focus and the core questions here are very different.

[9] Jarred Diamond (1987) referred to the Neolithic Revolution as "the worst mistake in the history of the human race." Harari (2015, Ch. 5) offers a plausible story of how this came about.

3.1 The Basic Setup

Consider a group of pre-Neolithic sedentary foragers who may be on the verge of embarking on agriculture. Suppose there are *n* people in the group, each with 1 unit of privately-owned land for horticulture and, later, agriculture and 1 unit of time. This assumption of private ownership of land is convenient and it fits in well with the hypothesis of Bowles and Choi (2019), who argued that the Neolithic transition was accompanied by an institutional change from common to private property. agriculture Apart from land, labor is the only other input. We take the production function on a plot of size *h* to be given by

$$q = \bar{A} h^{1-\mu} t^{\mu}, \tag{1}$$

where *q* denotes food output from foraging, *t* is the amount of effort applied (in terms of time), $\bar{A}$ is the total factor productivity of the foraging technology, and where $0 < \mu < 1$.

I posit that the utility of an individual depends on three goods: food, a cultural good, and leisure. The introduction of a cultural good needs some elaboration. In all societies, culture is the implicit background in which its members conduct their transactions. While we take culture as the unseen background in contemporary societies, in earlier societies cultures were explicitly recognized and deemed to be extremely important because it defined their way of life.[10] Culture defines the norms of accepted behavior, the myths about creation, stories about the group's history, etc. The maintenance of a group's culture and the passing on of the knowledge of these matters and of survival skills to children and grandchildren warrants effort. This requires the contribution of group members, and it is especially so for small groups or bands, which the hunter-gatherers are deemed to have belonged to. So, in our modeling, we have to explicitly incorporate the time devoted to cultural activities. Culture, however, is a public good among the members because it is collectively and freely consumed. Religious activities (if the group is religious) can constitute *one* important component of an individual member's contribution to culture as modeled here. If it were the only component of interest, it would be the club good of Iannaccone (1992).

For tractability, the utility function, U_i, of individual *i* is taken to be of the Cobb-Douglas form:

$$U_i = {c_i}^{\alpha} P^{\beta} {\ell_i}^{\gamma}, \tag{2}$$

[10] For a discussion of its importance to the Indigenous peoples of North America, for example, see Eswaran (2023).

where c denotes individual food consumption, P the amount of cultural good, and ℓ_i is the amount of leisure. All the exponents are assumed to be positive fractions, with $0 < \alpha < 1, 0 < \beta < 1, 0 < \gamma < 1, \alpha + \beta + \gamma < 1$ to ensure diminishing marginal utility to each good. An individual's food consumption is given by the output from the privately owned 1 unit of land.

The cultural good, as noted, is jointly consumed by the group. In the light of the discussion in the previous section, this would include the teaching of children and grandchildren, common rituals, feasting, etc. Given its public good nature, we write $P = p_1 + p_2 + \cdots + p_n$, where $p_i, i = 1,2, \ldots n$, denotes the total contribution to P of individual *i.*

I assume that all individuals entertain Nash conjectures in their decision making. In this case, individual *i* solves the problem

$$\max_{t_i, p_i} \quad (\bar{A}h^{1-\mu}t_i^{\mu})^{\alpha}(p_1 + p_2 + \cdots + p_n)^{\beta}(1 - t_i - p_i)^{\gamma}, \tag{3}$$

where (1) has been substituted for food consumption and from the time constraint the leisure of the individual has been written as $\ell_i = 1 - t_i - p_i$. However, I shall not present the solution to the group's choices here because this obtains readily as a special case of the solution to the version of the model that follows next.

3.2 Introducing Agriculture

Now consider the possibility of introducing agriculture. This requires work like forest clearance, land preparation, ensuring (small-scale) irrigation, building levees, digging wells and reservoirs, resolving conflicts over water, etc., which are all in the nature of public goods. Suppose that the aggregate effort of the group towards this end is denoted by *S*, the total factor productivity of the agriculture, denoted by the function $A(S)$, that replaces the earlier technology is given by the simple form

$$A(S) = A_0 S^{\delta}, \tag{4}$$

where the parameter δ (with $\delta > 0$) captures the efficacy of effort applied to the agricultural public good. Alternatively, δ is an inverse measure of the extent of diminishing returns to

aggregate agricultural investment effort, that is, δ is a measure of scale economies in agricultural investment effort. The magnitude of δ will determine how much effort individuals will divert from those devoted to farming, to the cultural good, and to leisure. If s_i is the effort applied to this investment by individual *i*, we may write $S = s_1 + s_2 \ldots s_n$. It is assumed that $A_0 n^{\delta} >> \bar{A}$, that is, if all group members applied their 1 unit of time to improving agricultural productivity the land productivity in agriculture would greatly exceed that in foraging.

Thus far, the model laid out so far may be deemed the basic setup. I now examine the equilibrium in this setup by considering, in succession, two variants suggested by the fact that Neolithic religions, as are many religions of today, were club goods. The first variant considers effort applied to the public good of agricultural investment is viewed at least partly as a *religious* activity and, hence, contributes to the cultural good consumed by the group. The second variant considers the effects of social bonding stemming from religion.

I. The Non-Altruistic Case

Suppose that, of the time s_i applied by individual *i* towards the irrigation project, a fraction πs_i is perceived as contributing to the religious club good. Part of the effort applied to the collective agricultural investment, then, does double duty as a contribution also to the cultural good. Thus, the total contribution of individual *i* to the cultural good may be written as $p_i = \pi s_i + g_i$, where g_i is the component of *i*'s cultural contribution that is *unrelated* to agricultural investment.

Consider, first, the scenario where each individual is egoistic and only considers their own wellbeing. I assume for ease of comparison that the production function with agriculture retains the form in (1). Since each individual is assumed to have 1 unit of land, we can set $h = 1$. The maximization problem (3) of this individual now becomes

$$(5) \qquad \max_{s_i, t_i, g_i} \quad U_i \equiv (A(S) t_i^{\mu})^{\alpha} (\pi s_1 + g_1 + \pi s_2 + g_2 \ldots \pi s_n + g_n)^{\beta} (1 - s_i - t_i - g_i)^{\gamma},$$

Assume that individuals in the group make their choices in Nash fashion. Assuming cooperative behavior will only strengthen the results obtained here, so the assumption of Nash behavior rigs the case against the role of religion modeled here. I dub the outcome here as the "Non-Altruistic Nash Equilibrium," because individuals are deemed to maximize their egoistic utility functions

only. The focus is on the symmetric equilibrium, in which all individuals end up setting the same values for their choice variables. The common choice variables in this symmetric equilibrium are denoted by the quartet $\{s^{\dagger}, t^{\dagger}, g^{\dagger}, \ell^{\dagger}\}$, and expressions for them in closed form are derived in the Appendix. The solution for the Non-Altruistic Nash equilibrium is given by

(6.a) $$s^{\dagger} = \frac{\alpha\delta}{(1-\pi)(\beta+n\gamma+\alpha\delta+n\alpha\mu)}; \quad g^{\dagger} = \frac{\beta(1-\pi)-\alpha\pi\delta}{(1-\pi)(\beta+n\gamma+\alpha\delta+n\alpha\mu)};$$

(6.b) $$t^{\dagger} = \frac{n\alpha\mu}{\beta+\alpha\delta+n(\gamma+\alpha\mu)}; \qquad \ell^{\dagger} = \frac{n\gamma}{\beta+\alpha\delta+n(\gamma+\alpha\mu)}.$$

The total equilibrium contribution of a group member to the cultural public good, $p^{\dagger} \equiv \pi s^{\dagger} + g^{\dagger}$, is given by

(7) $$p^{\dagger} = \frac{\beta}{\beta+\alpha\delta+n(\gamma+\alpha\mu)}.$$

Setting π=0 in these expressions will yield the Nash equilibrium values when irrigational activity is not deemed at all to be imbued with religious motivation, that is, when this activity is conceived of as a purely secular public good.

From the second expression in (6.a), we see that the individual's cultural contribution that is unrelated to their agricultural investment, $g^{\dagger}$, is positive only when

(8) $$\delta < \beta(1-\pi)/(\alpha\pi),$$

where the right-hand side of the above inequality is the critical value of scale economies in irrigation activity beyond which the non-religious cultural contribution, $g^{\dagger}$, becomes zero.

Why is a positive value of $g^{\dagger}$ not assured? This occurs because, when $\pi > 0$, part of agricultural investment activity, $\pi s^{\dagger}$, and $g^{\dagger}$ are perfect substitutes in their contributions to the cultural public good, as modeled here. When $s^{\dagger}$ increases in response to greater scale economies in agricultural investment, $g^{\dagger}$ starts getting crowded out in equilibrium. When δ exceeds the right-hand side of the inequality in (8), $g^{\dagger}$ is zero. Note that as π approaches its upper limit of 1 (that is, all of investment effort is deemed to be devoted to a sacred religious good), the smaller is the critical value of δ beyond which the non-religious cultural contribution is completely crowded out.

The following Proposition is easily derived by differentiating the solution in (6.a) and (6.b) with respect to the relevant parameters.

Proposition 1: When $\delta < \beta(1-\pi)/(\alpha\pi)$, a group member's

(a) investment effort in the Non-Altruistic Nash Equilibrium is (i) increasing in δ, and (ii) increasing in π, and

(b) farming effort, the total public contribution to the cultural good, and leisure are decreasing in δ.

Part (a) of the above proposition is straightforward: (*i*) when agricultural investment effort is more efficacious due to greater scale economies, more investment effort is elicited, drawing down the effort in farming, the cultural good, and leisure. And (*ii*), formalizes the above discussion on the role of religion as a club good promoting agricultural investment. This is one route through which Neolithic religion could have facilitated the transition from foraging to agriculture. Part (b) tells us that farming effort, $t^{\dagger}$, the individual total contribution to the cultural good, $p^{\dagger} \equiv \pi s^{\dagger} + g^{\dagger}$, and leisure, $\ell^{\dagger}$, are all declining in δ and in π; time is diverted from all its other uses into agricultural investment.

When (8) is violated and $g^{\dagger} = 0$, the optimization problem (5) must be recast as

$$\max_{s_i, t_i} \quad (A(S){t_i}^{\mu})^{\alpha}(\pi s_1 + \pi s_2 \ldots + \pi s_n)^{\beta}(1 - s_i - t_i)^{\gamma}. \tag{9}$$

The solution to (9), denoted by the triplet $\{s_1^{\dagger}, t_1^{\dagger}, \ell_1^{\dagger}\}$, follows from mimicking the steps shown in the Appendix to obtain the solution to (4) as:

$$s_1^{\dagger} = \frac{\beta+\alpha\delta}{\beta+\alpha\delta+n(\gamma+\alpha\mu)}; \quad t_1^{\dagger} = \frac{n\alpha\mu}{\beta+\alpha\delta+n(\gamma+\alpha\mu)}; \quad \ell_1^{\dagger} = \frac{n\gamma}{\beta+\alpha\delta+n(\gamma+\alpha\mu)}. \tag{10}$$

Note that this solution is independent of π. This is due to the Cobb-Douglas utility function; π occurs as a scale factor that does not affect the marginal conditions—and, hence, the solution—but it certainly affects the equilibrium utility. The total contribution of a group member to the cultural public good is now given simply by $p_1^{\dagger} \equiv \pi s_1^{\dagger}$.

We can now inquire how the endogenous total factor productivity in agriculture compares with that in foraging to see when a switch to agriculture would occur. [11] To make this comparison, recall that the total factor productivity in foraging/horticulture was denoted by $\bar{A}$. Assume that (8) is satisfied, so that (6.a) and (6.b) characterize the relevant Non-Altruistic Nash equilibrium in agriculture. For the total factor productivity to match or exceed that in foraging, we must have

$$A_0(ns^\dagger)^\delta \geq \bar{A}. \tag{11}$$

We have seen from Proposition 1 (a) that $s^\dagger$ is increasing in δ and also in π. An increase in the efficacy of effort due to greater scale economies in agricultural investment, δ, would, at some point, enable inequality (11) to be met even when agricultural investment has no religious significance, that is, when $\pi = 0$. But when agricultural investment does have religious significance, agriculture would become a preferable option to foraging at even lower levels than this value of δ. In other words, religious orientation in the group reduces the demands on how efficacious agricultural investment has to be before the agricultural technology becomes a superior alternative to foraging.

Why is this? When an activity is imbued with religious sentiments, it acquires the trait of a religious club good that contributes to the group's cultural good. This allows members to economize on the time devoted to the non-religious cultural good. The time thus released enables more time to be devoted to agricultural investment. In effect, agricultural investment activity has a double-barreled effect: it raises agricultural productivity (a secular activity) and it also contributes to the cultural good when it is tinged with religious fervor. Given the manifest evidence of Neolithic religion/spirituality and the proclivity for building gigantic monuments, this analysis suggest that it is likely that religion contributed to the origin of agriculture. Even if farming was discovered accidentally, its spread to neighboring geographical areas that required investments like land clearance, irrigational channels, etc. would have been aided by religion.

The above discussion brings out the important point that the feasibility of the agricultural technology depends on whether the group is secular or religious. This is an insight that, I believe,

[11] Ideally, we should compare the equilibrium utilities in the two scenarios. But, since the expressions for these utilities is technically cumbersome, comparing productivities provides a handy short hand because the implications drawn from the comparisons are the same. Moreover, productivity was more germane to the switch; ex-post, utility in fact declined with agriculture, as noted earlier [Diamond (1987)].

would be generally true and not just for Neolithic societies. If a religious world view is sufficiently entrenched, our actions are colored by that view. To the extent that this motivation inspires actions, it can benefit the performance of activities that may otherwise be deemed secular. The Neolithic Revolution, I submit, is plausibly one such scenario. The economic model suggests that Cauvin's (2000/1994) hypothesis is very plausible.

II. The Altruistic Case

In Section 2, the literature review showed that there is evidence that collective rituals regularly performed creates bonds between the intra-group (as well as out-group member if the rituals are across groups). This is an additional and separate effect from the club good aspect of religion that was addressed above. This social bond across members will naturally induce other-regarding preferences, that is preferences that put some weight on the wellbeing of others. I capture this through a parameter θ, with $0 \leq \theta \leq 1$. An individual is assumed to put a weight of θ on the utility of every other individual in the group so that other-regrading preferences of individual *i* is now represented by the utility function V_i given by

$$V_i \equiv U_i + \theta \sum_{j \neq i} U_j, \tag{12}$$

where the egoistic utility function U_i is given by the objective function in (4). Individual *i* maximizes (12) with respect to s_i, t_i, g_i after setting $\ell_i = 1 - s_i - t_i - g_i$.

As before, assume Nash behavior in the choices of s_i, t_i, g_i and focus on the symmetric equilibrium. Call this the "Altruistic Nash equilibrium" and denote the solution presented in the Appendix by the quartet $\{\tilde{s}, \tilde{t}, \tilde{g}, \tilde{\ell}\}$. We see, again, that $\tilde{g} > 0$ only when (8) holds. When $\delta < \beta(1-\pi)/(\alpha\pi)$, the solution is given by

$$\tilde{s} = \frac{\alpha\delta\rho}{(1-\pi)(\beta\rho+\alpha\delta\rho+n(\gamma+\alpha\mu))}; \quad \tilde{g} = \frac{(\beta(1-\pi)-\alpha\pi\delta)\rho}{(1-\pi)(\beta\rho+\alpha\delta\rho+n(\gamma+\alpha\mu))}; \tag{13.a}$$

$$\tilde{t} = \frac{n\alpha\mu}{\beta\rho+\alpha\delta\rho+n(\gamma+\alpha\mu)}; \qquad \tilde{\ell} = \frac{n\gamma}{\beta\rho+\alpha\delta\rho+n(\gamma+\alpha\mu)}, \tag{13.b}$$

where $\rho = 1 + (n-1)\theta$.

A member's total equilibrium contribution to the cultural public good, $\tilde{p} \equiv \pi\tilde{s} + \tilde{g}$, is given by

(14) $$\tilde{p} = \frac{\beta\rho}{(\beta\rho+\alpha\delta\rho+n(\gamma+\alpha\mu)}.$$

The analogue of the previous proposition for this case is readily derived by differentiating the solution in (13.a) and (13.b) with respect to the relevant parameters.

Proposition 2: When $\delta < \beta(1-\pi)/(\alpha\pi)$, a group member's

(a) investment effort in the Altruistic Nash Equilibrium is (i) increasing in δ, (ii) increasing in π, (iii) increasing in θ, and

(b) farming effort, the total contribution to the public good, and leisure are decreasing in δ, and

(c) the total contribution to agricultural investment and to the cultural public good is increasing in θ, and leisure is decreasing in θ.

Only the results pertaining to θ are commented on here, to avoid repetition. When altruism towards fellow group members increases, a group member exerts more investment effort because the benefit to other group members this effort is given more weight when θ is higher. For the same reason, the aggregate contributions of an individual to public agricultural investment and the cultural public good increase in θ. An individual also sacrifices more leisure for others' benefit when θ increases.

When (8) is violated, the explicit contribution to the cultural good falls to zero, that is, $\tilde{g} = 0$. In this case, individual *i* maximizes (12) with respect to s_i, t_i, after setting $\ell_i = 1 - s_i - t_i$. The Altruistic Nash equilibrium, denoted by the triplet $\{\tilde{s}_1, \tilde{t}_1, \tilde{\ell}_1\}$, when is $\delta \geq \beta(1-\pi)/(\alpha\pi)$ is given by

(15) $$\tilde{s}_1 = \frac{(\beta+\alpha\delta)\rho}{(\beta+\alpha\delta)\rho+n(\gamma+\alpha\mu)}; \quad \tilde{t}_1 = \frac{n\alpha\mu}{(\beta+\alpha\delta)\rho+n(\gamma+\alpha\mu)}; \; \tilde{\ell}_1 = \frac{n\gamma}{(\beta+\alpha\delta)\rho+n(\gamma+\alpha\mu)}.$$

The total contribution of a group member to the cultural public good is $\tilde{p}_1 \equiv \pi\tilde{s}_1$. Again, note that this solution, as before, is independent of π. It is easy to verify that an increase in ρ increases investment effort and decreases farming effort and leisure. An increase in θ increase agricultural investment and the total contribution to the public good, while reducing leisure.

III. The Social Optimum

We may wonder how the Nash equilibria of the previous two scenarios compare with what a social planner would choose. Assume that the planner maximizes the Benthamite welfare function, *W*, which is the sum of the utilities of all group members. Since the planner treats all individuals alike, the time allocations of all members will be the same and such as to maximize

(16) $$W = \sum_i U_i.$$

The social optimum is easily derived by maximizing the utility of a typical member after setting each endogenous variable to a common value across all members of the group. But we can readily obtain it with one observation. If in (12) we were to set $\theta = 1$ (that is, each individual weights the utilities of all members on par with their own), the objective function in (12) reduces to that in (16). In other words, when everyone treats their neighbors as themselves, each member would each be maximizing the social welfare function *W*. Therefore, we could obtain the social optimum by simply setting $\theta = 1$ (in which case, $\rho = n$) in the Altruistic Nash equilibrium. The social optimum, denoted by $\{s^*, t^*, g^*, \ell^*\}$ when $\delta < \beta(1-\pi)/(\alpha\pi)$, is the given by

(17.a) $$s^* = \frac{\alpha\delta}{(1-\pi)(\beta+\alpha\delta+\gamma+\alpha\mu)}; \quad g^* = \frac{\beta(1-\pi)-\alpha\pi\delta}{(1-\pi)(\beta+\alpha\delta+\gamma+\alpha\mu)};$$

(17.b) $$t^* = \frac{\alpha\mu}{(\beta+\alpha\delta+\gamma+\alpha\mu)}; \qquad \tilde{\ell} = \frac{\gamma}{(\beta+\alpha\delta+\gamma+\alpha\mu)}.$$

The total contribution of a group member to the cultural public good, $p^* \equiv \pi s^* + g^*$, is given by

(18) $$p^* = \frac{\beta}{(1-\pi)(\beta+\alpha\delta+\gamma+\alpha\mu)}.$$

Note that even the social planner's solution depends on π because the planner respects the group's religious preferences. It is readily seen that the planner's agricultural investment of a member increases in scale economies in agricultural investment, δ, and on extent to which agricultural invest is imbued with religious sentiments, π.

When $\delta \geq \beta(1-\pi)/(\alpha\pi)$, the planner sets $g = 0$ and the optimum $\{s_1^*, t_1^*, \ell_1^*\}$ is given by

(19) $$s_1^* = \frac{\beta+\alpha\delta}{\beta+\alpha\delta+\gamma+\alpha\mu}; \quad t_1^* = \frac{\alpha\mu}{\beta+\alpha\delta+\gamma+\alpha\mu}; \quad \ell_1^* = \frac{\gamma}{\beta+\alpha\delta+\gamma+\alpha\mu},$$

and the total contribution of a member to the cultural public good is $p_1^* \equiv \pi s_1^*$.

IV. The Benchmark Case

How does religion contribute to agricultural investment relative to when there is no religion? The latter is the equilibrium we would obtain in standard neoclassical model in which preferences are purely egoistic and religion plays no role. We may refer to this benchmark case as the No-Religion, Non-Altruistic Nash equilibrium. This solution is easily obtained by setting $\pi = 0$ in the solution of Non-Altruistic Nash equilibrium or $\pi = 0, \theta = 0$ in that of the Altruistic Nash equilibrium. We may denote this solution by the quartet $\{s_0^\dagger, t_0^\dagger, g_0^\dagger, \ell_0^\dagger\}$. This No-Religion Non-Altruistic equilibrium is given by

(20.a) $$s_0^\dagger = \frac{\alpha\delta}{\beta+\alpha\delta+n(\gamma+\alpha\mu)}; \quad g_0^\dagger = \frac{\beta}{\beta+\alpha\delta+n(\gamma+\alpha\mu)};$$

(20.b) $$t_0^\dagger = \frac{n\alpha\mu}{\beta+\alpha\delta+n(\gamma+\alpha\mu)}; \quad \ell_0^\dagger = \frac{n\gamma}{\beta+\alpha\delta+n(\gamma+\alpha\mu)}.$$

Since religion is totally absent in this case, investment effort does not contribute to the cultural good and so the non-agricultural contribution to the cultural public good never vanishes for any $\delta > 0$, in contrast to the earlier cases with religion. The total contribution to the cultural public good, $p_0^\dagger \equiv \pi s_0^\dagger + g_0^\dagger$, is given by

(21) $$p_0^\dagger = \frac{\beta+\alpha\delta\pi}{\beta+\alpha\delta+n(\gamma+\alpha\mu)}.$$

3.3 Examination of the Potential Role of Religion in Agricultural Investment

We are now ready to compare the outcomes in the various scenarios we have considered in order to assess the effect of religion. The following four cases are compared:

1. The equilibrium in the benchmark case with egoistic preferences and no religion (No-Religion Non-Altruistic Nash equilibrium)

2. The equilibrium with egoistic preferences but with religion (Non-Altruistic Nash equilibrium)

3. The equilibrium with altruistic preferences and with religion (Altruistic Nash equilibrium)

4. The social planner's optimum.

The first thing to do is to compare the magnitudes of the individual investment effort in agriculture in the four scenarios. This is done in the following proposition.

Proposition 3:

When $\pi > 0$ *(investment effort is imbued with some religious sentiment) and* $0 < \theta < 1$ *(there is some altruism), the following inequalities on agricultural investment hold:*

(22.a) $$s_0^\dagger < s^\dagger < \tilde{s} < s^* \quad for\ \delta < \beta(1-\pi)/(\alpha\pi),$$

(22.b) $$s_0^\dagger < s_1^\dagger < \tilde{s}_1 < s_1^* \quad for\ \delta \geq \beta(1-\pi)/(\alpha\pi).$$

In terms of investment effort applied to agriculture, the No-Religion Non-Altruistic Nash equilibrium is dominated by the Non-Altruistic Nash equilibrium, which in turn is dominated by the Altruistic Nash equilibrium. Even the last equilibrium, however, falls short of the social optimum.

We can explicitly see how the first aspect of religion discussed earlier, namely, activity imbued with religious sentiment, makes a difference. Figure 1 displays how the investment effort of an individual varies with the extent to which investment effort is imbued with religious motivation, π. The four cases listed above and considered in Proposition 3 are shown in order by the schedules AB, ACD, AEF, and AGH, respectively. The latter three schedules are increasing in π as long as (8) is satisfied, that is, over the range $\pi < \beta/(\beta + \alpha\delta)$, which is represented by the distance OI along the abscissa. For π over the range $[\beta/(\beta + \alpha\delta)\ ,1]$, the segments are flat as we have seen because agricultural investment effort becomes independent of π.

Fig. 1 brings home the potential role of religion in agricultural investments. Even the purely egoistic preferences of individuals whose investment is imbued with some religious motivation increases investment relative to the no-religion scenario (schedule ACD compared to AB). This is because investment activity contributed to the cultural public good, thereby enabling an individual to reduces their contribution to the latter. This releases time for more agricultural investment. When one accounts for the prosocial behavior induced by religion (schedule AEF), investment is seen to increases even more. This compounding of the effect of religion arises

because individuals recognize that their investment effort, being a public good, also benefits other group members for whom they care in this scenario.

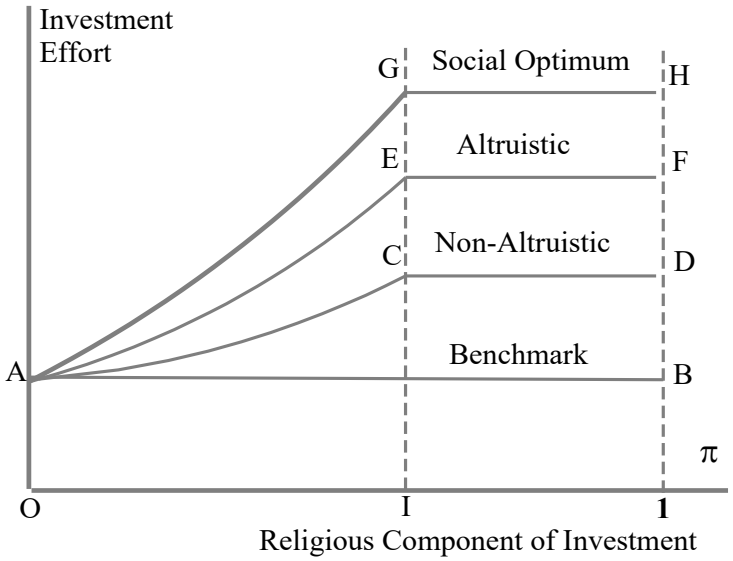

Figure 1: How religious orientation of effort affects the investment level.

A picture similar to Fig. 1 emerges when we examine how investment effort responds to the scale economies in agricultural investment, δ, in the various scenarios. This is illustrated in Fig. 2. In all cases, investment increases in a concave fashion in δ. When religion is relevant, there is a discontinuity in the slope at $\delta = \beta(1-\pi)/(\alpha\pi)$, and which is where exclusive cultural good contribution, g, becomes zero. This value of δ is shown as the distance OJ along the abscissa in Fig. 2. Once again, we see that religious orientation would have facilitated the uptake of agriculture during the Neolithic revolution.

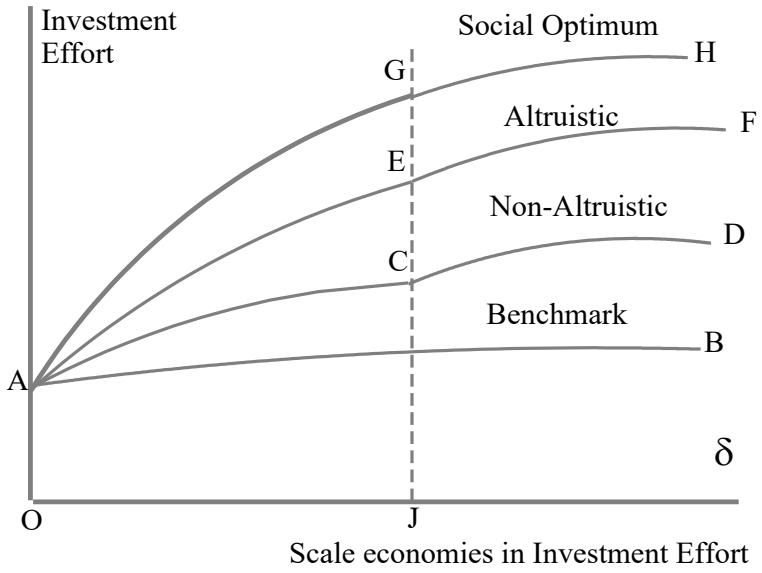

Figure 2: How scale economies in investment effort affects the investment level.

Neolithic megastructures like those found in Gobekli Tebe, we have seen, have been interpreted by archaeologists as places of ritual worship. As an explanation for the size, I suggest that they are meant to be a tribute to the reality revealed in their altered states of consciousness. In ecstatic or mystical states, the reality perceived tend to dwarf our visible universe and the massive structures may well have been statements of this vision. This strikes me as a more plausible explanation than one that suggests that the sizes of the structures were to deliberately weed out free-riders [e.g. Sterelny (2020)] as in standard club good model of religion. In any case, the fact that the groups could construct such megaliths bears witness to the fact that Neolithic groups were capable of massive collective effort and, therefore, religion could certainly have been capable of undertaking the investments needed to begin agriculture.

The theory offered here is consistent with the findings of Sosis (2000), who investigated the Utopian societies of America in the 19th Century. Using a sample of 200 Utopian communities, comprising religious and non-religious communes, he found that the former survived much longer than the latter. He suggests costly rituals that promote cooperation on collective action by weeding out free-riders as a possible reason but he suggests that there could be other theories that might predict the same result. The model I am presenting in this paper proposes precisely one such an alternative. The model here acknowledges free-riding but does not explicitly model the monitoring of it. The reason for the greater stability of religious communes here is that religious

zeal by itself, and social bonding it induces, are counterpoises against free-riding. As far as I am aware, this is the first formal theoretical model that explains the greater robustness of religious groups compared to non-religious ones, without relying entirely on verbal arguments.

Very large-scale investments in agriculture, like those illustrated by Allen, Bertazzini, and Heldrig (2023), may have been aided by religion but needed the formation of states to bring to fruition. This issue is examined in the next section.

4. How Might Religion have Aided the Creation of Ancient States?

There are several theories on the origins of ancient states [Claessen and Skalnik (1978), Allen (1997)].[12] Among them are theories that tie the emergence of the state to the advent of agriculture with large scale irrigation. A pioneering theory is that of Wittfogel (1957), who argued that the state was created in order to make the transition to agriculture with irrigation with massive infrastructure that warrants cooperation among a large number of people, the division of labor, and coordination of their various activities. He called this "hydraulic" agriculture in order to distinguish it from agriculture that requires only a modest amount of irrigation (of the sort that we considered in the previous section). Wittfogel attributed the need for effecting this cooperation and coordination as the cause of the formation of the state in his "hydraulic" hypothesis. Among the various theories of the origin of the state, this is the one that is best attuned to embodying the theory in this paper, though others are not excluded.

Borcan, Olsson, and Putterman (2021) examined the chronological appearance of agriculture and the emergence of the state on a global scale. The authors found a strong correlation between the two. The average lag between the two was over 3 millennia when states were internally generated (less if it is externally imposed). Appearance of agriculture one millennium earlier predicted, in their analysis, the appearance of the first state 317-430 years earlier. Mayshar, Moav, and Pascali (2022), using several data sets covering many millennia, showed that it is not agriculture per se but the cultivation of cereals that generated complex hierarchies (which are characteristic of states). This is because cereals are durable, capable of storage, and so are

[12] For a theory involving several factors, see Benati and Guerriero (2022).

amenable to appropriation by non-farming classes. Nevertheless, agriculture was in existence for around four millennia before the first states appeared [Scott (2017)].

Among the economic approaches to the theory of state origins, the theories fall into two rough categories of rationales: cooperation and extraction (see Allen, Bertazzini, and Heldrig (2023) for a succinct summary). Those in the former group emphasize the importance of cooperation and coordination of activities to accomplish what is good for society, Rousseau (1948/1762) being an early proponent of this view. The other is that special interests form a state to exploit the rest of the population [Engels (1996/1878), Carneiro, R. L. (1970)]. Allen, Bertazzini, and Heldrig (2023) recently gave compelling evidence for the cooperative theory of state formation. Relying on exogenous shifts from 5,000 BCE in the course of rivers in southern Iraq that warrant public irrigation schemes, they showed that states formed to provide the service in the settlements that remained in place as opposed to new locations closer to the river. (The extraction theory would predict state formation would occur at the new locations in order to extract rents.)[13]

What I propose below on the possible contribution of religion to state formation based on my model of agriculture and one that emphasizes cooperation, therefore, is consistent with the empirical reality. The model presented in the previous section shows that religion results in agricultural investment that exceeds what would obtain under a purely egoistic orientation of a group's members. Although members were modeled to behave in Nash fashion, religion induces some cooperation between them because it changes preferences of each member to put some weight on the wellbeing of other members. Even so, the Altruistic Nash equilibrium outcome generally falls short of the social optimum except in the unrealistic scenario where each member treats all the "others as themselves". Therefore, we expect that there will be gap between an individual member's agricultural investment effort in the social optimum and the Altruistic Nash equilibrium. This implies that there may be some agricultural technologies that would be adopted in the social optimum but would not be in the Altruistic Nash equilibrium.

[13] If the rivers deviate too far from their original courses, even the social planner may find relocation to be optimal and so the society in the original location will vanish. Danino (2010) has put forward the intriguing hypothesis that the Indus Valley Civilization (which was located in present-day Pakistan and North West India between the period 3,300 to 1,300 BCE) vanished because the course of the sustaining river Saraswati and its tributaries dramatically changed course due to tectonic shifts in the Himalayas. See Drew. (2021) for an excellent summary of Danino's argument.

The gap alluded to above is given by $s^* - \tilde{s}$, where s^* is given by (17.a) and $\tilde{s}$ and (13.a). In the Appendix the following result is shown.

Proposition 4: When $\pi < \beta/(\beta + \alpha\delta)$ *and* $0 < \theta < 1$*, an increase in the religious content of agricultural investment,* π*, increases the gap* $s^* - \tilde{s}$ *between the socially optimum investment and the one in the Altruistic Nash equilibrium* if $\theta < 1$*. When* $\pi \geq \beta/(\beta + \alpha\delta)$*, this gap is independent of* π*.*

Both the equilibrium investment and the socially optimal investment depend on the society's religious orientation, π. Even though agricultural investment increases in both outcomes with π, it increases by more in the social optimum. This is because, in the realistic case where $\theta < 1$ (that is, group members do not fully treat their neighbors as themselves), each member's objective falls short of the Benthamite welfare function. Thus, there is scope for moral hazard and the agricultural investment in the equilibrium falls even more short of the social optimum.

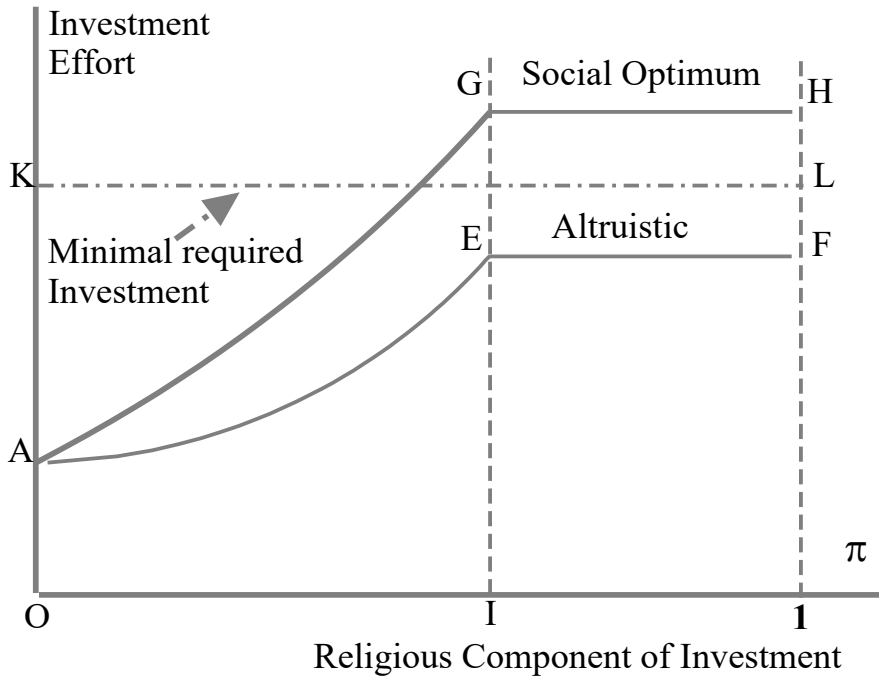

Figure 3: Illustrates the incentive to form a state.

Suppose that the minimal investment required for a massive irrigation project to be viable is shown by the distance OK along the ordinate in Figure 3. We can see that no amount of religious orientation would elicit the requisite investment in the Altruistic Nash equilibrium. However, as indicated in the Figure, the irrigation project would be viable in the social optimum. In the

absence of any religious orientation (that is $\pi = 0$), even the social optimum may fall short of OK. In situations like that shown in Figure 3, the group has an obvious incentive to form a state to mandate a socially optimal investment effort, a move that would be collectively beneficial because it internalizes the negative externality from moral hazard.

We might wonder what happens to the investment gap $s^* - \tilde{s}$ when the scale economy parameter δ increases. Unfortunately, it is not possible to analytically determine the answer. Nevertheless, it is always the case that agricultural investments in both scenarios (the equilibrium and the optimum) increase with δ and that the gap remains positive as long as $\theta < 1$. As a result, as the scale of agricultural investment increases (e.g. larger dams and reservoirs, lengthier irrigation canals, etc. are to be built), the social planner would likely be needed to implement them.

The scale of agricultural investment plausibly has something to do with the domestication of animals. There is a complementarity between plant and animal domestication in the Neolithic period, as there still is now in developing countries. Animals (especially goats, sheep, cattle, etc.) provided protein, hides, etc. in the diet and also supplied manure for plants. Importantly, oxen were also useful in agriculture for transport and providing power for ploughing the fields. Archaeological evidence suggests that cattle were domesticated in the Fertile Crescent between around 9,800 to 7,500 years before the present [Archbuckle et al (2016)]. This would be at least one millennium after plant domestication. Once oxen start getting employed in the fields, naturally more land could have been brought under cultivation, and the benefits of agricultural investment in irrigation would have exhibited higher scale economies. In other words, the use of animal traction in agriculture would have been positively correlated to the scale parameter, δ. If larger-scale agricultural investments are positively correlated with state formation, it would not be surprising that ancient states (partly aided by religion) were more likely in regions with animal traction. These are also the regions that would have been in more urgent need for coordination and cooperation. Foster (1981) cites archaeological evidence showing that only after autocratic governments and complex bureaucracies formed were large scale irrigation projects undertaken in ancient Sumeria (which was in southern Mesopotamia).

Complex bureaucracies and hierarchies are taken as empirical measures of the presence of states, as in Mayshar, Moav, and Pascali (2022). If this is the case, the model in my paper also suggests

another route through which religion probably aided the process of state formation. Religion by itself is known to generate hierarchies that introduce class distinctions and specify divisions of labor. Probably the best known and longest-lived is the institution of caste in India that has lasted at least three millennia. The caste system specified a rigid division of labor and the castes were ordered in a hierarchy [Dumont (1970)].[14] So if we gauge the existence of a state by the complexity of the bureaucracy that is present, it is conceivable that religion may be partly responsible for the appearance of states. Thus, the simultaneous appearance of complex hierarchies and large-scale irrigation could also correlate with the presence of religion. In fact, Mayshar, Moav, and Pascali (2022, p. 1138) tangentially allude to the possibility that their empirical findings on the positive correlation between the appearance of agriculture and state formation are consistent with the theory of Cauvin (2000/1994).

The literature on the ancient Near East, in fact, is rich in descriptions of how the state and religion were deeply intertwined [Jacobsen (1970), Pollock (1999), Gruber (1948)]. The relationship between religion and the state was one of two-way causation. On the one hand, religion was the motivator of secular activities of the state, in conformity with the logic spelled out above. On the other hand, the sovereign and the political leaders needed to borrow the credibility conferred by religion to exploit the general population [Postgate (1992)].[15] That politics hijacks religion is a point that is often emphasized and is something that occurs all too often in contemporary politics. But that is nor new; Hayden (2003, Ch. 11) gives an account of how this occurred in ancient states, too. What is less acknowledged, and one that has been the focus of this essay, is the ancient causality going from religion to secular actions in a benign manner. Given the compelling evidence by Allen, Bertazzini, and Heldrig (2023) for the cooperative theories of state formation against the exploitation theories, my theory provides a model for how this could have been instrumental in the Neolithic era.

Additional evidence is given by the existence of the so-called “temple economies” in ancient Mesopotamia. These existed in Mesopotamia before states formed and were conducting

[14] The religious origin of the caste system may have been quite benign, though it has had adverse consequences after it became entrenched (see Bidner and Eswaran (2015) on this).
[15] Norenzayan (2013) has argued the omniscient “Big Gods” who are capable of overseeing our smallest actions were conceived by humans because it was expedient for instilling moral values. Skaperdas and Vaidya (2020) have argued that it was politically expedient for sovereigns to promote Big Gods in pre-modern states because it reduced the cost of ruling. Grzymala-Busse (2020) reviews the importance of religion in the formation of modern European states.

essentially economic activities. The temples accumulated foodstuffs offered for sacrifices and stored excess grains for redistribution and acquiring other goods through trading. Makkay (1983, p. 2) states, "The continuous existence of sanctuaries and temples since the Early Neolithic thus afforded them a priority in economic matters over the state organization. This would imply that certain characteristic features of the temple economy must already have existed before the formation of the state." Writing (in the form known as cuneiform) is deemed to have arisen in Uruk (in Sumeria), which greatly facilitated administration and bureaucracy [Nissen et al (1993)].[16] The Temple of Uruk used writing for its records. Clearly, the states which arose subsequently would very likely have to liaise closely with temples; religion would have enabled the emergence of the states.

5. Concluding Remarks

With an economic model, this paper formally explores the question of whether religion could have triggered the Neolithic Revolution. The economic framework provided here supports this view that was first put forward by Cauvin (2000/1994). Religious orientation, I show, bolsters investment in public good agricultural projects in two ways. First, the activity inherently contributes to the club good aspect of religion that provides members with utility and, second, it induces more prosocial behavior that tempers free-riding in collective effort. The paper then argues that religion also very likely aided the emergence of states to provide investment in large-scale irrigation when decentralized effort fell short of what was required. The model and its predictions seem to be broadly consistent with the archaeological evidence that exists.

The model provided here, which draws on the idea of religion as a club good from Iannaccone (1992, 1994), shows how religious orientation can inform *secular* activities consciously, not as an unintended consequence.[17] A secular action that is imbued with religious belief economizes on resources by contributing to wellbeing in two different ways. First, it provides an input into

[16] More recent research indicates that writing may have evolved in several regions even earlier than in Sumeria [Lawler (2001)].

[17] There are several examples where religious orientations have resulted in beneficial secular actions but as unintended consequences. Martin Luther's insistence that Protestants should be literate so that they can read the Bible for themselves and the human capital it encouraged is one such example [Becker and Woessmann (2009)]. Fruehwirth, Iyer, and Zhang (2019) have demonstrated that religion is a causal buffer against depression in school children.

the secular activity and produces something that is valued (here it is an increase in agricultural productivity). Secondly, it simultaneously contributes to the religious club good that is of value in itself. This releases resources that can be used for secular (or religious) activities. The fact that the activity in itself contributes towards two different desirable goals tempers moral hazard in teams if one or both the goals entail team work. This is an insight on the secular benefit of religion that, as far as I am aware, has not been previously modeled explicitly in economic theory.

The role of religion as a club good is worth noting. If religious activity were modeled as a private good that generates only a private benefit to individuals, what would change? Strictly speaking, the qualitative nature of the comparative statics would still obtain but we would expect the quantitative aspect to be much weaker. This approach would miss the important fact that religion simultaneously two valuable inputs. The archaeological evidence on religious beliefs during the Neolithic period shows that these beliefs were obtained through collective rituals, which are known to bolster belief and create bonds between the humans. Positing religious beliefs as a private good would neither explain the strength of the beliefs nor generate the other-regarding preferences to facilitate collective action. The evidence points to collective action as essential for large-scale agriculture and the formation of the state. Therefore, it is important to model religion as a club good in the manner of Iannaccone (1992).

In an influential paper, Barro and McCleary (2003) unearthed the important empirical finding relevant for contemporary religions. They found that, for given church attendance levels, belief in hell, heaven, and life after death increased economic growth; in contrast, for given beliefs, church attendance decreased economic growth. The authors caution that the net effect of church attendance need not be negative because attendance may increase beliefs. The model in my paper may be seen as providing the micro-foundation for their conjecture, albeit in the Neolithic context. But the scope of this model is wider than the application here: in general, rituals and participation are seen to endogenously strengthen faith, which can be a powerful motivator in action.[18] In some sense, the distinction between secular and sacred actions is arbitrary because it is in the eye of the performer. Even the most mundane secular action can be rendered sacred by

[18] In a more recent religion that the Neolithic ones, consider the quote from the New Testament, "Show me your faith without your works, and I will show you my faith by my works." [*James2:18*] Likewise, in Hinduism adherents are urged to perform even their most mundane actions as an offering to Diety [e.g. *Bhagavad Gita 9:27*].

an attitude that it is being done to serve God. The model of this paper provides a way of formally articulating this view and, I believe, it may capture the essence of how pious actions can benefit a secular world.[19] This insight may be potentially a matter for serious public policy considerations.

In summary, this paper has shown the possibility of religion, through the actions it instigated, in effecting the transition from sedentary foraging to agriculture in permanent settlements. Religion could also plausibly have been a midwife aiding the birth of ancient states.

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[19] Of course, believers can also persuade themselves that even their most destructive actions are done in the service of God, as in the Crusades and in contemporary religious wars.

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APPENDIX

I. The Non-Altruistic Case

Instead of maximizing the objective function in (4), it is more convenient to maximize the logarithm of it, which is a monotonic function of the object function. Differentiating partially with respect to $s_i, t_i \; and \; g_i$ we obtain the respective first order conditions. The second order condition are satisfied by the assumed restrictions on the exponents of the utility function. After obtaining the first order conditions, we may invoke symmetry since all individuals are alike and set $s_i = s, t_i = t, and \; g_i = g$ for all i. The respective first order conditions then reduce to

(A1.a) $$\frac{\alpha\delta}{ns} + \frac{\beta\pi}{n(\pi s+g)} = \frac{\gamma}{1-s-t-g},$$

(A1.b) $$\frac{\alpha\mu}{t} = \frac{\gamma}{1-s-t-g},$$

(A1.c) $$\frac{\beta}{n(\pi s+g)} = \frac{\gamma}{1-s-t-g}.$$

In (A1.a) and (A1.c) it is assumed that the solution is interior, that is, $s > 0, t > 0, g > 0$. That s and t must necessarily be strictly positive follows from the fact they are essential: their marginal utility goes to infinity if they go to zero. Similarly, ℓ must be strictly positive. However, for reasons explained in the text, the quantity g need not always be strictly positive.

Solving (A1.a) – (A1.c), we obtain (6.a) and (6.b) in the text as the solution for the Non-Altruistic Nash equilibrium.

When inequality (8) is violated, $g = 0$ and the relevant maximization is given in (9) in the text. Mimicking the above steps, the first order conditions with respect to s and t are given by

(A2.a) $$\frac{\alpha\delta+\beta}{ns} = \frac{\gamma}{1-s-t-g},$$

(A2.b) $$\frac{\alpha\mu}{t} = \frac{\gamma}{1-s-t-g}.$$

Solving these, we obtain the solution given in (10) of the text.

II. The Altruistic Case

The problem here seems more complicated than the Non-Altruistic Case. However, after taking the first order conditions with respect to $s, t,$ and g (assumed positive), there is an enormous amount of simplification that obtains when we invoke symmetry. The respective first order condition for this case are given by

(A3.a) $$\frac{\alpha\delta\rho}{ns} + \frac{\beta\pi\rho}{n(\pi s+g)} = \frac{\gamma}{1-s-t-g},$$

(A3.b) $$\frac{\alpha\mu}{t} = \frac{\gamma}{1-s-t-g},$$

(A3.c) $$\frac{\beta\rho}{n(\pi s+g)} = \frac{\gamma}{1-s-t-g},$$

where $\rho = 1 + (n-1)\theta$. Solving these, we obtain the solution given in (13.a) and (13.b) in the text.

When inequality (8) is violated, $g = 0$ and the first order conditions with respect to s and t are

(A4.a) $$\frac{(\alpha\delta+\beta)\rho}{ns} = \frac{\gamma}{1-s-t-g},$$

(A4.b) $$\frac{\alpha\mu}{t} = \frac{\gamma}{1-s-t-g}.$$

Solving these we obtain the solution given in (15) of the text.

Proof of Proposition 4

(a) When $\pi < \beta/(\beta + \alpha\delta)$, we have from (17a) and (13a) respectively that

$$\frac{ds^*}{d\pi} = \frac{\alpha\delta}{(1-\pi)^2(\beta+\alpha\delta+\gamma+\alpha\mu)} \text{ and } \frac{d\tilde{s}}{d\pi} = \frac{\alpha\delta\rho}{(1-\pi)^2(\beta\rho+\alpha\delta\rho+n(\gamma+\alpha\mu))},$$

so that

$$\frac{d(s^*-\tilde{s})}{d\pi} = \frac{\alpha\delta}{(1-\pi)^2}\left\{\frac{1}{\beta+\alpha\delta+\gamma+\alpha\mu} - \frac{\rho}{\beta\rho+\alpha\delta\rho+n(\gamma+\alpha\mu)}\right\}.$$

Since $\rho < n$ when $\theta < 1$, it follows that the term in the braces is positive, and thus that

(A5) $$\frac{d(s^*-\tilde{s})}{d\pi} > 0.$$

When $\pi \geq \beta/(\beta + \alpha\delta)$, this derivative is zero because both s^* and $\tilde{s}$ are independent of π.