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October 2016

No: 1129

Warwick Economics Research Papers

ISSN 2059-4283 (online)

ISSN 0083-7350 (print)

Geography, Transparency and Institutions*

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April 17, 2016

Abstract

We propose a theory by which geographic attributes explain cross-regional institutional differences in: (1) the scale of the state, (2) the distribution of power within state hierarchy, and (3) property rights over land. The mechanism that underlies our theory concerns the state's extractive capacity. In particular, we argue that the ability to appropriate revenue from the farming sector is affected by the transparency of farming which, in turn, is affected by geography and technology. We apply the theory to explain the differences between the institutions of Ancient Egypt, Southern Mesopotamia and Northern Mesopotamia.

KEYWORDS: *Geography, Transparency, Institutions, Land Tenure, State Capacity, State Concentration*

JEL CLASSIFICATION NUMBERS: *D02, D82, H10, O43*

*We have benefited from comments from Daron Acemoglu, Bob Allen, Josh Angrist, Ernesto Dal Bo, Eddie Dekel, Diana Egerton-Warburton, Christopher Eyre, James Fenske, Oded Galor, Maitreesh Ghatak, Jeremy Greenwood, James Malcomson, Andrea Matranga, Jacob Metzger, Stelios Michalopoulos, Motty Perry, Torsten Persson, Herakles Polemarchakis, Louis Putterman, Debraj Ray, Ariel Rubinstein, Yona Rubinstein, Larry Samuelson, Matthew Spigelman, Yannay Spitzer, Nathan Sussman, Juuso Valimaki, Joachim Voth, David Weil, and from comments from participants in various seminars and conferences.

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1 Introduction

Following North (1981), recent theories about the success of nations give a paramount role to the protection of property rights. Acemoglu and Robinson (2012) argue that the greatest detriment to economic prosperity is the presence of extractive institutions that compromise property rights. Ancient Egypt, however, had a prosperous civilization, built the great pyramids and was stable over several millennia, in spite of having an extractive government and no land property rights for its peasant farmers.

We propose that North’s thesis about property rights pertains to post-agricultural societies, where private capital accumulation assumes a paramount role, but is less relevant for understanding agricultural societies where land is the main capital asset. This calls for an alternative theory to explain the success of some nations in the preindustrial world and the failure of others.¹ In this paper, we seek to explain variations within pre-modern farming societies in: the scale of the state; the relative power of the center versus the periphery; and the land tenure regime, including land property rights. Unlike Acemoglu and Robinson (2012), who argue that institutions are by and large determined by the vagaries of human history, we propose a mechanism that explains how differences in institutions are the result of differences in geography and technology.

Our basic argument is that the distinguishing factor between the institutions of earlier states was the government’s ability to appropriate revenue from the farming sector, and that this ability was determined primarily by the transparency of production, which, in turn, is affected by geographical and technological conditions. In a nutshell, we attribute the power and resilience of Ancient Egypt’s central government, the relative weakness of its regional centers, and the peasantry’s non-ownership of land, to the fact that its farming activity was highly transparent, and thus appropriable.² From this perspective, Egypt is a polar case. Low transparency, on the other hand, explains the presence of owner-occupied farming and the relative weakness of the center in ancient Northern Mesopotamia.

We focus on the ancient states of the Near East because these were pristine cases of societies under relatively stable economic and military conditions, prior to the emergence of monetized taxation and military innovations. We believe, however, that our theory about

¹For brevity, we consider all pre-modern state societies to have been ones in which agriculture served as the primary basis for taxation, even if this is not fully correct.

²We thus employ the term “transparency” in reference to production, rather than to government. In a somewhat analogous approach, Stasavage (2010) explains how the compact geographic span of small pre-modern European city-states rendered their governments more transparent, had a positive impact on their ability to obtain resources via taxes or credit, and thus enabled them to withstand aggression by larger states.

the key role played by the tax technology provides an important insight for understanding all pre-modern, agriculture-based states.³ Moreover, it makes at least two contributions to understanding some modern phenomena. First, since social institutions exhibit much inertia, our explanation of earlier institutions can improve our understanding of current ones. And to the extent that institutions impact the prosperity of nations, it can help us understand the deep rooted factors that account for the current variation in the wealth of nations.⁴ Secondly, our transparency theory formalizes a key scholarly argument that attributes the unprecedented increase in the relative scale of government in the past century to a decline in the cost of collecting taxes. The claim is that the shift away from self-employment in agriculture into production by hired labor transformed the capacity to tax, since it was accompanied by a paper trail that rendered private production much more transparent to the modern state and facilitated income taxation.⁵ In this sense our main claim that the state's tax capacity was transformed by the increased transparency of production reveals an analogy between the long-term effects of the Agricultural Revolution in antiquity and the modern Industrial Revolution.

Our research agenda touches on a wide body of literature. To better understand our contribution we postpone the literature survey to section 4, following the presentation of our theory in section 2, and its application to the specific case of the civilizations of antiquity in section 3.

Our theory is based on a variant of the conventional principal-agent paradigm.⁶ We incorporate three key features. First, our framework introduces variation in the extent of informational asymmetry between agents, representing tenant farmers/tax payers, and the principal, representing an absentee land-owner or the government. In particular, our main exogenous variable, representing the degree of transparency of farming, is the accuracy of a signal that the principal observes with regard to the state of nature, from which she attempts to infer (with some error) whether the agent worked diligently or not. Second, we limit the incentive scheme that is available to the principal by assuming that in addition to remuneration (carrot), the only feasible sanction (stick) is the threat of dismissal upon suspected shirking, and that dismissal is costly also for the principal.⁷ In the spirit of Shapiro and Stiglitz's (1984) "efficiency wages" theory of employment contracts, this implies

³The notion of a 'tax technology' was proposed by Mayshar (1991).

⁴See Bockstette, Chanda and Putterman (2002) and Spolaore and Wacziarg (2013).

⁵See Kau and Rubin (1981) and Kleven, Kreiner and Saez (2015).

⁶In treating institutions as endogenous and in employing a formal game theoretic model for explaining historical institutions, we follow the lead of Greif (2006).

⁷Our assumption that the sanction is in the form of a threat of eviction is consistent with the literature on tenancy contracts (e.g. Banerjee and Ghatak, 2004).

that unlike the standard applications of the principal-agent framework, the agent's outcome is not pinned down to his outside option.⁸ Third, to make the threat of dismissal meaningful, we embed the model in a multi-period setting.

The model's results are fairly intuitive: the more accurate the signal, the smaller is the role of the carrot, the larger the role of the stick, and the larger is the state's revenue. Our interpretation of these results is that greater transparency induces a form of servitude, since the tenant is denied tenure and may be evicted upon suspected shirking. On the other hand, opacity results in the state allowing the agent to retain a larger share of the output, without any threat of dismissal.⁹

Consistently with North's (1981) depiction of the evolution of property rights in western societies since the Middle Ages, in our framework, property rights are in fact granted by an authoritarian government that seeks solely to maximize its revenue. In North's framework, the elite grants property rights to the non-elite to encourage private investment: property rights serve as a commitment device to overcome the hold-up problem of ex-post expropriation. In our framework, however, private investment plays no role. By focusing on the informational constraints that hinder the collection of taxes on output, our theory offers an alternative explanation for the emergence of property rights to land. When transparency is high enough, the threat of dismissal — an evident indication of the lack of property rights — serves as a prime motive for the agent to exert effort. But with sufficient opacity — when the cost of erroneous dismissal outweighs the benefits — the absolute, non-benevolent state willingly gives up the option to dismiss, thus granting farmers *de facto* title to the land they cultivate. That is, according to our theory, the extent of information asymmetry has an important role in explaining property rights to land.

⁸One might question why we do not allow for corporal punishment as an incentive device, as was common with slaves, since this is painful for the agent but plausibly imposes only minor costs on the principal. We do not attempt to resolve this puzzle here, but note that Chwe (1990) points out that corporal punishment is rare in labor relations, even though it is common for criminal offences. Moreover, in ancient Egypt and Mesopotamia, the peasants were almost invariably free tenants, rather than slaves, and slaves were not usually employed in agriculture (Dandamaev, 1984, p. 277) We surmise that this may be due to the fact that in the absence of the threat of dismissal, slaves (unlike tenants) require close ongoing supervision.

⁹In our model, the principal is assumed to observe output but not the state of nature or the agent's effort. In online Appendix A we present an alternative framework that delivers similar qualitative results, in which the principal does not observe output and the moral hazard problem pertains to hiding (or misreporting) output by the agent. In online Appendix B we examine an alternative modeling strategy to demonstrate that when the principal can elect costly monitoring to obtain a signal on the agent's effort, the principal will choose to monitor and to punish the agent upon suspected shirking only if the accuracy of the signal is sufficiently high and the cost of monitoring sufficiently low. Thus, as in the main model, opacity leads to property rights, whereas transparency of effort at a low cost leads to a form of servitude. Dari-Mattiacci (2013) provides a similar theory, based on information asymmetry, to explain slavery.

In a two-layered extension of the model, designed to explain variations in the extent of state centralization, we examine the role of different degrees of transparency at different levels of government hierarchy. We show that when farming activity is sufficiently transparent, not only locally to the intermediary (governor), but also globally to the upper level of the hierarchy (king), the intermediary retains a smaller share of the revenue and is subject to dismissal. On the other hand, if farming activity is sufficiently opaque to the king, the governor retains autonomy and a larger share of revenue. We contend that the success of early central states, such as ancient Egypt, was due to such high global transparency, which enabled the central authority to keep the subordinated lords at bay, and to extract a larger share of revenue from the periphery to the center.¹⁰ In contrast, the weak and fragmented structure of government in Northern Mesopotamia reflects the region’s low local and global transparency; while high local, but not global, transparency of farming in Southern Mesopotamia was manifested in strong local urban elites that retained their power in the face of repeated attempts to subjugate them to a unified central state.

2 Theory

2.1 The basic model

We consider a simple Principal-Agent model in which both the annual output produced by the agent and the agent’s choice of effort can be either low or high: $Y \in \{L, H\}$, and $e \in \{l, h\}$, respectively. The state of nature is also binary: either good or bad: $\theta \in \{G, B\}$. Output is a function of the effort exerted by the agent and the state of nature, whereby output is high if and only if the state of nature is good and the agent exerts high effort:

$$Y = \begin{cases} H & \text{if } e = h \text{ and } \theta = G; \\ L & \text{otherwise.} \end{cases}$$

The ex-ante probability that the state of nature is good is denoted by: $p \in (0, 1)$. The

¹⁰According to Ma (2011), the long-term success of Imperial China was similarly due to its ability to restrain the power of local officials. This was accomplished by the replacement of a hereditary feudal system with one based on rotating meritocratic bureaucracy. The effective denial of tenure to provincial bureaucrats served to overcome the local informational advantage that would otherwise enable them to gain independent power. Thus, whereas in Ancient Egypt (as we argue below), the lack of informational advantage to provincial officials was essentially due to the signals available directly to the Pharaoh, the denial of informational advantage to local Chinese officials was by design, through fundamental administrative innovations. Sng (2014) argues that the vast size of the Chinese Empire created inherent difficulties in supervising local intermediaries. The latter thus used their power to extort taxpayers, while the central state sought to keep the tax rates lower, to prevent revolts.

agent chooses the level of effort before he learns the state of nature.¹¹ After choosing the level of effort, both the agent and the principal observe a public signal about the state of nature: $\sigma \in \{g, b\}$. The accuracy of this signal, $q \in [0.5, 1]$ is such that:

$$Pr(g|G) = Pr(b|B) = q; Pr(g|B) = Pr(b|G) = 1 - q.$$

The accuracy level q represents the degree of transparency of production. If $q = 1$ then the signal perfectly reveals the state of the world (in this case, if $\sigma = g$ and $Y = L$, the principal can be certain that the agent shirked); if $q = 0.5$ then the signal is uninformative. We denote the annual cost (in units of output) of providing for the agent (and his family) until the next harvest period by $m + \gamma$, where $m \geq 0$ is the cost of subsistence in case the agent exerts low effort, and $\gamma > 0$ is the annual cost of exerting high effort. We assume that even low output is sufficient to cover the cost of upkeep of an agent who exerts high effort: $L \geq m + \gamma$. We assume also that $H > L + \gamma/p$. This implies that it is always desirable for the principal to incentivize the agent to exert effort.

Both the agent and the principal are assumed to be risk neutral. It is assumed that the agent's only alternative employment is as a domestic servant. We normalize his utility in this case to zero. The agent's annual utility as a tenant farmer equals his expected income, denoted by I , less the cost of subsistence and effort. Thus, the agent's annual utility if he exerts high and low effort is given by $I - (m + \gamma)$ and $I - m$, respectively. We assume that the agent has no other sources of income or wealth, and that he cannot save or borrow. The agent's intertemporal discount factor is denoted by $\delta \in (0, 1)$.

The principal's incentive scheme is such that if output is low, she pays the agent a basic wage ω . If output is high, she pays the agent $\omega + a$, where $a \geq 0$ is an added bonus. The basic wage ω must sustain an agent who exerts effort until the next harvest: $\omega \geq m + \gamma$. When output is high the principal retains the agent. The agent is also retained when output is low but the signal indicates that the state of nature is bad ($\sigma = b$). But if output is low and the signal indicates that the state of nature is good, the principal may dismiss the agent and replace him with another. For simplicity, we assume that the principal employs a non-probabilistic dismissal strategy, that is, the dismissal probability d satisfies: $d \in \{0, 1\}$.¹² If the agent is dismissed, then the principal incurs a fixed cost $x > 0$ that represents the

¹¹In practice, both the agent's effort and the relevant state of nature for agriculture are vectors whose components are distributed over the agricultural seasons.

¹²In online Appendix C we consider the case where the dismissal probability is unrestricted: $d \in [0, 1]$. In online Appendix D we consider an alternative extension, where the principal may warn the agent when he suspects him of shirking, and dismiss the agent only after an endogenously determined number of warnings. The qualitative results of the model regarding the effect of transparency q on the optimal contract are unchanged in both extensions.

cost of dismissing the previous agent and the present value of lost output for recruiting and training a new agent. We assume that the dismissal cost x is sufficiently high to preclude the possibility that the agent will be dismissed whenever output is low, irrespective of the signal. In particular, we assume that $x > \hat{x} = p\delta\gamma / (1 - \delta/2)(1 - p)$.

The contract strikes the optimal balance between the use of the carrot (a) and the stick (d). Since the principal is restricted to either dismissing the agent or not, only two types of contracts can be optimal. We refer to the contract where $d = 0$ as the ‘pure-carrot’ contract, and to the contract where $d = 1$ as the ‘stick-and-carrot’ contract, and denote this pair of contracts with subscripts c and s , respectively. Under the pure-carrot contract, the agent is never dismissed and is incentivized only through bonuses. Under the stick-and-carrot contract, the agent is dismissed whenever output is low but the signal is good ($Y = L, \sigma = g$), which occurs with probability $\mu = (1 - p)(1 - q)$.¹³

The principal thus has to choose $a \geq 0, \omega \geq m + \gamma$ and $d \in \{0, 1\}$ to maximize $\pi = p(H - a) + (1 - p)L - \mu dx - \omega$, subject to providing the agent with the incentive to exert effort. The following proposition describes how the optimal contract depends on the precision of the public signal q , that is, on the transparency of production.

Proposition. If $x > \hat{x}$, then the optimal contract that is selected by the principal has the following properties:

1. the agent’s basic wage is set at its lowest possible value, or $\omega = m + \gamma$.
2. There exists a threshold $\hat{q} \in (0.5, 1)$ such that:
 - if $q < \hat{q}$, then the optimal contract is a pure carrot contract: $d_c = 0$, and $a_c = \gamma/p$;
 - if $q > \hat{q}$, then the optimal contract is a stick and carrot’ contract: $d_s = 1$, and
$$a_s = \frac{\gamma}{p} \left(1 - \frac{pq\delta}{1 - \delta(p+q-2pq)} \right);$$
 - if $q = \hat{q}$, then both contracts above are optimal.

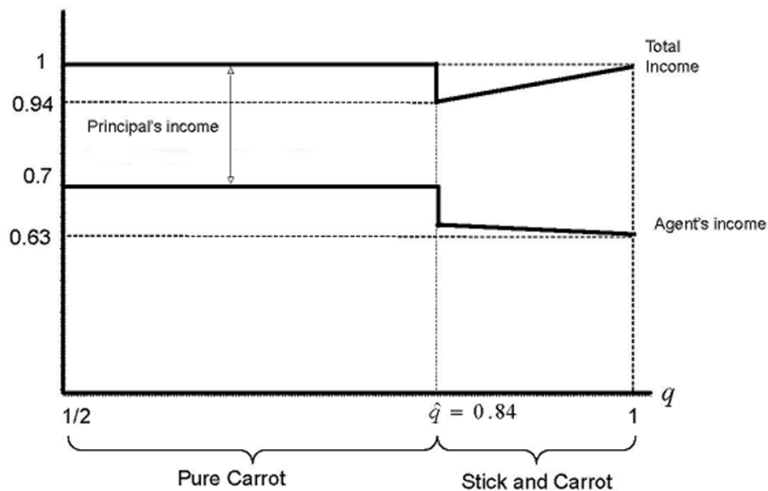
The proof of this proposition is provided in Appendix 1.

2.1.1 Discussion

We illustrate the results of this proposition in a graph (Figure 1) for a simple particular calibration. We set: $H = 1.1, L = 0.6$ and $p = 0.8$, so that a bad harvest with a significantly lower crop occurs about once every five years, and the expected crop size of each plot is

¹³One may argue that the principal may have an incentive to renege on the contract chosen, and to avoid paying the bonus to the agent, or to not dismiss the agent when this is called for by the contract. This is not a serious concern, however, if the principal is patient and faces many agents who are likely to believe that once the principal reneges, she will continue to do so in the future.

set to one: $E(Y) = pH + (1 - p)L = 1$.¹⁴ To be consistent with tenants' output share of about two thirds and with the relatively high cost of maintaining a family throughout the year, we set the subsistence cost to $m = 0.5$ and the effort cost to $\gamma = 0.1$, thus making the basic wage is $\omega = 0.6$. Given an interest rate (in grain) of one third, as was customary in the ancient world, we set $\delta = 0.75$. Finally, we set $x = 2$, so that the present value cost of dismissing and replacing an agent is two expected crops.¹⁵



Periodic expected income as a function of signal accuracy

In this figure, the agent's expected income I as a function of accuracy q is depicted by the lower solid line. Total expected income $I + \pi$ is depicted by the upper solid line; and the difference between these two lines represents the principal's expected income. The figure clearly identifies the two regimes: 'pure-carrot' and 'stick-and-carrot,' and the switch between them at the critical transparency level \hat{q} .

If the economy is less transparent ($q < \hat{q}$), the principal optimally refrains from ever dismissing the agent. In this case, the contract is socially efficient (since expected output is 1) and the expected income of both the principal and the agent is independent of q . In this

¹⁴One should think of this unit as representing an annual net output of about 1.5 tons of grain, after deduction of the grain that is needed for seed (about 15 percent of the crop) and expected spoilage in storage (about 10-20 percent). For a more elaborate attempt to calibrate early Near Eastern farming see Hunt (1987).

¹⁵With these parameters $\hat{q} > 0.5$ is achieved already with $x = 0.48$. However, in the version of the model in which the dismissal probability is continuous, (online Appendix D), a higher x is required for obtaining a range of $\hat{q} > 0.5$ in which $d = 0$ is optimal. Thus, for consistency, we set $x = 2$.

pure-carrot regime the expected income of the agent, I_c , and the principal, π_c , are:

$$I_c = m + 2\gamma \text{ and } \pi_c = p(H - L) + L - 2\gamma - m,$$

and their combined expected income is thus: $p(H - L) + L$.

In contrast, in the stick-and-carrot regime, when $q > \hat{q}$:

$$I_s = m + 2\gamma - \frac{pq\delta\gamma}{1 - \delta(p + q - 2pq)}, \pi_s = p(H - L) + L - m - 2\gamma + \frac{pq\delta\gamma}{1 - \delta(p + q - 2pq)} - \mu x,$$

and the expected total income is:

$$I_s + \pi_s = p(H - L) + L - \mu x.$$

The expected total income reveals that the stick-and-carrot contract is socially inefficient. This is because it entails an expected loss of μx , since the agent may be dismissed even though he works diligently. The efficiency loss μx declines as accuracy improves, and in the limit, when the signal is accurate ($q = 1$), the stick-and-carrot regime becomes socially efficient.

The principal's payoff is continuous at the threshold of transparency \hat{q} and increases with q thereafter. The gains to the principal from a rise in q in the latter range are derived both from a rise in total income and from a decline in the agent's income. Indeed, it is the agent who bears the entire burden of the stick-and-carrot regime: at the threshold accuracy, \hat{q} , his expected income I drops discretely by the expected cost of dismissal $\mu(\hat{q})x$. And beyond that threshold, his expected per-period income declines with q . In that range, the benefit that the agent obtains due to the reduced probability of dismissal enables the principal to reduce the bonus payment a_s , while maintaining the incentive constraint.

Comparing the outcome when the signal fully discloses the state of nature ($q = 1$) with the outcome when the signal is highly inaccurate ($q < \hat{q}$) is revealing. In both cases the diligent agent is never dismissed and the economy is efficient. However, the distribution of income is quite different. The agent's (gross) income falls from $I_c = m + 2\gamma$ ($= 0.7$ in the example) in the range of the opaque signal to $I_s = m + 2\gamma - p\delta\gamma/[1 - \delta(1 - p)]$ ($= 0.63$) when $q = 1$, as the bonus that is required to dissuade the agent from shirking is reduced to a minimum.¹⁶

These results confirm that when transparency is sufficiently low, the agent-tenant is never dismissed and could be considered a de facto owner of the land that he cultivates. In contrast, when transparency is sufficiently high, the farmer may be evicted and thus cannot

¹⁶When the agent is very patient ($\delta = 1$), his utility from being employed in agriculture is dissipated entirely.

be considered to have ownership rights to the land. In this range, the increase in transparency enables the principal to rely more on the stick of dismissal and less on the carrot of bonus payments. This implies, correspondingly, a smaller share of output for the tenant and an increase in the revenue appropriated by the state. The effect of increased transparency on the optimal combination of the stick and carrot is robust and does not depend on our specific modeling assumptions. It reflects the logic that the credible threat of using a stick reduces the cost of incentivizing the agent with a carrot. At the same time, in order to maintain credibility of the threat, punishment must be used whenever warranted. Since the likelihood of wrongful punishment declines with transparency, the expected cost of including a stick in the contract decreases with transparency.¹⁷

2.2 A Two-Level Hierarchy Model

We now consider a schematic extension of our basic model, introducing more levels of government. We assume that each plot is located within a village, a district and a province and that there are intermediary officials between the tenant farmer and the king. The previous two-tier case can easily be extended to add more tiers. We attach subscripts 1 or 2 to the variables at each level of the hierarchy, from the bottom up.

Two independent state variables are now assumed to determine the state of nature in each plot of land: $\theta_1 \in \{G, B\}$ is plot specific, and $\theta_2 \in \{G, B\}$ is district specific. The plot specific state can be thought of as injury to the tenant during the critical harvest time, or flood or fire damage. The district specific state would be something affecting the entire district, such as widespread drought or blight. We denote by $p_1 \in (0, 1)$ the probability that each plot of land is in a plot-specific good state, and by $p_2 \in (0, 1)$ the corresponding probability for each district. We assume that the plot-specific states are independent across plots within a district, and independent also of the district state. As in the basic model, output in each plot can be either low or high: $Y_1 \in \{L_1, H_1\}$ and the agent's effort can be either low or high: $e \in \{l, h\}$. Plot output is assumed to be high if and only if the agent exerts high effort and both the plot's and district's states of nature are good ($\theta_1 = \theta_2 = G$), which pertains with probability $p_1 p_2$.

The district specific state of nature, θ_2 , is revealed to both the farmer and the governor after the farmer's effort decision is made. In addition, if the district specific state is good

¹⁷Finally, we address also the issue of the closure of the model as far as population size is concerned. According to Malthusian considerations, if farmers' expected income exceeds the subsistence level, we should expect a steadily growing farming population. In Online Appendix F, we close the model by assuming that any excess workers from the rural sector, including dismissed agents, are employed outside of farming, where the wage is low (particularly in during famines) and does not guarantee reproduction.

($\theta_2 = G$), then the governor receives plot-specific signals $\sigma_1 \in \{g, b\}$ for each plot in the district. These signals are accurate with probability $q_1 \in [0.5, 1]$ and are (conditionally) independent across plots. The relations between the district governor and the farmers under her control are just as in the basic model. The contract selected by the governor will thus have the same structure as before: it specifies a basic wage $\omega_1 = m + \gamma$, a bonus a_1 if output is high, and a dismissal probability $d_1 \in \{0, 1\}$ at a cost of x_1 to the governor, if output is low ($Y_1 = L_1$) but both the district's state and the plot's signal are good ($\theta_2 = G, \sigma_1 = g$). Thus, subject to the farmer exerting high effort, he is dismissed with probability: $\mu_1 d_1 = (1 - p_1) p_2 (1 - q_1) d_1$. That is, the governor's maximization problem is but a variant of the principal's problem in the basic model, in which $p_1 p_2$ substitutes for p as the probability of high output, and the probability of dismissal is $\mu_1 d_1$ instead of μd . Thus, the governor chooses a pure-carrot contract ($d_1 = 0$) if transparency is below some threshold, $q_1 < \hat{q}_1$, and a stick-and-carrot contract if $q_1 > \hat{q}_1$. Above \hat{q}_1 , the expected income of the governor is increasing with q_1 .¹⁸

We also assume that the number of plots in each district, N_1 , is sufficiently large so that the total revenue obtained by the district governor can be substituted by its expected value. The governor's revenue is then limited to two possible outcomes, depending on the district-specific state of nature θ_2 . Denoting by L_2 and H_2 the governor's income in a bad year ($\theta_2 = B$) and a good year ($\theta_2 = G$) respectively, we have:

$$\begin{aligned} L_2 &= N_1 [L_1 - (m + \gamma)], \\ H_2 &= H_2(q_1) = N_1 [p_1(H_1 - L_1 - b_1) + L_1 - (1 - p_1)(1 - q_1)d_1 x_1 - (m + \gamma)]. \end{aligned}$$

Where the parameters a_1 and d_1 are those selected by the governor (as a function of q_1). As in the basic model, beyond a threshold \hat{q}_1 , the good-year revenue H_2 is increasing in q_1 .

For the relations between the king and the district governor, we employ a variant of our basic model in which, instead of possibly exerting low effort, the governor may hide some output in good years and report to the king L_2 instead of H_2 . At this level of the hierarchy we assume an analogous information structure to that in the basic model. The king does not know the specific states θ_1 of individual plots, nor the states θ_2 for any of the districts. But he receives an independent signal $\sigma_2 \in \{g, b\}$ about each of the district states, whose accuracy is denoted by the probability $q_2 \in [0.5, 1]$.

The king is assumed to employ a two-edged incentive scheme analogous to the one above:

¹⁸The corresponding bonus payments are: $a_{1c} = \gamma/p_1 p_2$ under 'pure carrot' and $a_{1s} = (\gamma/p_1 p_2) [1 - p_1 p_2 q_1 \delta_1 / (1 - \delta_1 (1 - p_2) - \delta_1 p_2 (p_1 + q_1 - 2p_1 q_1))]$ under 'stick and carrot'. If $p_2 = 1$, this is identical to the analogous expressions under the basic model.

a bonus a_2 if the governor reports collecting H_2 , and a threat of dismissal at a cost of x_2 to the king, if the governor's report is L_2 , but the signal σ_2 indicates that the district harvest is expected to be high. The king thus chooses $a_2 \geq 0$ and $d_2 \in \{0, 1\}$ to maximize:

$$\pi_2 = \max_{a_2 \geq 0, d_2 \in \{0, 1\}} p_2(H_2 - a_2) + (1 - p_2)[L_2 - (1 - q_2)d_2x_2].$$

subject to providing the governor with the incentive to report truthfully.

The details of the solution to this problem are relegated to Appendix 2, and are very similar in spirit to the solution of the basic model. Once again, the balance of power between the king and the district governor depends on the transparency of the district economy to the king, q_2 . When local conditions are sufficiently opaque to the king, the intermediary governor enjoys substantial autonomy in that she pays a (relatively low) fixed tribute and always retains her position. But if the transparency of the local provincial economy to the king is sufficiently high, then the governor is subject to dismissal and retains a relatively lower share of the revenue collected.

3 Application: The major civilization of the ancient Near East

Our theory provides the following predictions that link transparency to institutions. According to our basic model:

- (1) When farming is locally transparent, farmers do not own the land they cultivate,
- (2) When farming conditions are more transparent, state capacity is higher and inequality between the elite and the farming population is greater.

And according to the hierarchical extension of the model:

- (3) When farming is less transparent to the central state, local lords retain autonomy and higher income.

In this section we demonstrate that these insights are consistent with the institutions that prevailed in the three major civilizations of the ancient Near East during the fourth to the second millennia BCE: Egypt, Southern Mesopotamia (Babylonia, Sumer), and Northern (upper) Mesopotamia. Intensive agriculture was first adopted in the highlands of Anatolia and northern Mesopotamia in the seventh millennium BCE. Agriculture was adopted in the alluvial planes of Southern Mesopotamia and in the Nile Valley only two and three millennia later, respectively. It was in Sumer that the first major city-states were formed in the fourth millennium (Liverani 2006). Still, the first central territorial state was formed in Egypt, in about 3000 BCE, starting from a core in Upper (southern) Egypt (Kemp 2006). The

rapidity of the formation of a central state, and its subsequent stability, are among the key features that distinguish between ancient Egypt and Southern Mesopotamia, leading Baines and Yoffee (1998, p. 268) to conclude: “the two civilizations are profoundly different.”

Scholars often note additional major distinguishing features between these ancient civilizations (Trigger 2003). One of them is land tenure arrangements. In Egypt the land nominally belonged to the King, and in southern Mesopotamia land was typically owned by the temples and the urban elite. This meant that in both regions land was cultivated by tenants, but in Northern Mesopotamia land was mostly owner-cultivated. Another major distinguishing feature concerns the role of cities. Fortified city-states existed in pre-dynastic Egypt, but Egyptian cities ceased to be fortified after the formation of the central state and played a limited role as administrative centers. This led Wilson (1960) to characterize Ancient Egypt as “a civilization without cities.” In contrast, for most of the time up to the first millennium, southern Mesopotamia was ruled by rival and independent city-states. These cities retained their power and resisted repeated attempts to unify Mesopotamia under a central state. This led Adams (1981) to characterize southern Mesopotamia as “the Heartland of Cities.” At the same time, the highlands of Northern Mesopotamia gave rise to more limited city-states than the alluvial plains of Southern Mesopotamia.

We now consider each of these three civilizations separately and review their geographical features, to demonstrate how the differential transparency of agriculture in each region can account for their distinctive institutional characteristics. To summarize briefly, we argue that ancient Egypt occupies a polar extreme, with farming being highly transparent both at the local and the global levels. Northern Mesopotamia is closer to the other extreme, with low transparency at both the local and the central levels.¹⁹ Southern Mesopotamia, we suggest, presents an intermediate case, being comparatively transparent at the local level, but quite opaque to the central state.

3.1 Egypt

The Nile flows northwards, receiving its water mainly from the early-summer monsoon rains in eastern Africa. As a result it surges in summer, at which time it floods the narrow river valley. The Egyptian basin irrigation system was based on lateral dikes across the river valley, constructed to retain the flood water for about two months. The water soaked the land and deposited nutrients before it was drained back to the Nile in time for the sowing of the staple cereals (mostly barley). The moisture trapped in the soil was the sole source

¹⁹Agriculture in Northern Mesopotamia was, however, significantly less opaque than the more arid regions of the Ancient Near East. Noy-Meir (1973) demonstrates the extreme effects of spatial variations in micro-climate and terrain quality on the heterogeneity of desert plant populations.

of water during the growing season. Harvest was in late March, before the hot winds could parch the grain stalks and cause the kernels to disperse. This form of farming within the Nile Valley originated at the southern tip of Upper Egypt in the fifth millennium BCE, from where the Egyptian central state subsequently emerged.²⁰ The homogeneity of the land within each basin implied very high local transparency.

Since few details of the tenancy arrangements in ancient Egypt have survived, historians often employ evidence from the more recent past. In describing district life in Egypt from the medieval period up to the nineteenth century, G. Baer (1969, p. 17) contends that it was characterized by three phenomena: (a) the village-head periodically redistributed land to the peasants; (b) the village inhabitants were collectively responsible for tax payments; (c) the village as a whole was responsible for maintaining irrigation infrastructure and for providing labor for public works. Eyre (1997, p. 378; 1999, pp. 51-52) similarly maintains that in ancient Egypt farmers did not have secure tenure and the village community as a whole was responsible for paying taxes. The village-head exercised tight control over village land and could reassign fields as he saw fit, even if by custom the same fields were annually assigned to the same farmer, or to his heir.²¹

This description supports our assumptions that the threat of dismissal (or relocation) of individual farmers was a widely used incentive in Egypt and that land was not owned by the cultivating farmers. Indeed, the prevailing notion in ancient Egypt was that the entire land belonged to the Pharaoh (Baines and Yoffee 1998, p. 206), even if this coexisted in various periods with a practice by which much land was de facto owned by the temples, by various lay organizations, and by powerful individuals (Manning 2003, pp. 65-98). From our perspective, though, it is significant that when land in the Nile valley was privately held, it was owned by absentee landlords who did not work the fields.²²

This state of affairs is consistent with prediction (1). The high local transparency of farming eliminated the main disadvantage of absentee land ownership, and left peasants

²⁰For brevity, we focus on the Nile Valley, thus avoiding the Nile delta and the Fayum depression. The basin irrigation system prevailed with surprisingly minor variations for about five millennia, until the construction of the first Aswan Dam in the early twentieth century. Willcocks (1899) and Butzer (1976) provide detailed descriptions of this system.

²¹Eyre (1997) contends that the divorce between land-ownership and actual farming was endemic to Egypt and persisted until the mid-twentieth century. According to G. Baer (1969, pp. 62-78), even the major agrarian reforms during the nineteenth century, which gave land title to the cultivating peasants, ended up with much of the land reverting back to large absentee landlords after the small cultivators failed to pay the required taxes.

²²Hughes (1952, pp. 1-2) summarizes that in the first two millennia of the historic period there was never “a large body of small landholders who managed and worked their plots themselves . . . the lowest classes were largely serfs on the domains of Pharaoh, the wealthy and the temples.”

vulnerable, by denying them any informational advantage. Significantly, in the few known cases where private land lease documents survived from antiquity, the contracts were for one year only (Hughes 1952), providing further support for our proposed mechanism that tenants were constantly under the threat of eviction.²³

Transparency should not be confused with predictability. The fluctuations in the Nile's annual inundation level were substantial and caused significant unpredictable annual variations in crop output. Particularly high inundation would break the lateral dikes and flood villages in the Nile valley, causing as much of a threat as very low inundation levels. The timing, length and severity of the hot spring winds at harvest time contributed to the uncertainty. However, in any given year, the conditions that farmers faced were fairly homogeneous within each irrigation basin system, and also across basin systems. As a result, farming activity was highly transparent not only locally, but also to the central government. The Nile's annual peak inundation was recorded already in the third millennium BCE (Kemp 2006, p. 64). Nilometers that facilitated measurement of the inundation were set up along the Nile, and it appears that the Pharaohs used this information as a control device. Cooper (1976, p. 366) describes the taxation of Egyptian agriculture in the middle ages: "Agriculture was so well regulated in Egypt that, on the basis of the Nile flood recorded by the Nilometer, the government knew in advance what revenue to anticipate." In particular, "The height of the Nile flood determined how much and in what manner the tax assignments were made in each district." We conjecture that this was generally the case also in antiquity.²⁴

The Nile's global transparency enabled the Pharaohs to employ a stick-intensive incentive scheme towards the district governors, and down the chain of middlemen who remitted taxes from the periphery to the center. That is, consistently with predictions (2) and (3), the high transparency of farming helps explain why the Pharaohs were able to run a lean state bureaucracy and to siphon off a substantial share of the tax revenue, without engaging in direct control. In turn it explains why the provincial centers retained so little independent power. This is consistent with Eyre's (1994, p. 74) summary: "The crucial factor for the central power was its ability to enforce fiscal demands and political control ... [P]ower lay in control over the ruling class ... not in the detailed administration of the individual peasantry." Indeed, at least in the early Old Kingdom period, the positions of governors

²³Another feature that reduced the advantages to long-term leases in the Nile valley was that land fertility was sustained by the Nile's annual deposits, so that land could not in effect be over-exploited. In addition, agrarian capital investment was by way of dikes and local canals that were undertaken communally.

²⁴The transparency of Egyptian farming was also due also to the relative ease of monitoring farming activity in real time by inspectors traveling along the Nile. Kemp (2006, pp. 254-6) provides evidence for such a monitoring expedition from about 1140 BCE.

and state bureaucrats were by a revocable appointment, and nonhereditary.²⁵ The revocable and non-hereditary status of district governors and state bureaucrats are closely related to the relative weakness of the cities in the different districts. These cities remained essentially administrative centers, without amassing substantial independent wealth to threaten the predominance of the center.

The high transparency at all levels of the state hierarchy can also explain the rapidity of the formation of a strong central state in Egypt and its remarkable subsequent stability.

3.2 Southern Mesopotamia

As in Egypt, farming in arid Southern Mesopotamia relied entirely on riverine irrigation. The water regime in the Tigris and the Euphrates, however, is very different from that in Egypt. Both these rivers flow southward, and are fed by the winter rains and the spring melting snow in the mountains of modern Turkey and Iran. The long distance between these mountain ranges and Southern Mesopotamia meant that water levels were low in October-December when irrigation was most needed (Adams, 1981 pp. 3-6; Postgate, 1994 p. 178), but high in the harvest season, in late spring. This mismatch prevented irrigation by flooding (as in Egypt). Cereals were cultivated on the outer slopes of rivers' levees, including the levees of abandoned courses of the rivers. An extended canals system was required to cope with the water shortage in the cultivation season, by capturing water upstream and directing it towards the fields. It also required control mechanisms to distribute the water, since its quantity was insufficient to irrigate all of the arable land.²⁶ The swelling of the rivers in the spring posed another threat of flooding the ripe fields at harvest time, and had to be overcome by diverting excess water away from the fields and into the marshy flood plain at the lower end of the cultivation zone (Adams, 1981, p. 245; Wilkinson 2003, p. 89).²⁷

These two major problems apparently delayed the adoption of extensive agriculture in Babylonia well after agriculture flourished in Northern Mesopotamia and irrigation systems were established in southwest Iran (Wilkinson 2003, pp. 72-76). In addition to the intric-

²⁵Baines and Yoffee (1998, p. 206) state: "The king's most powerful influence was probably on the elite. Their status and wealth depended on him — often on his personal favor and caprice."

²⁶Adams (1981, p. 6) estimates that due to the shortage of water, only 8,000-12,000 square kilometers could be cultivated out of a potential that Wilkinson (2003, p. 76) estimates to be about 50,000 square kilometers. The shortage of water at the critical cultivation season is evidenced by the use of irrigation fees, as early as the late third millennium BCE. This underscores the power available to those upstream who could deny water.

²⁷Unlike in Egypt, the soil nutrients were not replenished automatically and salt was not washed away. The need to replenish land fertility and the shortage of water combined to establish a system of relatively frequent land fallow.

ate canal system that was employed to overcome these problems, agriculture in Southern Mesopotamia benefitted from another innovation. This was the cultivation in deep furrows in very narrow and long fields that sloped down from the feeding canal towards the marshy plain (Liverani 2006). This method enabled conservation of seed and water, and also helped divert the saline topsoil away from the plants. Since the land hardened during the long dry summers, the deep furrows were plowed by oxen.

Farming conditions in Southern Mesopotamia were quite complex. Even fields within the same zone could vary in quality, depending on how high they were above the saline water table in the adjacent marsh. The overriding factor though was the dependency of cultivation on rationed water which was controlled upstream, and which could have been directed elsewhere. Farmers were thus completely dependent on the local elite who controlled the flow of water at various canal junctures. In turn, the elaborate canal system provided the elite with indispensable control and with information on the local state of agriculture.

Accordingly, we categorize farming activity in Southern Mesopotamia as highly transparent to the local elite. Consistent with prediction (1), we contend that this transparency explains why owner-cultivated farming was practically nonexistent in Southern Mesopotamia. As in Egypt, cultivation was conducted by sharecroppers, who were overseen by a hierarchy of intermediaries, under the ultimate control of dominant elite families who resided in the urban centers and controlled each city's temple (Renger 1995, Liverani 2006). In accord with prediction (2), this high local transparency due to the local elite's ability to efficiently control the peasantry, explains also why powerful early city-states were able to form and to persist in Southern Mesopotamia. Indeed, once irrigation agriculture was introduced, it led to relatively rapid development of civilization. More than thirty major city-states have been identified in Southern Mesopotamia in the fourth and third millennia BCE. Writing originated in about 3200- 3100 BCE in the largest of these cities, Uruk, when its population reached about twenty thousand (Yoffee 2005, p. 43).

At the same time, the complex irrigation system in Southern Mesopotamia required skilled local managers with a "thorough knowledge of local conditions on a day-to-day basis" (Hunt 1987, p. 172). Unlike the case of Egypt, the local managing elite in Southern Mesopotamia were thus indispensable and irreplaceable. In other words, we interpret farming activity in Southern Mesopotamia as rather opaque to any distant central government. Consistent with prediction (3), this opacity explains why the local elite in Southern Mesopotamia were extremely resilient, and why strong cities were one of the most distinctive features of Mesopotamian civilization. Thus, even when an early city-state in Southern Mesopotamia managed to conquer a competing city-state, it still needed the cooperation of the local elite of the subjugated city to obtain on-going tax revenue from the conquered territory. It was

the specific knowledge possessed by the local elites, we contend, that assured the autonomy of Southern Mesopotamian cities.

This explains why several aggressive attempts to unify Southern Mesopotamia under one of the rival city-states in the third and second millennia BCE ended in failure after a relatively short period — in marked contrast to the quick and durable unification of Egypt. The rival city states of Southern Mesopotamia fought each other periodically for a millennium before they were first consolidated under Sargon of Akkad in about 2350 BCE. However, Sargon’s central state lasted less than two centuries and started to disintegrate well before that. In about 2100 BCE another territorial state was formed, under the third dynasty of the city of Ur. This highly oppressive and bureaucratic state lasted only one century before it too collapsed. The next territorial state was established by Hammurabi of Babylon in 1790-1760 BCE, but it weakened substantially under his heirs, and collapsed by about 1600 BCE. Thus, until the first millennium, Mesopotamia was ruled most of the time by rival city-states, with only brief intermittent periods of a central territorial state.²⁸ Our explanation of this historic pattern is consistent with Yoffee’s (2005) description of the fate of Sargon’s earliest central state. According to Yoffee, Sargon was well aware of the intermediation problem. When he ascended to power he sought “to disenfranchise the old landed aristocracy” (p. 37). But after conquering the diverse city states in Southern Mesopotamia, he ruled them through appointed “royal officials, who served alongside the traditional rulers of the conquered city-states” (p. 142). It was this “uneasy sharing of power ... [that] led to a power struggle” and to the ultimate demise of Sargon’s territorial states (Yoffee 1995, pp. 292-293; 2005, p. 143).

3.3 Northern Mesopotamia

Farming became prevalent in Northern Mesopotamia long before it was adopted in Southern Mesopotamia. Also urbanization was identified there earlier, already in the late fifth and early fourth millennia BCE; but it ceased in the later part of the fourth millennium.²⁹ The

²⁸The Neo-Assyrian Empire in the first millennium BCE developed various administrative methods to subject formerly independent conquered city-states. In particular, they adopted bi-directional deportations, in which they deported the entire elite of a conquered state and replaced it with people from elsewhere. And still, even under the Neo-Assyrian and Persian empires, the elites in the cities in southern Mesopotamia retained much of their former autonomy (Van de Mieroop 1997, pp. 128-139).

²⁹The large size of these early cities and the architectural remains of the dwellings suggest that these cities were inhabited not only by the elite, but also by the farming peasants (Ur 2010). This pattern of inhabitation is consistent with the presumption of the elite’s inability to raise the needed resources to secure the countryside from banditry, which forced the peasants to seek protection within the walls of the central city.

geographic conditions in the highlands of Northern Mesopotamia are quite different from those in riverine Southern Mesopotamia and Egypt, since agriculture depended mostly on rain. Due to the uncertain and idiosyncratic nature of rainfall, and to the relative unevenness of the terrain, farming there was comparatively opaque even at the local level.³⁰ Wilkinson (1994; 2003, p. 210) concludes that the settlement pattern in Northern Mesopotamia was characterized by a scatter of a large number of roughly equivalent, nucleated units. Each unit was administered by a central settlement, with a radius of control of about five kilometers, determined by the “constraining effect of land transport and the convenience of being within one day’s round trip of the center” (1994, p. 503).

Without disputing this observation, we take issue with Wilkinson’s explanation that this pattern was due to the fact that no center was able to dominate another, since none had an “overwhelming situational or demographic advantage” (2003, p. 210). By the winner-takes-all (increasing returns to scale) nature of violent conflicts, a priori advantage is not a prerequisite for the formation of larger territorial states under city leaders who happen to defeat their neighbors. From our perspective, the key to the nucleated pattern of semi-autonomous administrative units in early Northern Mesopotamia was the inability of the winner of any such territorial conflict to extract on-going revenue from distant conquered lands. In a more pronounced version of the situation in Southern Mesopotamia, and consistently with our third prediction, we thus propose that the localized nature of the early city-states in this region was due to the opacity of farming activity that limited the span of control of its urban centers.³¹

The relatively low transparency of farming in Northern Mesopotamia, even at the local level, can also explain the drastically different land tenure regime in that region. In contrast to the tenancy pattern in Egypt and Southern Mesopotamia, owner-operated farming was prevalent in Northern Mesopotamia from early on. Cuneiform documents from the mid-second millennium BCE from Nuzi (near modern Mosul) reveal that while the local kings and the elite owned large estates, the temples did not possess economic power, and much land was owned by nuclear families who worked their patrimonial property. The Nuzi evidence also reveals that land ownership in Northern Mesopotamia was in a constant state of flux. Small landholders regularly lost title of their land to rich families through debt and sale under duress (Zaccagnini 1999; Jas 2000). But the persistence of owner-occupied farming reveals that the process of land consolidation must have been matched by an opposing process by which large, presumably less efficient, estates were gradually dissolved. This prevalence of

³⁰See Wilkinson (1994) and Jas (2000).

³¹The requirement of transporting the crop tribute to the center over land (rather than by water) was another significant contributing factor for the limited span of early potential states in Northern Mesopotamia.

owner-cultivated private farming in Northern Mesopotamia is consistent with prediction (1) that low transparency makes tenancy less profitable to absentee owners.³²

4 Related Literature

The related literature is extensive. We shall thus review only the leading alternative theories on the pattern of state governance in the ancient near east and some related theories on statehood.³³

We start with Wittfogel’s (1957) influential hydraulic theory of “oriental despotism,” according to which large-scale irrigation infrastructure was necessary to realize the agricultural potential in riverine environments. Strong, despotic states are presumed to have been a prerequisite for constructing and administering these irrigation projects. Wittfogel’s many critics pointed out, however, that the irrigation systems in ancient Egypt and Mesopotamia (and elsewhere) were constructed communally prior to the emergence of a strong central state. Moreover, even after a central state emerged, these irrigation systems were managed locally, rather than from the center. Due to the cogency of these counter-arguments, Wittfogel’s theory is now considered defunct. But this leaves unexplained the correlation that he pointed out between riverine environments and strong ancient states. Our theory explains this correlation by reversing the causality direction of Wittfogel’s theory. It is not that a despotic state was required to construct and to operate irrigation systems, but rather that irrigation-based agriculture provided transparency and facilitated state control.³⁴

An alternative functional theory posits that the state in early agricultural societies served a redistributive purpose. Thus, Adams (1981 p. 244) views the Mesopotamian city-states as formed to cope with uncertainty through precautionary storage against years of shortage:

³²Jas (2000) quotes Warriner (1948, pp. 21, 104), who noted that the different ancient land tenure regimes in Northern and Southern Mesopotamia persisted to the modern era: “In the north, the forms of tenure are similar to those of Syria, with a class of small proprietors taking some but not all, the land. In the south large owners or sheiks own virtually all the land, letting it to share-tenants, through a series of intermediary lessees.”

³³With regard to the related literature on property rights we note that rights to land do not arise spontaneously in our framework (as in Demsetz 1967), but rather granted by an authoritarian government (as in North 1981). Hierarchy serves here in a rudimentary role as part of a uni-directional extraction mechanism, and does not function in the management of downstream activities, as is customary.

³⁴Billman (2002) provides additional evidence, reporting that an early irrigation system in 400 BCE-800 CE from the Moche valley in the arid northern coast of Peru created an opportunity for leaders “to control land and the flow of water;” thus enabling them “to finance the creation of centralized, hierarchical political organizations,” and leading to the formation of an early territorial state. In addition to the informational consideration that we stress here, another major advantage that riverine environments provide to central states is in facilitating a cheap mode for transporting tax receipts that are remitted in kind.

“In the largest sense, Mesopotamian cities can be viewed as an adaptation to the perennial problem of periodic, unpredictable shortages. They provided concentration points for the storage of surpluses.” Our framework, however, suggests that the attested extensive inter-annual storage in ancient Egypt and Mesopotamia may have served primarily to protect the urban elite against shortfalls in revenue in years of famine, rather than to aid the farming population in the countryside.

Other scholars offer non-functionalist theories. In his comprehensive study of the history of government, Mann (1986, pp. 38-40 75-102, 108-115) uses the metaphor of a “social cage” to explain the success of ancient Egypt and other early states. He suggests that Egypt’s success was due to the deserts that isolate the Nile Valley and inhibited the peasants from avoiding taxation via out-migration, thus enabling the state to extract surplus from the farming sector.³⁵ From our perspective, however, while this entrapment theory fits Egypt, it hardly fits other “caged” areas (like the Pacific islands) in which states did not emerge. Moreover, this theory does not contribute to explaining the emergence of city-states in Mesopotamia, or to account for the differences that we examine between the civilizations of the Ancient Near East.

Another influential theory was proposed by Tilly (1975). Tilly applied this warfare theory, summarized in his statement that “War made the state, and the state made war” (p. 42) in seeking to explain how new military technologies disrupted the international equilibrium in Europe since the middle-ages and forced states to consolidate in order to finance ever costlier wars, leading to the formation of territorial national states. This warfare theory has been applied more broadly to explain the history of government, among others by Finer (1997) who refers to this positive feedback theory as the “extraction–coercion cycle” (pp. 15-19). It is evident however that warfare theory can hardly explain the state’s success in ancient Egypt. In fact, Dal Bó, Hernández and Mazzuca (2015) emphasize that Egypt’s natural circumscription insulated it from the outside and implied that once a central state was formed, its monopoly on the use of violence was not seriously challenged by nomad bandits and competing states. As a result, there was no on-going need in Egypt for fortified regional centers, or even for a strong army. This is in contrast to Mesopotamia, where nomadic bandits and local rivalries posed a perennial problem.

As we see it, the critical missing element in the warfare theory is an explanation of what enabled a victor to extract on-going revenue from a conquered territory to make the conquest viable and long-lasting. In other words, while admitting that fiscal capacity contributes to

³⁵Mann adopts Carneiro’s (1970) theory of “environmental circumscription” which was proposed to explain the emergence of states in circumscribed areas that trap the agrarian indigent population. The theory was applied to Egypt also by Allen (1997).

a state’s military capacity, we deny the general validity of the reverse causal relation that military capacity necessarily increases fiscal capacity.³⁶ Our theory on the environmental and technological determinants of fiscal capacity supplies this critical complementary element to the warfare theory.

These considerations, though, point out that we assume here an isolated unitary state with an absolute power to coerce and to appropriate, without incorporating potential rivalry between competing polities, and without taking into account the resources required to maintain such power and to deter secession. Moreover, we posit a leviathan state, but avoid explaining how it could have emerged. The literature on these issues is extensive (see most recently Boix, 2015). In a companion contribution (Mayshar, Moav, Neeman and Pascali, 2015) we examine the emergence of hierarchy and emphasize another facet of the tax technology theory proposed here. We argue that the transformative facet of the Neolithic Revolution that gave rise to social hierarchy was not the surplus created by the increase in productivity of agriculture, as is conventionally contended, but rather the induced change in the appropriability of specific crops.³⁷ In particular, even after the adoption of highly productive agriculture, state institutions did not emerge in regions where farming relies on non-seasonal roots and tubers that are typically perishable and largely non-appropriable. Complex hierarchies and state institutions emerged only in regions where farming relied on seasonal and non-perishable cereal crops that require storage from one harvest to the next, and are thus amenable to appropriation. The appropriability of these crops generated a demand for protection from bandits, and, at the same time, facilitated taxation by a non-food producing elite that had an interest to supply such protection.

5 Conclusion

Stigler (1961) stated that “knowledge is power.” We apply this maxim to examine how the extent and the structure of informational asymmetry shaped the institutions of pre-modern state societies. Our overarching contention is that through its effect on the tax technology, the transparency of production has a major effect on the scale of the state, on its hierarchical structure, and on land tenure practices. This theory helps explain why ancient

³⁶Stasavage (2010) makes a similar argument in demonstrating the revenue advantages that a smaller territory may confer, thus explaining how some small European states were able to retain their independence.

³⁷Consistently with this claim, de la Sierra (2013) employs evidence from the mining regions of the Democratic Republic of Congo to show that a rise in the price of the metallic substance coltan — produced from relatively bulky and hence transparent ores — led to the cessation of conflict between rival armed groups and to the monopolization of violence in the coltan rich regions; whereas an increase in the price of gold, which is easier to conceal and is hence less transparent, did not.

Egypt was rapidly united and was subsequently very stable and highly centralized, while Sumer remained a complex of competing city-states. It explains also why land in Egypt belonged (at least nominally) to the Pharaoh, while in Southern Mesopotamia it belonged to the temples and to the elite, and in Northern Mesopotamia there was substantial owner-occupied farming.

Our environmental theory of early institutions contributes to the understanding of antiquity by developing a new paradigm. Our variant of the principal-agent model enables analyzing the effects of differences in the extent of informational asymmetry on hierarchical extractive institutions. While we apply our theory to the institutions of antiquity, it is applicable to all pre-modern, predominantly agricultural state societies. More generally, it sheds light on how new production technologies can impact the tax capacity of the state and shape institutions, unrelated to the impact of the environment. In particular, whereas the prevailing perception is that asymmetry of information hinders efficiency, our framework reveals that the lack of transparency of agents' activities ('privacy') may in fact be beneficial to them in protecting agents' freedom, and possibly in promoting their material well-being.

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Appendix 1 - Proof of the Proposition

Denote by V the present value of the agent’s utility from employment in agriculture in a stationary equilibrium where he exerts high effort every period. The normalization that the agent’s utility upon dismissal is zero implies:

$$V = [\omega + pa - m - \gamma] + [1 - d\mu]\delta V, \quad (\text{A1})$$

where $\mu = (1 - p)(1 - q)$ is the probability of a bad harvest and a good signal, and $d\mu$ is the probability of dismissal. Solving From (A1):

$$V(a, d) = \frac{\omega + pa - m - \gamma}{1 - \delta(1 - d\mu)}. \quad (\text{A2})$$

The principal selects $a \geq 0$, $\omega \geq m + \gamma$ and $d \in \{0, 1\}$ to maximize:

$$\pi = \max p(H - b) + (1 - p)L - \mu dx - \omega, \quad (\text{A3})$$

subject to incentivizing the agent to exert high effort:

$$\begin{aligned} p[a + \delta V] + (1 - p)[q + (1 - q)(1 - d)]\delta V + \omega - m - \gamma &\geq \\ p[q(1 - d) + (1 - q)]\delta V + (1 - p)[q + (1 - q)(1 - d)]\delta V + \omega - m, & \end{aligned} \quad (\text{A4})$$

where $V = V(a, d)$.

Since ω cancels out from (A4), it is optimally set to $\omega = m + \gamma$, thus confirming (1). Plugging (A2) into (A4) and simplifying yields the incentive constraint:

$$pa \left(1 + \frac{pqd\delta}{1 - \delta(1 - d\mu)} \right) \geq \gamma. \quad (\text{A5})$$

Part (2) follows from the maximization of (A1) subject to (A5). Because the Principal sets a as low as possible, the incentive constraint is binding in the optimal solution.

The threshold \hat{q} , is given by the unique solution in the interval $[0, 1]$ to the quadratic equation $V(a_c, 0) = V(a_s, 1)$, that can be expressed as:

$$\hat{q}/(1 - \hat{q}) = (1 - p)x[1 - \delta(p + \hat{q} - 2p\hat{q})]/p\delta\gamma. \quad (\text{A6})$$

To see that $\hat{q} > 0.5$ if $x > \hat{x} = p\delta\gamma/(1 - \delta/2)(1 - p)$, note that while the left-hand-side of (A6) is convex and increasing from zero to infinity as q increases from zero to one, the

right-hand-side is positive and linear in q . The threshold \hat{x} is obtained by requiring that for $\hat{q} = 0.5$, the right-hand-side (A6) be equal to one.

Finally, the third pure strategy of dismissal of the agent upon observing low output regardless of the signal is dominated by the pure-carrot contract if $x > \delta p \gamma / (1 - p)$. Thus, it is never optimal in the range where $x > \hat{x}$. \square

Appendix 2

The incentive constraint for the governor is:

$$a_2 \geq (H_2 - L_2) - q_2 d_2 \delta_2 V_2,$$

where $\delta_2 V_2$ is the governor's discounted value of keeping her position. Under the optimal contract the incentive constraint is binding. Setting the governor's utility of unemployment to zero, we obtain, in analogy to (A1):

$$V_2 = p_2 a_2 + [1 - d_2(1 - p_2)(1 - q_2)] \delta_2 V_2, \quad (\text{B1})$$

From (B1) it is possible to solve for $V_2(a_2, d_2)$ as in (A2), and then to solve explicitly for the king's optimal incentive scheme a_2 and d_2 . Thus, subject to parameter restrictions on x_2 and δ_2 that are analogous to those above, there exists a threshold $\hat{q}_2 > 0.5$ such that if district farming is sufficiently opaque to the king ($q_2 < \hat{q}_2$) the governor enjoys a carrot regime, in which she is autonomous in the sense that she is never dismissed, namely $d_{2c} = 0$. In this regime, the king's per-period revenue is $\pi_{2c} = L_2$, independently of the state of nature, and the governor retains $a_{2c} = H_2 - L_2$ whenever the district state of nature is good, and zero otherwise.

On the other hand, when district farming is sufficiently transparent to the king ($q_2 > \hat{q}_2$), a stick-and-carrot regime prevails. Under this regime, the governor is dismissed whenever the king is led to expect high revenue, on the basis of observing $\sigma_2 = g$, but the governor reports low revenue. This occurs with probability $(1 - p_2)(1 - q_2)$. In this regime, following a similar derivation to the one in the above, $d_{2s} = 1$ and $a_{2s} = (H_2 - L_2) - q_2 \delta_2 V_{2s}$, where:

$$V_{2s} = \frac{p(H_2 - L_2)}{1 - \delta_2(p + q_2 - 2pq_2)}.$$

The king's expected revenue in this case is:

$$\pi_{2s} = (L_2 - m_2) + pq_2 \delta_2 V_{2s} - (1 - p)(1 - q_2)x_2.$$

The threshold transparency level \hat{q}_2 is determined by the implicit condition $\pi_{2s} = \pi_{2c}$. As in the basic model, the transparency threshold \hat{q}_2 increases with the cost of dismissal x_2 and decreases with the governor's discount factor δ_2 .