The Network Formation Origin of Tribal Societies

Javier Mejia *†

New York University–Abu Dhabi

First version: April 2018
Current version: June 2018

Abstract

This paper proposes a network formation model for explaining the stability of tribal societies. The model is supported by the idea that every two members of a tribe should have benefited from being connected to each other in order for the whole tribe to be stable. It also considers the constraints that the ecosystem brought to social interaction in pre-modern contexts. The model has three predictions. First, both homogeneous and heterogeneous tribes could have been stable regardless of technological development. Second, the social complexity of tribes was a function of technological development (having access to agriculture should have enabled the emergence of larger and more complex societies), interaction costs (if they were too low or too high, no complex society should have emerged), and environmental conditions (poor ecosystems should not have allowed the formation of complex societies). Finally, the model predicts that collapses of agricultural societies could not come from environmental pressures, but from high interaction costs. The predictions are consistent with some of the most relevant human history patterns.

JEL Classification: D85, J11, N30, Z13

* I am grateful to Andrés Álvarez, Dan Tran, Fabio Sánchez, Jeanne Metivier, José Guerra, Juni Hoppe, Matthew O. Jackson, Santiago Gómez, Santiago Tobón, Tómas Rodríguez, and the participants of the Network Discussion Group at Stanford University and the Graduate Students Seminar at Los Andes University for their valuable comments.
† Email: javiermejia@nyu.edu/mejiaja20@gmail.com. Website: http://javiermejia.strikingly.com/
1 Introduction

Most societies in pre-modern history were configured as sets of groups deeply connected within them, but fairly isolated from one another—i.e. as tribes. However, we do not know much about the determinants of this kind of social configuration. Why did individuals belong to a tribe? What kept the tribe together? What determined the size of the tribe? Was it possible that several tribes could merge into one? What incentives would they have to do it?

The mainstream explanations of tribes’ stability emphasize the role of cooperation institutions as mechanisms for increasing the likelihood of survival in extreme environments. For instance, authors such as Dowling (1968), Marshall (1961), and Woodburn (1998) consider institutions that guarantee sharing as the basic element of hunter-gatherer societies. Sharing operated as a mechanism to offset the chronic uncertainty of hunt. These explanations are usually accompanied by a cultural homophily argument. For example, many ethnographers consider that family is the fundamental social unit in nearly all societies, and that families self-organize in broader communities (Hamilton et al., 2007). Thus, under the mainstream explanations, a tribe was a natural institutional arrangement among family related individuals that minimized uncertainty. This implies homogeneous and hierarchically well-defined groups of reciprocal exchange.

However, tribes were quite heterogeneous groups (see Kelly, 2013). At least since Fried (1975), we know that tribes frequently gathered individuals who spoke different languages, practiced different rituals, and followed different political leaders. They were not hierarchically well-defined groups of reciprocal exchange either. For example, Knight et al. (2012) describes that sharing was not an attribute of every hunter-gatherer group, questioning the idea of sharing institutions as the essence of tribe cohesion. Even the idea of family as the building block of tribes is questionable if we consider that the definition of family itself varied across tribes (see Cordell and Beckerman, 1980; Hill et al., 2011). Indeed, the concept of “relative” was rather a result of being part of the tribes.

---

1 I will refer to tribes as ancient societies. Nevertheless, one hundred and fifty million tribal individuals survive worldwide, constituting around forty percent of indigenous population (Survival International, 2018). In fact, much of the evidence about the functioning of tribal societies comes from ethnographic studies of current tribal groups. In addition, despite the increasing complexity of modern societies, tribal-like configurations subsist in several dimensions. Homophily studies (see McPherson et al., 2001; Cururìni et al., 2009, 2016) and structural holes literature (see Burt, 2005; Stovel and Shaw, 2012; Quintane and Carnabuci, 2016) present extensive evidence in this regard. Therefore, the understanding of tribal configurations is also an issue of current interest.
tribe, than a cause of belonging to the tribe (see [Bird-David, 1994; Beckerman and Valentine, 2002; Ryan and Jethá, 2010]). In short, a theory of tribal cohesion based on a particular institutional structure or some homophilic pattern is not consistent with the heterogeneity of tribes in the data.

I address this discussion, offering a more general explanation of the stability of tribal configurations. This explanation, presented as a formal model, is supported by the idea that every two members of a tribe should have benefited from being connected to each other in order for the whole tribe to be stable. In addition, I consider the constraints that the ecosystem brought to social interaction. My explanation does not depend on any particular type of institutional arrangement or a homophily pattern. Moreover, it is consistent with the most relevant patterns of human history.

To be specific, the model has three predictions. First, both homogeneous and heterogeneous tribes could have been stable and viable regardless of technological development. Second, the social complexity of tribes was a function of technological development (having access to agriculture should have enabled the emergence of larger and more complex societies), interaction costs (if they were too low or too high, no complex society should have emerged), and environmental conditions (poor ecosystems should not have allowed the formation of complex societies). Finally, the model predicts that collapses of agricultural societies could not come from environmental pressures, but from high interaction costs.

2 Related literature

This paper relates to four sets of literature.

First, it is a contribution to the literature in economics that studies pre-modern societies. Most of this literature focuses on the Malthusian forces that explain economic stagnation ([Kremer, 1993; Aiyar et al., 2008; Ashraf and Galor, 2011; Voigtländer and Voth, 2012]. A recent agenda has started to open the box of those Malthusian forces to offer a better understanding of how pre-modern societies worked. They explore aspects like technological adoption and social stratification ([Dow and Reed, 2011, 2013, 2015; Ashraf and Michalopoulos, 2015]). This paper brings the question of tribal configuration to this agenda.

Second, I contribute to a very broad field that explores social interactions in tribal
societies. This field crosses several disciplines, including anthropological demography, human evolutionary ecology, and archaeology (Service 1971; Fried 1975; Jones 1997; Gil-White 2001). Traditionally, this field has focused either on the macro-typology of groups or on the micro-aspects of relationships—e.g. mate choice, parental investment decisions. A recent group of studies combines the interest for macro-patterns with analysis of individual motives and pairwise interactions (see Hamilton et al. 2007; Dunbar and Shultz 2010; Apicella et al. 2012; Pearce 2014; Migliano et al. 2017; Page et al. 2017). These studies offer empirical analyses or non-formal theories. My paper shares the concern for understanding the macro-patterns based on individual behavior. However, I use a different method. My contribution to this field lies in the theoretical formalization of the individual-decisions that generate aggregate patterns in the social structure.

Third, this paper dialogues with the literature on the origins of social complexity and institutional formation, which comes mostly from anthropology and political science (Sahlins and Service 1960; Service 1975; Wright 2001; James 2006; Henrich and Boyd 2008). Economics has recently taken an interest in the field as well (Alesina and Spolaore 1997; Alesina et al. 2016; Depetris-Chauvin and Özak 2018). This literature has focused on group-level behavior. For instance, they have identified that the emergence of specialization and division of labor were associated with increasing complexity in social interactions. As in the previous set of literature, the contribution of the paper to social-complexity studies comes from the focus on individual behavior and dyadic-level interactions.

Lastly, because of its theoretical approach, this paper can be considered part of the network formation theory. In particular, the paper relates to three agendas in this theory: i) the origins of small world structures (Johnson and Gilles 2003; Jackson and Rogers 2005; Galeotti et al. 2006; Carayol and Roux 2009), ii) the stability of structural-holes environments (Goyal and Vega-Redondo 2007; Kleinberg et al. 2008; Buskens and Van de Rijt 2008), iii) the consequences of homophily (Currarini et al. 2016, 2009). Agendas i and ii study the coexistence of long-distance connections with high clustering at local level. Agenda iii explores the role of homophily in the generation of those high clustering environments. As iii, my model focuses on the emergence of clusters but considers a process unrelated to the attributes, preferences, or spatial proximity of nodes.
3 Social interactions

In this section, I model individuals that interact in non-market contexts. Individuals intend to have access to a wide variety of types of knowledge that increase their likelihood to survive—e.g. shelter construction, hunting abilities, medical-plants use. Knowledge will be sparsely distributed in society. As markets do not exist, social links are the only way to access the different types of knowledge. This assumption represents empirical regularities on the role of both kinship and non-kinship ties in the transmission of knowledge in hunter-gatherer societies (see Salali et al., 2016).

The cost of creating a link between two individuals will depend on the number of connections they have in common. This captures the idea that network closure supports dyadic interactions (see Raub and Weesie, 1990; Lippert and Spagnolo, 2011; Jackson et al., 2012). For example, connecting to someone that has already links with one’s tribe is cheaper than connecting with someone else to whom members of one’s tribe have no connections. Intuitively, those other links guarantee punishment mechanisms in case of a wrong behavior of the new connection. This reduces the uncertainty of the interaction, therefore its cost. Notice that this is particularly important in the absence of a state, which is the case for most of the societies I consider in this paper.

3.1 Knowledge, ties, and social distance

Consider an ecosystem in which there is a finite set \( N = \{1, \ldots, n\} \) of agents—in Section 5 I endogenize the number of agents. Each agent is born with a unique type of knowledge. Let \( X = \{x^1, \ldots, x^n\} \) be the vector of types of knowledge across society at the beginning of time—i.e. before any social interaction—and \( X^i = \{0, \ldots, 0, x^i, 0, \ldots, 0\} \) the correspondent vector of individual knowledge, where \( x^i \in \mathbb{R}_+ \). I will call agent \( i \) the guru of knowledge type \( i \) or plainly, guru of \( i \).

Now, let me define a social network as a tuple \( g = (N, E) \), where \( N \) is the predefined agent set and \( E \) is the link set. The link set is defined as \( E = \{(i, j) : \sigma_{i,j} = 1; i, j \in N\} \), where the binary variable \( \sigma \) represents the existence of a link between \( i \) and \( j \) if \( \sigma_{i,j} = 1 \). The network \( g \) will be an element of the set \( g^N \) that contains all the possible networks for \( n \) nodes.

---

2Several other mechanisms have been identified in the literature. For instance, the generation of common values and codes related to belonging to a particular group, which represents barriers to the interaction with others outside the group.
Consider the social distance between nodes \( i \) and \( j \) as the number of links in the shortest path between them, namely, \( D_{ij} \).

The only way to acquire a non-born knowledge type is through some connection with a guru. Thus, knowledge diffuses over the social network. Let \( \chi^i : g^N \to \mathbb{R}_+ \) be a general and continuous knowledge-transmission function, with \( \chi^i(D_{ij}(g)) < x^j \) being the amount of knowledge that \( i \) receives from \( j \)'s innate knowledge type. I will assume certain decay with distance in the amount of knowledge transmitted; \( \chi''(D_{ij}(g)) < 0 \), \( \chi''(D_{ij}(g)) > 0 \), \( \chi^i(D_{ij} = 1) = x^{i_{\text{max}}} \), and \( \lim_{D_{ij} \to \infty} \chi^i(D_{ij}(g)) = 0 \). In other words, agents closer to the guru will absorb more of her knowledge than those farther from her. The vector of individual knowledge under social interaction is \( X^i = \{\chi^i_1, ..., x^i, ..., \chi^i_n\} \).

### 3.2 Preferences and costs

Now, consider that each agent has well-behaved preferences—i.e. reflexive, complete, transitive, continuous, and weakly monotonic—over her knowledge types, represented as a continuous utility function, \( w^i : X^i \to \mathbb{R} \). As the amount of every type of knowledge is a function of the distance to the guru, it follows that there must be an equivalent utility matched to the distance set \( D^i = \{D_{i1}(g), ..., D_{in}(g)\} \) (see Lemma 3.1).

**Lemma 3.1.** Let \( \succeq \) be a preference ordering on \( X^i \) satisfying the above conditions, then \( \exists \) a continuous function \( v^i : D^i \to \mathbb{R} \) that represents \( \succeq : x \succeq y \iff v(x) \geq v(y) \).

**Proof.** It follows from considering that under social interaction \( X^i \) is a decreasing function of \( D^i \) and that preferences over \( X^i \) are continuous, strictly monotonic and transitive. \( \square \)

**Corollary 3.1.1.** There is a utility function \( 
\tilde{u}^i(g) = \sum_{j \neq i} b(D_{ij}(g)) \) that represents \( \succeq \). Where \( b : \{1, ..., n - 1\} \to \mathbb{R} \), and \( b = (k) > b(k + 1) \forall k \)

Lemma 3.1 and its corollary enable to match the preferences over knowledge to preferences over the social network. This is an essential step to fit the model into the framework of network formation theory. Specifically, the resulted preferences have a distance-based-utility representation, as the one developed by Bloch and Jackson (2007).

Now, consider an interaction cost that decreases with the number of links in common—i.e. decreases with support. In particular, forming and maintaining a link between
agents $i$ and $j$ costs each of the agents, $c \frac{S_{ij}}{1+S_{ij}}$, where $S_{ij} = \sum_{j \in g} 1\{\exists k, ik \in g, kj \in g\}$ is the support between $i$ and $j$, and $c \in \mathbb{N}$ is the cost of distant interactions—i.e. links with agents to whom there is zero support.

Under these assumptions, the utility for agent $i$ of network $g$ will be the following:

$$u_i(g) = \sum_{j \neq i: j \in N} b(D_{ij}(g)) - \sum_{j \neq i: j \in N} \frac{c}{1+S_{ij}}$$

(1)

3.3 Stability

For simplicity, I will assume a particular kind of decay in the utility provided by links. Specifically, I will consider the specification of the connections model (see [Jackson and Wolinsky, 1996]), where $b(k) = \delta^k$, with $0 < \delta < 1$.

Thus, the utility that agent $i$ receives from network $g$ is given by the following expression:

$$u_i(g) = \sum_{j \neq i: j \in N} \delta^{D_{ij}(g)} - \sum_{j \neq i: j \in N} \frac{c}{1+S_{ij}}$$

(2)

I will analyze the solution of the model in terms of pairwise stability, which captures the idea that mutual consent is necessary to form or maintain a link (see [Jackson and Wolinsky, 1996]).

**Definition 3.1. Pairwise Stability**

A network $g$ is pairwise stable if

1. for all $ij \in g$, $u_i(g) \geq u_i(g - ij)$ and $u_j(g) \geq u_j(g - ij)$, and
2. for all $ij \notin g$, if $u_i(g + ij) > u_i(g)$ then $u_j(g + ij) < u_j(g)$.

Proposition 1 characterizes the conditions for the existence of stable networks that contain cliques.

**Proposition 1. Stability**

1. If $c < \delta - \delta^2$, then, the fully connected network is the only pairwise stable network.
2. if $c > n(\delta - \delta^2)$, then, no stable network has a clique.
3. if \( \delta - \delta^2 < c < \frac{n-K}{K}(\delta - \delta^2) \), then, any network composed exclusively by cliques of size \( \frac{n}{K} \), or larger, is stable.

4. if \( \frac{n-2}{2}(\delta - \delta^2) < c < n(\delta - \delta^2) \), then, the only stable network that has a clique is the fully connected network.

Proof. (1) Consider a network in which two agents are not directly connected. They would gain at least \( \delta - \delta^2 - c > 0 \) by creating the link. Thus, they will create the link. Therefore, the initial network could not be pairwise stable.

(2) Notice that \( \frac{c}{n} \) is the minimum possible cost of creating and maintaining a link in a clique. As the benefit of a link in a clique is \( (\delta - \delta^2) \), it follows that no clique can be part of a stable network.

(3) It follows as (2), noticing that the condition for a link to be profitable in a \( \frac{n}{K} \) size clique is \( c < \frac{n-K}{K}(\delta - \delta^2) \).

(4) It follows from (3) and (2).

Proposition 1 describes some usual patterns of network formation models. For instance, when interaction costs are low enough, full connectivity appears. However, this model presents some new patterns as well. As the cost of forming a link reduces with support, very large cliques are usually stable. Moreover, under the same set of parameters, several networks with different numbers of cliques might be stable.

Even though a tribe did not require a strictly one-to-one interaction between each of its members, most experts agree that the main characteristic of tribes was their high/dense connectivity (see Thomas and Mark, 2013). Some tribes consisted of a unique band—e.g. family-level foragers—while others consisted of several bands with broader spheres of interaction—e.g. big man collectivities (see Johnson and Earle, 2000). In order to distinguish these types of tribes, I introduce the following definitions:

**Definition 3.2.** Simple and complex tribal societies

- The set \( g^N \) represents a simple tribal society if the only stable network it includes is the fully connected network.

- The set \( g^N \) represents a complex tribal society if it includes more than one stable network composed exclusively by cliques.
Based on these definitions, I interpret Proposition 1 as a categorization of tribal societies. *Simple tribal societies* appear if links’ costs are fairly low \((c < \delta - \delta^2)\) or fairly high \((\frac{n-2}{2}(\delta - \delta^2) < c < n(\delta - \delta^3))\). If costs are moderate \((\delta - \delta^2 < c < \frac{n-K}{K}(\delta - \delta^2))\), *complex tribal societies* can be stable. This means that societies with several groups are stable. Moreover, more than one arrangement of groups are stable. This can be interpreted as the existence of several dimensions of interaction. For instance, certain groups had a common identity and associated periodically for harvest or war, but stayed isolated in smaller nuclei for daily activities\(^3\). Finally, if social interactions are too high \((c > n(\delta - \delta^2))\), no tribal configuration is possible. Figure 1 summarizes these conditions.

4 Environmental constraints

In contrast to most applications considered in network formation studies, where resource availability is not a concern, tribal societies generated fairly low levels of surplus. In tribal societies, it is important to guarantee that the environmental conditions can support the network. Intuitively, societies with more resources can support a broader range of network structures.

The availability of resources brings two types of constraints to the network configuration. On the one hand, it limits the size of total population—i.e. it limits the agent set. On the other hand, it limits the connectivity of the network—i.e. it limits the edge set. Let me start by defining the relation between population size and resource availability. In order to do this, I will distinguish between the capacity to exploit ecosystem resources by societies that had access to agriculture—i.e. *agricultural societies*—and those that did not—*hunter-gatherer societies*.

Hunter-gatherer societies did not have access to agriculture. They followed seasonally available resources. Thus, in terms of resource distribution, they faced a given stock of resources. In particular, consider that the ecosystem had \(Y \in \mathbb{R}_+\) amount of natural resources, and let \(Y^i : Y \times N \to \mathbb{R}_+\) be the amount of natural resources available

\(^3\)Authors such as [Hamilton et al. (2007)](http://example.com), [Dyble et al. (2016)](http://example.com), and [Salali et al. (2016)](http://example.com) describe multilevel interactions as an essential aspect of hunter-gatherers, pointing out its role as a mechanism for transferring knowledge and food
for the individual \(i\), with \(Y_i'(Y, n) > 0, Y_i''(Y, n) < 0, Y_i'(Y, n) < 0, Y_i''(Y, n) > 0, Y_i'(Y, n = n_{\text{max}}) = Y_{i_{\text{min}}}\), and \(\lim_{n \to 0} Y_i(Y, n) = \infty\). Put it differently, the amount of natural resources per capita decreased with group size, until the ecosystem reached its carrying-capacity, \(n_{\text{max}}\), over which larger group sizes were not viable.

Agricultural societies were able to transform the ecosystem, producing additional resources. I consider a simple relation between group size and natural resources. Specifically, consider \(n = AY\), where \(A\) is a technological parameter\(^5\). Thus, the amount of resources available for an individual \(i\) was \(Y_i = 1/A\), which was independent of group size. Intuitively, \(Y_i\) was the subsistence consumption level.

To consider the constraints that resource availability put to the connectivity of the network, notice that individuals can only benefit from their endowments by forming a connection to someone else. Therefore the cost of the first connection between each pair of agents cannot come from the endowment, it must be covered by the natural resources available. Posterior connections can be covered by the profits of the first connection. Therefore, for a set of links to be viable, it is sufficient that \(c\)–which is a link’s cost starting from an empty network–is less or equal to \(Y_i\).

In summary, Definition 4.1 show the conditions that make a network viable.\(^7\)

Definition 4.1. Viable society

\[ A \text{ network } g \text{ is a viable society if } n \leq n_{\text{max}} \text{ and } c \leq Y_i. \]

5 Equilibrium

Societies in equilibrium should have been stable from a network perspective and viable from an economic one. Definitions 5.1 and 5.2 formalize this idea and Figure 3 offers a \(^4\)This conception of carrying-capacity ignores storage technologies, as well as cyclical patterns in resource supply.\(^5\)It is easy to show that this is a reduced form of a Malthusian economy, with a fixed factor of production, in steady state (see Ashraf and Galor 2011). \(^6\)Underlining this idea there is the assumption that every agent values resources in the same way and resource units are equivalent to utility units. Formally, this is equivalent to incorporate natural resources in the utility function in a quasilinear manner. \(^7\)In addition to environmental constraints, it is feasible that biological limitations of the human brain could limit the size of the network (??). I will ignore this potential issue.
Definition 5.1. Equilibrium society

A tuple \( W = (g, c, Y^i) \) is an equilibrium society if \( g \) is pairwise stable, \( n \leq n^\text{max} \), and \( c \leq Y^i \)

Definition 5.2. Equilibrium groups A clique of size \( S^* \) is an equilibrium group if there is an equilibrium society with a network composed by cliques of such size.

Based on the definitions of equilibrium, the model sheds light on the determinants of tribal configuration. The essential aspect in the analysis is the number and size of equilibrium groups. In particular, the minimum and maximum group size, namely \( S^\text{min} \) and \( S^\text{max} \).

[Figure 3 here]

Proposition 2 presents the conditions that characterize social complexity in the model. First, it describes that there are several ways in which society can be configured. An equilibrium society would still be so if, keeping the same network structure, agents are exchanged. This implies that tribal stability and viability do not depend on the attributes of individuals. Both homogeneous and heterogeneous tribes could have flourished. Second, the model claims that both agricultural and hunter-gatherer societies could have reached complex structures. However, given the same ecosystem, having access to agriculture should have enabled the emergence of larger and more complex societies. Finally, Proposition 2 indicates that social complexity is a function of the cost of distant interactions. In contexts in which interacting with people from different tribes was either too cheap or too expensive, only simple societies should have emerged. Only if interaction costs were moderate, complex societies were equilibria, and in such cases, the minimum group size increased with interaction costs.

Proposition 2. Social complexity

1. If network \( g' \) has the same topology as network \( g \) and \( W = (g, c, Y^i) \) is an equilibrium society, then \( W' = (g', c, Y^i) \) is also an equilibrium society.

2. In both hunter-gatherers and agricultural societies, \( \exists (c, Y^i) \) with \( Y^i_{\text{min}} \leq c \leq Y^i \), such that complex societies are equilibrium societies.
3. For all \((c, Y^i)\) with \(c \leq Y^i\), agricultural societies have larger \(S_{\text{max}}^*\) than hunter-gatherer societies.

4. For complex societies, \(S_{\text{min}}^*\) is an increasing function of \(c\).

5. If \(c \leq Y^i < (\delta - \delta^2)\) or \(n(\delta - \delta^2) < c \leq Y^i\), no complex society is an equilibrium society.

Proof. (1) It follows from the symmetric utility function \[2\]

(2) It follows from noticing that if \(\delta - \delta^2 < c = Y^i < \frac{n-K}{K}(\delta - \delta^2)\) complex societies are stable and viable.

(3) It follows from noticing that resources per capita are independent of group size in agricultural societies. As the cost of forming a link reduces with the support, infinitely large cliques will always be feasible. Meanwhile, in hunter-gatherer societies, ecosystem’s carrying-capacity constrains the maximum size of groups to a finite number.

(4) From the stability condition of complex societies it follows that \(S_{\text{min}}^*\) is the closest natural number to the right of \(\frac{c+(\delta-\delta^2)}{(\delta-\delta^2)}\) on the number line.

(5) It follows from the stability conditions of Proposition \[1\] \qed

The model also claims that under certain circumstances society could collapse completely– i.e. no social connection is stable or viable. In particular, if the carrying-capacity of a location was too low, any social configuration of hunter-gatherer societies was non-viable. Meanwhile, agricultural societies could have existed in any environmental condition. The collapse of agricultural societies must have come from extremely high interaction costs–i.e. \(c > Y^i\). Proposition \[3\] formalizes these conditions.

**Proposition 3.** Societal collapse

1. In hunter-gatherer societies, there is at least one value for \(c \leq Y^i\) such that all equilibrium groups are of size \(S^* \leq 1\), for all \(Y^i \geq Y^{imin}\).

2. In agricultural societies, for all \(c \leq Y^i\) there is at least one equilibrium group of size \(S^* > 1\).

Proof. (1) It follows from noticing that one-man society is a trivial stable network. If \(Y^{imin} \leq c \leq Y^i\), one-man society is also viable, thus, it is an equilibrium society.
(2) It follows from noticing that resources per capita are independent of group size. As the cost of forming a link reduces with the support, very large cliques will always be feasible.

6 Concluding Remarks

In this paper, I propose an explanation of tribal-society stability without any institutional or cultural assumption. This explanation fits a basic regularity that has been ignored by the theoretical literature in the field: the heterogeneity of tribal societies. As my model predicts, there is abundant evidence that tribal societies could have been stable and viable under several institutional conditions and different cultural features. In addition, the model sheds light on the forces behind complexity and societal collapse.

In the model, three elements determine tribes complexity. First, technological development. The model claims that both agricultural and hunter-gatherer societies could have reached complex structures. However, given the same environmental conditions, having access to agriculture should have enabled the emergence of larger and more complex societies. Second, environmental conditions. Under certain circumstances, poor ecosystems should not have allowed the formation of complex societies. Third, interaction costs. In contexts in which interacting with people from different groups was either too cheap or too expensive, only simple societies should have emerged. Only if interaction costs were moderate, complex societies were equilibria, and in such cases, the minimum group size increased with interaction costs.

The model also claims that under certain circumstances societies could have collapsed. In particular, if the carrying-capacity of a location was too low, no social configuration of hunter-gatherer societies would have been viable. Meanwhile, agricultural societies could have existed in any environmental condition. The collapse of agricultural societies must have come from extremely high interaction costs.

In this way, this paper contributes to a better understanding of how humanity could flexibly cooperate in increasing larger and more complex groups, which has been shown as an essential aspect of its evolutionary success (Harari and Perkins 2017). Moreover, the paper brings new elements to the discussion on social collapse, which has been dominated by environmental concerns. Regardless ecological conditions, the model claims that constraints to communicate and interact with others could have led to societal collapse. These two issues are relevant nowadays in a context in which

Therefore, this paper is only the first step in a broader agenda. The most immediate next step is to test empirically the model’s predictions. Even though these predictions fit basic narratives on human history, it is necessary to prove that they were true regularities in the data. The recent systematization of world-wide data by paleontologists and ethnographers make it a promising endeavor. Additional steps are the exploration of the consequences of economic inequality and of additional technological boundaries in the configuration of tribes.

References


7 Figures

Figure 1: Cliques in stable networks

Note: This figure presents the relation between the size of cliques (vertical axis) and the cost of distant interactions (horizontal axis). Grey areas represent stable networks composed by cliques of size $S$.

Figure 2: Environmental constraints

Note: The left-side figure presents the relation between population and per capita resources in a hunter-gatherer society. The right-side figure presents the relation between population and per capita resources in an agricultural society.
Figure 3: Equilibrium groups

Note: These figures present the values of \( c, Y^t, \) and \( S \) for equilibrium groups in a given situation. The left-side figure presents a case for a hunter-gatherer society. The right-side figure presents a case for an agricultural society.