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Entropy and War, Toy Models

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Abstract

This study investigates the relationship between entropy and societal dynamics, with a particular focus on the origins and implications of war. By using entropy as a measure of uncertainty and inequality, the research examines societal stability through patterns of stratification and wealth distribution. Employing simplified models of various wealth distributions, the study explores their effects on social stratification and the potential for conflict. Drawing on historical and contemporary examples, it delves into the interplay between resource limitations, societal stratification, and the likelihood of war. The findings suggest that entropy provides a valuable framework for understanding the stability of civilizations, offering a novel perspective on addressing inequality and fostering societal resilience. Notably, the role of elites in shaping conflict dynamics within the current Pareto distribution of wealth is highlighted as critically important. As stewards of societal prosperity, elites bear the responsibility of managing entropy growth through means other than war. A conflict would be justified only if they fail to achieve this objective through alternative methods, such as economic growth.

Keywords

Water-energy-food nexus; resources; social stratification; entropy; economy; growth; human progress

Εἰρήνη ὑμῖν.
(Καινή Διαθήκη, Ευαγγέλιον Κατά Λουκά, κδ, 36· Κατά Ιωάννη, κ, 19).

Peace be with you.
(New Testament, Gospel Luke, 24:36; John, 20:19) [1].

1. Introduction

The current phase of civilization is highly critical, as the world must choose whether to thrive or face collapse in the aftermath of a nuclear holocaust.

Civilization, derived from the Latin “civitas” meaning “city,” [2] signifies societies characterized by organized communities [3], permanent settlements, and shared cultural attributes such as traditions, laws, and artistic achievements. Its foundation lies in the transition from nomadic lifestyles to agricultural practices, enabling resource exploitation, hydraulic works for water and energy, and the development of complex structures [4]. This shift required specialization, trade, and central management, fostering social stratification. Karl August Wittfogel emphasized the role of hydraulic systems in shaping civilization, as their construction necessitated specialized knowledge and bureaucratic control, often leading to hierarchical governance systems [5].

Stratification generally refers to the variability in people's access to resources. The fundamental resources for survival, water, energy, and food—are often simplified in modern society as money, which provides access to these necessities. However, since money is not a stable measure, societal stratification is also assessed using alternative indicators, such as the size of settlements.

Currently, numerous conflicts around the world have the potential to trigger a rapid collapse of civilization. The worst-case scenario involves nuclear war. Other potential scenarios include an electromagnetic pulse (EMP) [6], disruptions to underwater communication cables [7], or damage to other critical infrastructure [8].

Carl von Clausewitz, Niccolò Machiavelli, and Karl Marx offered distinct perspectives on the origins of war.

Carl von Clausewitz viewed war as an extension of political objectives. In his seminal work “On War” [9], he famously stated: "War is … a continuation of policy by other means". Niccolò Machiavelli approached war from the standpoint of statecraft and power dynamics. In The Prince, he argued that rulers must be prepared to engage in war to maintain their states and achieve political stability. Machiavelli asserted that the readiness and ability to wage war are essential for a prince to secure and preserve power [10]. Karl Marx interpreted war through the lens of class struggle and economic interests. He posited that wars are often the result of underlying economic conflicts between different social classes. Marx and Engels, believed that the ruling class uses war to further its economic interests and suppress the proletariat, viewing war as an instrument to perpetuate existing class structures [11]. These perspectives collectively highlight that the origins of war can be attributed to a complex interplay of political objectives, power struggles, and economic interests.

In order to do our approach, we will use entropy as a tool. The concept of entropy, originating from thermodynamics and information theory, has been increasingly applied in social sciences to analyze economic inequality and conflict dynamics. In "Entropy and Wealth," Koutsoyiannis and

Sargentis [12] argue that entropy, defined as a measure of uncertainty, can be utilized to describe income distribution within societies objectively. By applying the principle of maximum entropy to publicly available income data, they demonstrate that income distribution aligns with this principle, suggesting that higher entropy correlates with increased societal wealth. This approach provides a novel perspective on wealth distribution, challenging traditional measures like the Gini coefficient and offering a more nuanced understanding of economic disparities [13].

In conflict studies, entropy has been employed to explain the occurrence and intensity of intrastate conflicts. Trinn's research [14] posits that such conflicts can be viewed as 'eruptive' forms of social fissioning, where the political system imposes entropy on economic and cultural systems, leading to discontinuous outbursts. These outbursts collectively follow a power-law distribution, indicating that conflicts are not random but exhibit patterns that can be analyzed through the lens of entropy. Related perspectives [15-18] enhance our understanding of the underlying mechanisms driving social unrest and highlight the potential of entropy-based models in predicting and mitigating conflict.

Stochastic processes play a pivotal role [19-21] in entropy calculations across various domains. Entropy inherently quantifies uncertainty within a system, making it a fundamentally stochastic concept [12]. This probabilistic approach provides a new interpretation of economic inequality, enabling the identification of low-entropy instances that may signal societal instability or potential conflict as “The entropy of the world strives to a maximum” [22].

By embracing the stochastic nature of entropy, researchers can develop more robust models that capture the complexities of social and economic systems, leading to more effective policy interventions.

The highlights of this study are:

- Entropy as a Lens for Societal Stability: The study explores how entropy, which is a measure of uncertainty, can be applied to understand societal stratification, wealth distribution, and the potential for conflict.
- Origins of War and Resource Limitations: War is examined through an entropic perspective, linking it to sudden resource constraints and inequalities that destabilize societies.
- Role of Elites in Conflict Dynamics: The paper highlights how elites in a Pareto wealth distribution play a crucial role in either maintaining peace through economic growth or justifying war when alternative strategies fail.

In this study, we describe human needs using the foundational levels of Maslow's hierarchy [23]. By considering an abstract concept of wealth in a toy model, we examine how these needs are met across five basic types of stratification. Every kind of stratification is evaluated from an entropic perspective, revealing that some types, such as exponential distributions, perform better than gamma and Pareto distributions.

Additionally, we observe that increasing wealth is associated with an increase in entropy. When evaluating the stability of these distributions under sudden resource limitations, we find that as entropy decreases, the stability of the distributions becomes compromised. Although gamma and Pareto distributions present challenges from an entropic perspective, both have appeared in social structures—gamma distributions in hunter-gatherer societies and Pareto distributions in contemporary societies.

Our toy models indicate that Pareto distributions while exhibiting higher entropy values, are particularly vulnerable to sudden resource constraints. This highlights the critical role of elites within Pareto distributions in maintaining societal stability and preserving peace.

2. Methodology

This study employs a multi-step methodology that integrates toy models to explore the connections between entropy and war. The methodology involves the following steps: (i) Description of human needs, (ii) Description of various types of stratification, (iii) Development of toy models representing the distribution of wealth in different types of stratification, (iv) Evaluation of the wealth distributions in these toy models from an entropic perspective, alongside standard tools such as the Lorenz curve and Gini index, (v) Explanation of the dynamics of war through an entropic lens.

Entropy is the primary analytical tool used in this study. However, since the term "entropy" has been employed with varying interpretations, the following section will clarify its' stochastic definition which is applied in this analysis and contains both thermodynamic and information entropically perceptions [12].

Contrary to the common perspective, entropy is not a disorder; it is a measure of uncertainty. When we have a discrete stochastic variable $\underline{x}$ with probability mass function $P_j \equiv P(x_j)$,

(a) It is possible to set up a numerical measure Φ of the amount of uncertainty which is expressed as an actual number.

(b) Φ is a continuous function of P_j.

(c) If all the P_j are equal ($P_j = 1/\Omega$) then Φ should be a monotonic increasing function of Ω.

(d) If there is more than one way of working out the value of Φ, then we should get the same value in every possible way.

From these general postulates about uncertainty, a unique (within a multiplicative factor) metric Φ results, which serves as the definition of entropy (Equation 1):

$$\Phi[\underline{x}] \coloneqq \mathrm{E}[-\ln P(\underline{x})] = -\sum_{\mathrm{j}=1}^{\Omega} \mathrm{P_j} \ln \mathrm{P_j} \tag{1}$$

While for constant background density equal to the inverse of the monetary unit (i.e. $1/\lambda$ with λ equal e.g. to 1 \$) the entropy provides a measure of society's wealth (even if x expresses income), if we change the background measure to the value $1/\mu$, where μ is the mean income, the thus calculated entropy is a measure of inequality. Calling the latter quantity standardized entropy and denoting it as $\Phi_\mu[\underline{x}]$, we get the Equation 2:

$$\Phi_\mu[\underline{x}] = \Phi[\underline{x}] - ln\frac{\mu}{\lambda} \tag{2}$$

This has been recently introduced as an index of inequality by Sargentis et al. [24] (albeit denoted as $\Delta\Phi[\underline{x}]$).

The entropic perspective on social dynamics proposes the following:

1. In the same distribution:

a. when the average income of people increases in real terms (economic growth), the entropy Φ also increases.
b. Conversely, when the average income decreases, the entropy Φ declines.

2. An exponential distribution represents the optimal distribution, achieving maximum standardized entropy.

As entropy is related to transformation and change, the evaluation of distributions with an entropic mindset, follows the Clausius' famous aphorism [22]:

"Die Energie der Welt ist constant. Die Entropie der Welt strebt einem Maximum zu."
(The energy of the world is constant. The entropy of the world strives to a maximum).

However, entropy is rarely used to evaluate distributions. Therefore, this study also incorporates two well-known measures of socio-economic inequality: the Lorenz curve [25-28] and the Gini index [29-31].

3. The Needs

Income is typically measured in monetary units such as dollars, euros, or other currencies. However, money is only valuable insofar as it provides access to basic needs, as outlined in the initial levels of Maslow's hierarchy [23] (e.g., water, energy, food [32-34], and shelter) (Figure 1). Money, however, is a subjective measure, varying not only across historical periods [35] but also simultaneously across different countries, as was noted by Sargentis and Koutsoyiannis [13]. Consequently, because the same amount of money offers differing levels of access to resources in different contexts, it cannot be considered a stable metric.

Figure 1 The initial steps in the pyramid of Maslow.

Social groups often operate with their forms of currency, and membership in such a group allows individuals to exchange these currencies or engage in collective work to increase the group's overall wealth. Furthermore, the use of a specific currency within a group ensures equal access to resources among its members.

Therefore, in the following analysis, we conceptualize income as an abstract measure of wealth (not necessarily tied to monetary currency) to quantify stratification within similar social groups and to facilitate the entropic evaluation across these groups.

The following steps of the Maslow pyramid are the need for security and, after that, the need for "belonging," which is also relative to the wealth of the group (Figure 1). These needs center around feeling connected, accepted, and part of a group or community. Even though these needs are often emphasized as the human desire for interpersonal relationships, love, and a sense of being valued by others, examples of belonging could include military culture and integration into military structures, especially in societies that are aggressive, militaristic, and operate within the logic of an imperialistic dynamic. Meeting these needs is essential for emotional well-being and helps individuals develop a sense of identity and mutual support within a community.

4. The Different Types of Stratification in Toy Models

It is difficult to distinguish the elite from the plebeians solely based on wealth. Social groups cannot be considered numerical models, as there are deeper motivations for money [36] and power [37]. Power is divided into legislative, executive, and judicial branches, which are exercised (theoretically) by distinct bodies or institutions, as defined by Aristotle [38] and Montesquieu [39]. However, the official narrative does not account for religion, sports teams, the mafia, the wealthy, or large corporations, all of which hold significant power and, in many cases, influence the elite. To simplify the model, we consider that stratification occurs solely based on the distribution of an abstract form of "wealth".

To present and evaluate the different types of stratification, we have created the following theoretical toy models. We assume a group of 500 members, all sharing the same total abstract "wealth" of something (water, energy, food, gold, money), which is distributed as follows: random (Figure 2); normal (which tends to equality) (Figure 3); exponential (Figure 4); Pareto with significant inequalities (Figure 5); and gamma with minor disparities (Figure 6).

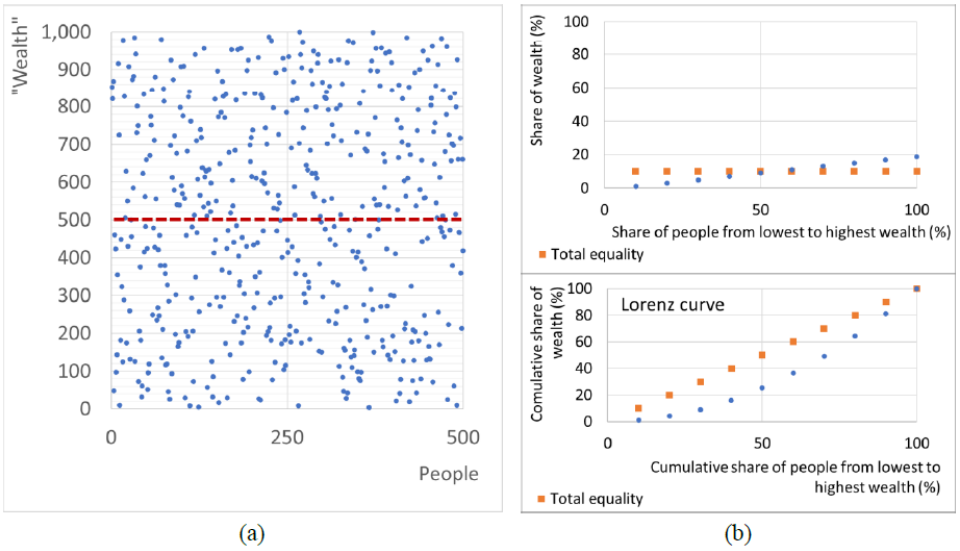

Figure 2 Random distribution. Mean = 502, Φ = 6.8, Φ_μ = 0.57, Gini = 0.33. (a) People correlated with "wealth", with the mean "wealth" indicated by the red dashed line. (b) Top: Tenths of the share of available income; Bottom: Lorenz curve.

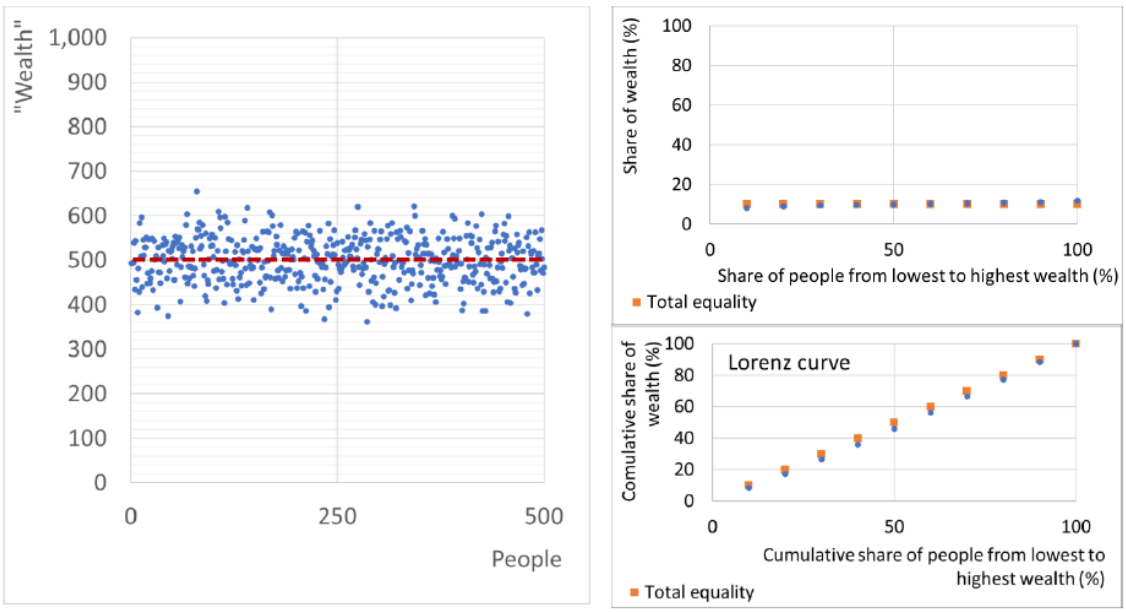

Figure 3 Normal distribution which tends to equality. Mean = 500, Φ = 5.21, Φ_μ = -1.01, Gini = 0.05. (a) People correlated with "wealth", with the mean "wealth" indicated by the red dashed line. (b) Top: Tenths of the share of available income; Bottom: Lorenz curve.

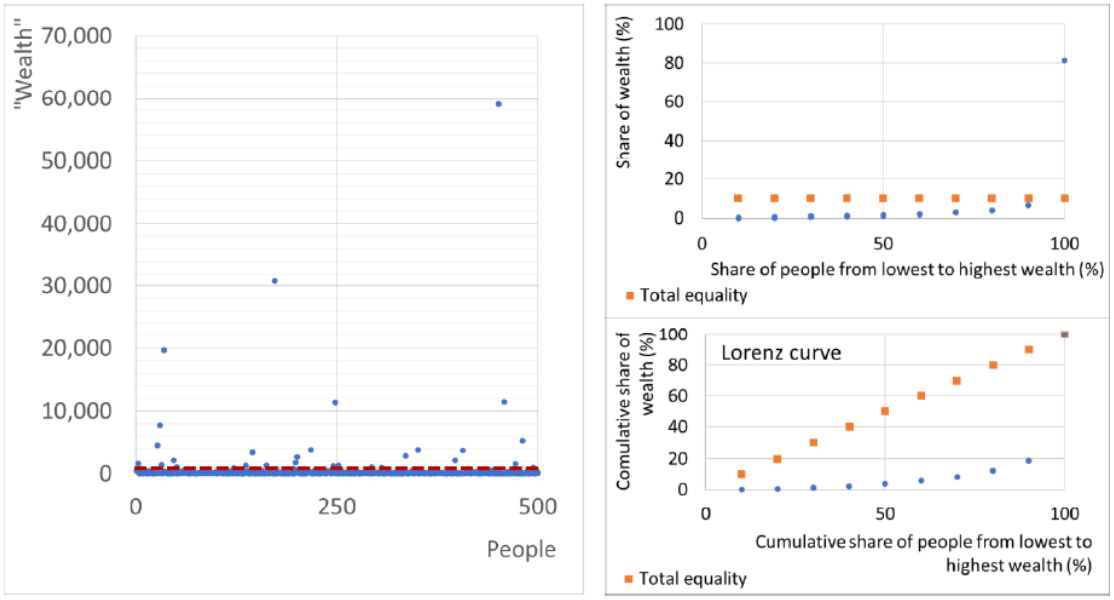

Figure 4 Pareto distribution. Mean = 500, Φ = 6.80, Φ_μ = 0.29, Gini = 0.79. (a) People correlated with "wealth", with the mean "wealth" indicated by the red dashed line. (b) Top: Tenths of the share of available income; Bottom: Lorenz curve.

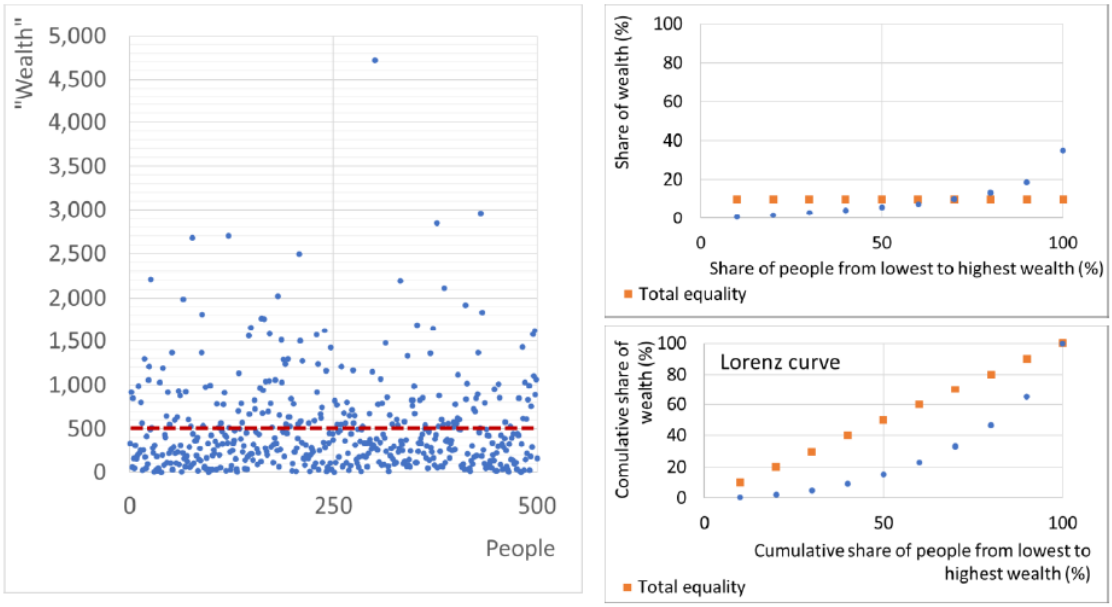

Figure 5 Exponential distribution. Mean = 500, Φ = 7.11, Φ_μ = 0.93, Gini = 0.5. (a) People correlated with "wealth", with the mean "wealth" indicated by the red dashed line. (b) Top: Tenths of the share of available income; Bottom: Lorenz curve.

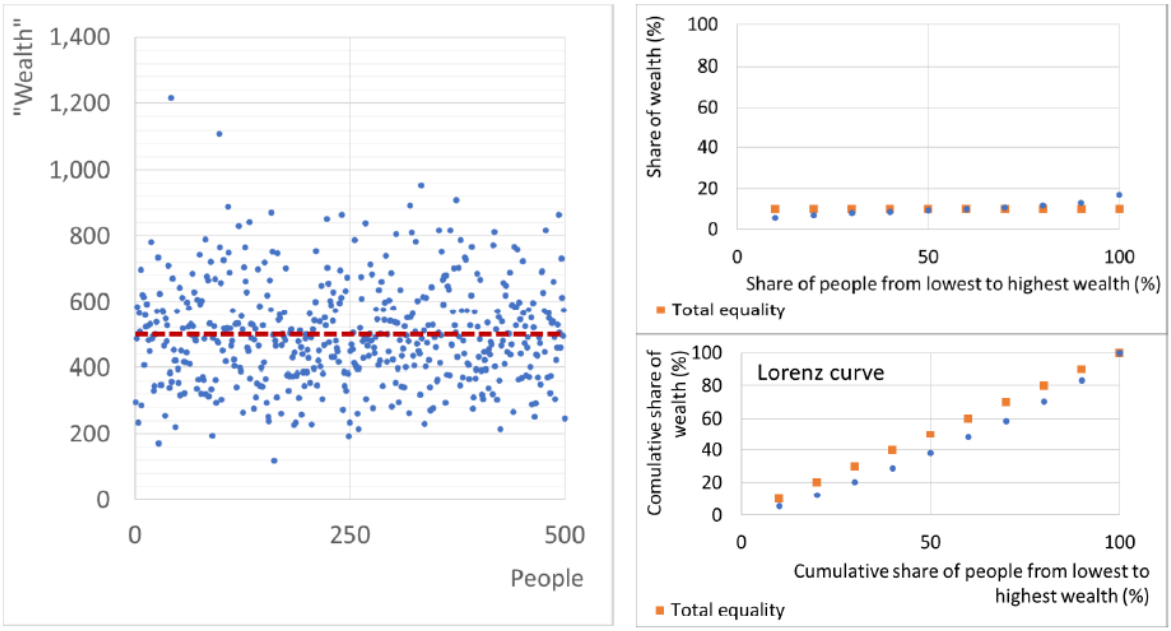

Figure 6 Gamma distribution. Mean = 500, Φ = 6.33, Φ_μ = 0.12, Gini = 0.17. (a) People correlated with "wealth", with the mean "wealth" indicated by the red dashed line. (b) Top: Tenths of the share of available income; Bottom: Lorenz curve.

In the following examples, we plot how "wealth" is distributed among the people, and we have divided the population into percentages to perform the necessary calculations. With this discretization, we calculated the Entropy (Φ) and the standardized entropy, which could be used as an index of inequality (Φ_μ). In addition, we have used the commonly used tenths of share to estimate the Gini index and to plot the Lorenz curve.

The results of the above distributions are summarized in Figure 7.

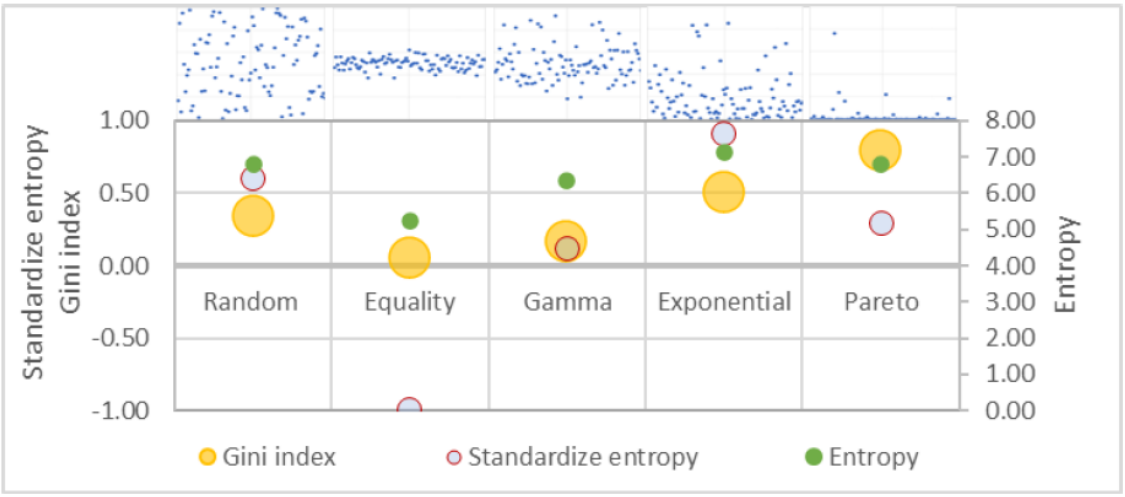

Figure 7 The results of Entropy, Standardize entropy and Gini index, with the same abstract "wealth" (250,000) in the toy-models of: Randon, Normal (tending to equality), Gamma, Exponential and Pareto type distributions.

In the Soviet Union, the Gini index was approximately 0.29-0.30 [40]. A theoretical "communist society," which tends toward equality, is depicted in the normal distribution of Figure 3, where the Gini index approaches 0. This scenario has a negative standardized entropy, indicating that it is a precarious situation, even though most people are in better conditions than in a Pareto distribution with the exact total "wealth". The so-called Gamma distribution in our toy model (the type of distribution that we would say socialist) has an entropy of Φ = 6.33, a standardized entropy of 0.12, and a Gini index of 0.17.

Considering the exponential type of distribution, we observe that its entropy (7.13 and 6.8, respectively) and its standardized entropy are higher than in the Pareto distribution (0.91 and 0.29, respectively) and theoretically, standardized entropy tend toward the maximum value of 1.

5. Prehistoric Economies

5.1 Animals and Hunter-Gatherers

Social stratification in animal groups often manifests as dominance hierarchies, where some members occupy ranked positions that influence access to resources such as food, mates, or shelter. Animals perceive hierarchy differently depending on their species, social structure, and ecological context. Broadly, their perception can fall along two extremes [41]:

1. Dominance by an elite: In some species, such as wolves, hyenas, or macaques, hierarchy functions as a power structure where a few dominant individuals have preferential access to resources. Subordinates accept their position through submissive behaviors (e.g., bowing, avoiding eye contact) to minimize conflict. This resembles a system where an elite "rules" over the rest of the group [42]. However, even some species, like wolves, which are ruled by the dominance of the elite, are very carefully limited in the borders of their area, as shown by the Voyageurs Wolf Project [43], which studies wolves and tracked wolf territories based on intensive GPS location (Figure 8a).

2. Socialist-like societies of mutual aid: In other species, such as some primates, elephants, or dolphins, hierarchy is more fluid and cooperative. Social bonds, reciprocal grooming, and support during conflicts suggest a system where individuals share resources and responsibilities to maintain group cohesion. Here, hierarchy serves as a framework for collaboration rather than exploitation [44].

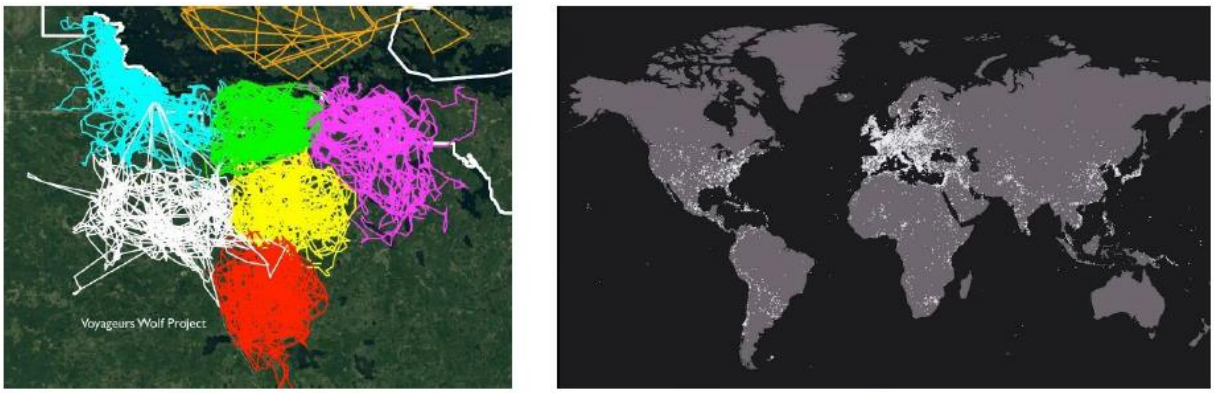

Figure 8 (a) Wolf territories based on intensive GPS location [45]. (b) Map of every battle that has taken place since 2500 BC [46].

In both social extreme formations of animals' stratification, we do not observe wars between groups, but humans made the difference. Figure 8b indicates the map of every battle that has taken place since 2500 BC according to Wikipedia (10,624 battles).

The broader picture of the Gini index in prehistoric societies is presented by Fochesato et al. [47], and the evolution of the Gini index is discussed in a related paper by Kohler et al. [48]. In our case study, the random distribution of "wealth" leads to stratification with a Gini index of 0.33. In hunter-gatherer societies, the estimated Gini index of 0.17 corresponds to a gamma distribution with minimal inequalities. Interestingly, we observe a stratification that is not obvious, as it has a significantly lower standardized entropy (0.12) compared to the random distribution (0.57).

In a random distribution, considering a sudden limitation of resources (e.g., a 20% reduction), this would primarily affect the weaker members of the group and could potentially jeopardize 10% of the group (Figure 9a). In contrast, in a gamma distribution, although the entropy perspective may not highlight it as clearly, it is more reliable in this case. Even if income decreases, the members will not starve to death (Figure 9b). This suggests that cooperative rules, which reduce stratification, could be crucial for the survival of group members, emphasizing the importance of cooperation over dominance. Early humans likely made efforts to establish such rules.

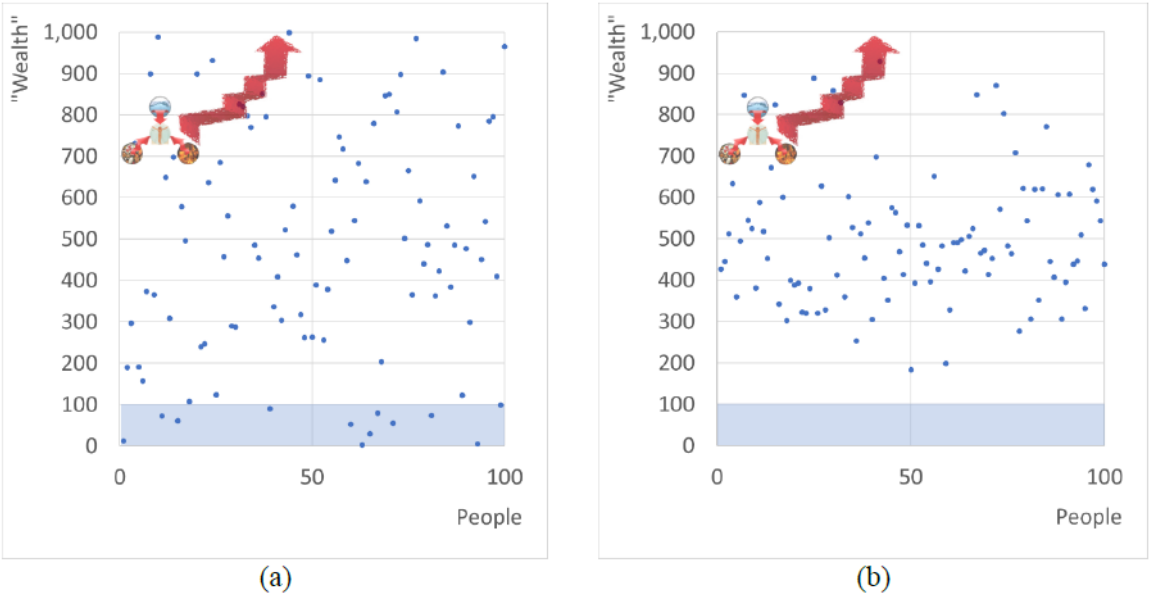

Figure 9 Limitation of 20% in a group of 100 people with average “wealth” equal to 500. (a) Random distribution. (b) Gamma distribution.

If we assume that these limitations occur analogously, it becomes more likely that losses will be shared and distributed throughout the population in a gamma-type distribution compared to a random distribution.

5.2 Minoans: The Endless Bell Epoch

Perhaps the most interesting period in history is the Minoan era, which could be considered as an endless "bell epoch." The Minoans were a highly advanced civilization that thrived for an extended period, from approximately 3000 BC to 1400 BC. During this time, the civilization remained largely isolated, as there were no technological advantages that allowed for interaction with other civilizations through warfare, aside from trade.

Although the isolated environment for more than 1500 years could be compared to the "Easter Island trap," Sargentis et al. [49] argued that this remarkable civilization managed to thrive due to its sophisticated social structure and wise elite.

Interestingly, Fochesato et al. [47] estimate the Gini index of the Minoans to be 0.5. corresponds to exponential stratification. The Gini index of an exponential distribution is always 0.5, regardless of the scale parameter. This property is characteristic of the exponential distribution due to its fixed functional form and constant hazard rate. The Gini index is derived from the Lorenz curve, which has a fixed shape for the exponential distribution, resulting in a continuous Gini coefficient of 0.5.

From an entropic perspective, this distribution appears to be the most stable, and we can hypothesize that if a system matures in an isolated environment, it will likely lead to exponential stratification. It is also important to note that exponential stratification is the result, from an entropic standpoint, of stratification when “wealth” is limited.

5.3 The War in Antiquity

Let's consider two primitive social groups. One has invested in collective work to build the necessary hydraulic infrastructures and has agriculture, resources, and storage capacity, while the other lacks these. The latter group recognizes that it is easier to acquire resources than to build the necessary infrastructure, cultivate crops, and perform all the work required to obtain them. In the event of a sudden limitation of resources in the latter group (where entropy decreases), this could be vital, as the creation of resources requires labor, preparation, and time [50].

Kohler et al. [48] argued that the increase in available energy (e.g., the use of animals) in agrarian societies and the progress of technology in ancient times are related to the rise in inequality and stratification, which led to the accumulation of "wealth", the formation of advanced warriors, etc. In these societies, the limits of the exploited areas also imposed limitations on available resources. As explained earlier, a limitation of resources, from an entropic perspective, leads to exponential stratification. However, we also observe that inequality triggered Pareto-like distributions [51], which were identified as early as 1930 BC in Ancient Egypt (Gini index 0.68) [52].

Roser [53] noted that antiquity was characterized by a zero-sum economy. Therefore, the group lacking resources would have had the option to wage war to seize resources from the group that had them. As resources were limited and people sought new sources, another option was colonization, which became the new norm. Even though population density was very low, it is possible that wars in distant colonies were not morally justified by the ancestors. In the very first written poem by Homer, Iliad [54], the cause of the Achaeans' attack on the Trojans was attributed to the abduction of Helen the Fair, rather than the desire to seize wealth and resources [55].

The Gini index in Classical Athens is estimated to be about 0.38 [56]. When comparing ancient Macedonian society to other Greek cities, the ancient Macedonians seem to have had a more intensely stratified society. A small portion of the population was royalty, nobility, and companions (Heraitoi), while the majority consisted of citizen-soldiers, not farmers, artisans, or merchants [57]. This suggests that the priority of this society was not to acquire resources through peaceful means but through domination and war. In their culture, it seems the ancient Macedonians took a reverse path in Maslow's pyramid (Figure 10a), prioritizing "belonging," which shaped their military, to acquire primary resources.

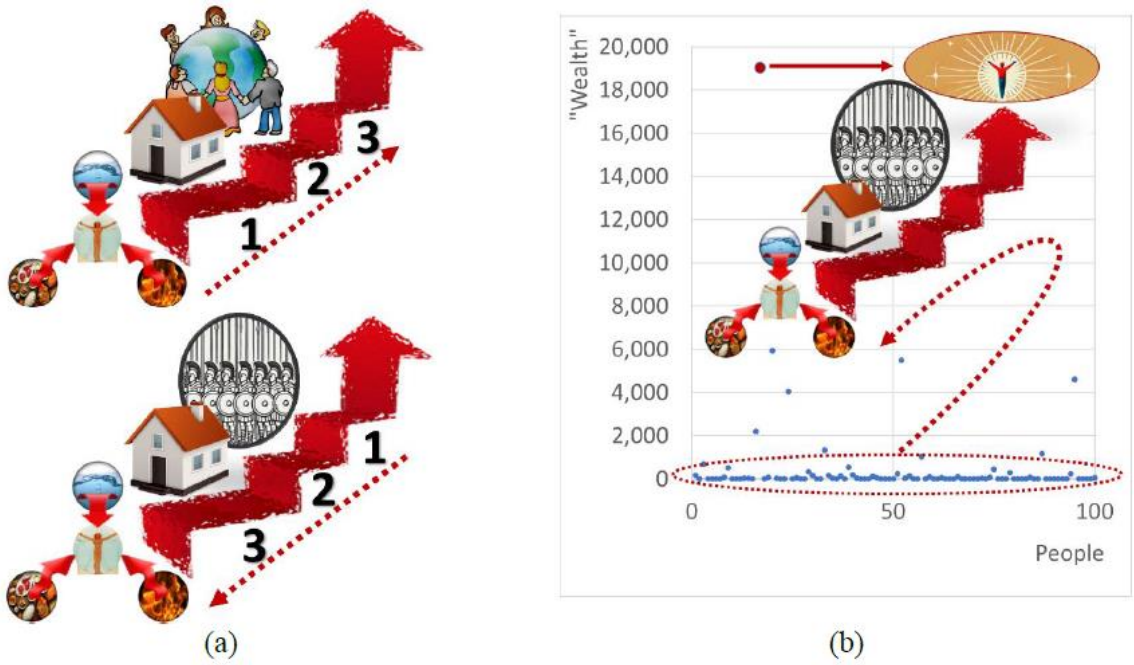

Figure 10 (a) Top: The first steps in the Maslow pyramid; Bottom: The reverse of the Maslow pyramid, as depicted by Macedonians. (b) An explanation of the aggressive dynamic in Pareto distribution in a group of 100 people.

The wars of Alexander the Great were significant, not for practical reasons, but for glory, possibly gold, and goals that align with the top of the Maslow pyramid, described as self-actualization (Figure 10b). History has justified these wars as a "legacy" to the world [58, 59]. Still, it is striking how brutally Alexander the Great sliced through the Gordian Knot with his sword [60] (which was likely an artwork), his desire to be worshiped as a god [61] by the conquered, and his greed to dominate the entire known world of that era. Contrary to these practices, there were other tribes with strong military cultures, such as Sparta, which opposed the imperialistic wars (on that scale) as they were self-sufficient and frugal.

The impressive aspect is how the elite persuades people to risk their lives for a subjective purpose. This could be justified in a Pareto-type distribution, where the leader may not be innovative enough to implement a "growth" strategy and increase entropy, within a framework of peace. Therefore, war could become a tool for maintaining dominance firstly in his group (Figure 10b).

From an entropic perspective, the domination of other groups leads to an increase in average "wealth", which also increases entropy. Since entropy must be maximized, a society that aims to increase its "wealth" and entropy, could become aggressive. For example, if we consider a Pareto distribution with a mean of 500, the entropy Φ would be equal to 6.8, while the same distribution with a double mean would have an entropy Φ equal to 7.49.

During the same era as the Ancient Macedonians, the Roman Empire preferred to achieve Pax Romana through large infrastructure projects and growth [62, 63]. From this perspective, the Roman Empire generated a growth dynamic that increased entropy, thereby enhancing the stability of the society and allowing it to last about 1000 years—contrasting with Alexander the Great, whose impact was a brief flash in history.

6. Discussion

The Pareto distribution is the most sensitive and vulnerable, as the elite (represented by the red dot in Figure 11a) are very far from the rest of the population. A significant problem with this distribution is that, because the elite is so distant from the people, it becomes difficult for the masses to communicate their concerns to the elite without causing unrest.

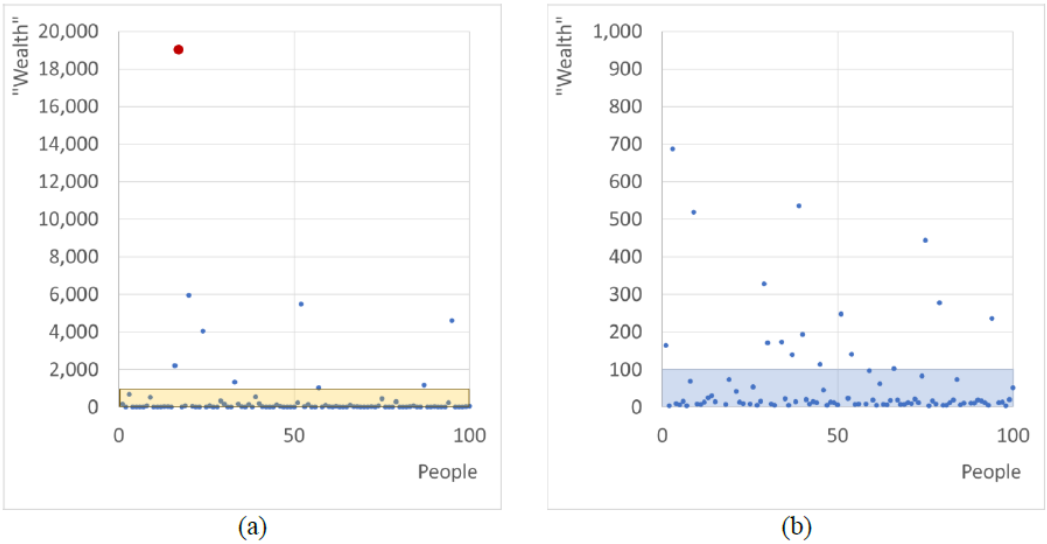

Figure 11 Limitation of 20% in a group of 100 people with average "wealth" equal to 500. (a) Pareto distribution. The top of the elite is marked with a red dot, and the yellow area highlights the window of the diagram showing the base of the distribution. (b) The base of Pareto distribution (values 0-1000).

With the same "wealth" as in previous examples, most of the population would live in poverty (compared to other distributions). Furthermore, a sudden limitation of resources (for example, a 20% reduction) would jeopardize the lives of 72% of the population (Figure 11b). When comparing the Pareto distribution to the exponential distribution, we note that in the exponential distribution, the distance between classes is continuous (Figure 12a). A possible limitation of 20% of "wealth" would jeopardize 25% of the population, as shown in Figure 12b, indicating more resilience than the Pareto distribution.

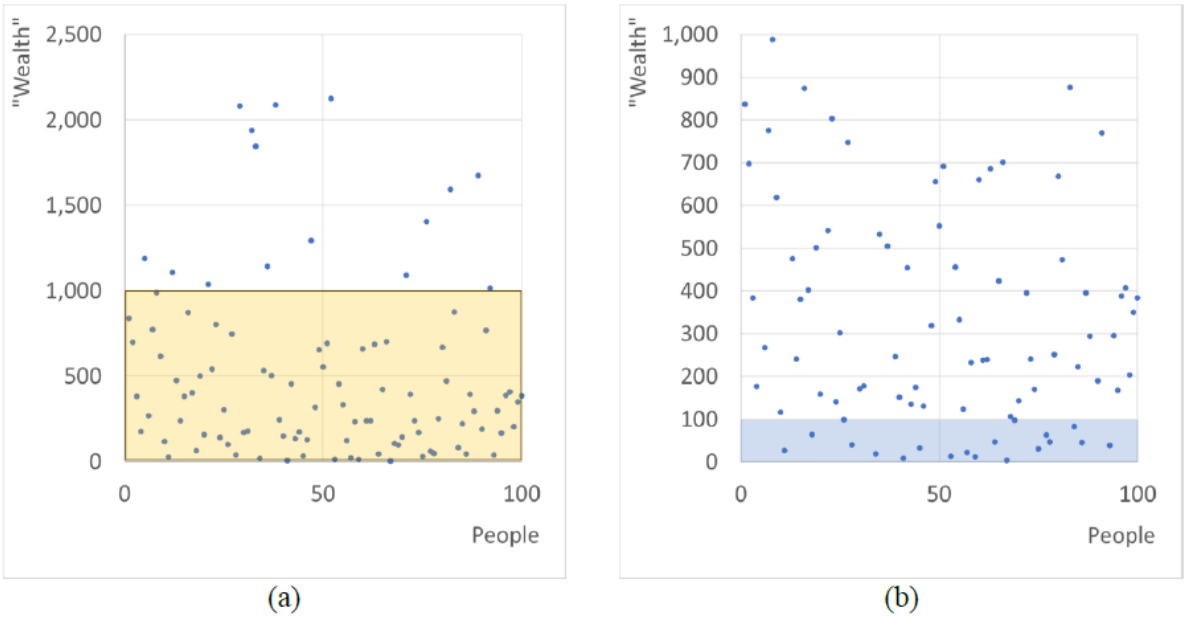

Figure 12 Limitation of 20% in a group of 100 people with average "wealth" equal to 500. (a) Exponential distribution. The yellow area highlights the window of the diagram showing the base of the distribution. (b) The base of exponential distribution (values 0-1000).

The commonly used data on income distribution (tenths of share in databases) shows Gini values ranging from 0.17 (gamma distribution) to 0.5 (exponential distribution). However, it is common to see Gini values exceeding 0.5 in history [64]. Including the elite in present times, stratification has tended to follow a Pareto-type distribution. These conclusions are drawn from the distribution of wealth in the US (2016), which was estimated at 0.81 according to a recent report from Oxfam, which states that the wealthiest 1% now hold nearly twice as much wealth as the rest of the world combined over the past two years [65], and from a recent paper by Koutsoyiannis and Sargentis [12]. The visualization of global stratification, according to the Oxfam report, is presented in Figure 13, with the Gini index estimated at 0.88.

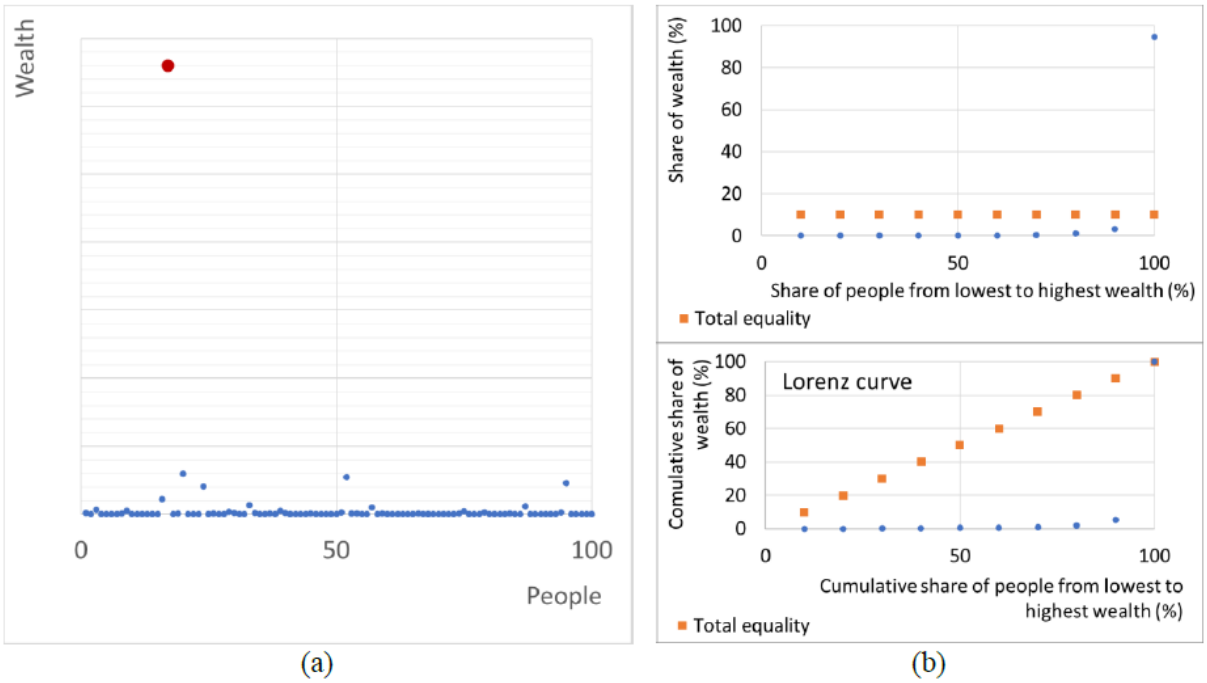

Figure 13 The present view of stratification in a group of 100 people. Gini = 0.88. (a) People correlated with wealth. (b) Top: Tenths of share of available income; Bottom: Lorenz curve.

Since the Pareto distribution with intense inequalities, is highly sensitive to changes and limitations of resources [66], it requires highly sophisticated management or constant growth (to increase entropy). For example, in Ancient Egypt, the wise Pharaoh listened to the advice of Joseph and stored food for difficult times to feed the population [67]. In the present day, growth is the only tool to increase entropy, but the sustainability of this growth needs trading, interactions, the management of a horrifying complexity, and a peaceful framework that is in question.

As the stability of societies has been closely linked to the nature of their wealth distributions, we note that in the early 2000s, when income distribution of wealth adhered to an exponential model [12], the global landscape was relatively peaceful, with few large-scale conflicts disrupting international stability [68].

In contrast, recent studies have highlighted a shift towards a Pareto [12], or power-law, wealth distribution, characterized by a significant concentration of wealth among a small fraction of the population. For instance, in 2024, the wealth of billionaires increased by $2 trillion, growing three times faster than in 2023 [69]. This escalating inequality has coincided with a rise in global conflicts and social unrest [70], suggesting a potential correlation between Pareto-like wealth distributions and societal instability.

Historical examples further illustrate this pattern. The late 19th and early 20th centuries, marked by pronounced wealth disparities akin to Pareto distributions, experienced significant social upheavals, including labor strikes and revolutions [71]. Conversely, periods with more equitable wealth distributions, such as the post-World War II era in many Western countries, saw sustained economic growth and relative social harmony. For example, in France, the share of total wealth held by the top 1% fell from around 55% at the start of World War I to approximately 30% by the end of World War II, benefiting the middle class [72]. These observations underscore the potential impact

of wealth distribution patterns on societal stability and the importance of striving for more equitable economic systems.

With the rapid advancement of technology in our era, it is challenging to consider today's system as "isolated" with a Malthusian perspective [73-75] like Minoans, as human progress leads to the continuous discovery of new resources (e.g., the increase in oil reserves [76]) and societies in present are far more efficient in their management (e.g., improvements in land-use efficiency for food production [77]). Within this framework, it is given that appropriate technological adaptations will be utilized by the most capable or the new elites that will emerge to create new social equilibria.

This becomes evident through the “green policies” implemented in the European Union. The rapid technological adaptation to green technologies and energy reliance on renewable sources, which have not yet resolved critical technological issues such as the intermittent nature of their production [78] and storage, increased the EU's energy costs [79]. Nevertheless, the EU's perspective was that through “green policies”, it would implement a New Green Deal [80]. Although this approach seemingly boosted money circulation in the European market, new products were consumed despite concerns that these policies could jeopardize long-term prosperity [81]. The fact that these technologies were immature turned Europe from a pioneer into a follower (Dunning–Kruger Effect [82]) and hostage of other economic actors who approached these technologies with caution [83, 84].

The above politics trigger a parallel with the societal collapse observed on Easter Island due to the creation of the Moai, the famous useless monuments that absorbed all the resources for some vague and futile competition among inhabitants [49], with the rather in vain and monumental constructions of wind turbines.

7. Limitations and Future Work

While the entropic perspective offers valuable insights into the stability of different wealth distributions, it is essential to acknowledge the limitations of the simplified models used in this study. The "toy models" employed, such as the assumption of a fixed wealth distribution, provide a controlled framework for exploring fundamental principles of stratification. However, real-world wealth distributions are influenced by numerous dynamic factors, including technological advancements and cultural shifts. These complexities mean that no single model can fully capture the intricacies of economic inequality and conflict.

Additionally, while historical comparisons between different eras—such as ancient conflicts and modern geopolitical struggles—highlight recurring patterns of inequality and war, these comparisons must be contextualized even if it is generally considered that the motivations behind conquest in Alexander the Great’s era were shaped by territorial expansion. In contrast, modern conflicts are increasingly driven by global resource competition and economic interdependence; we can assume that both share a common denominator: the self-actualization (according to Maslow) of the elite. It is interesting to compare the era of Alexander the Great with the present, where back then, the elite was on the front lines of war, while today, the elites are absent from battle theater, driving the lower classes into the meat grinder of war.

While entropy provides a unifying framework for analyzing stratification and stability across time, it must be applied with caution to avoid overgeneralization. Integrating historical case studies with

modern statistical methods would allow for a more nuanced understanding of how wealth distributions interact with conflict dynamics across different societal contexts.

By refining these models and incorporating additional real-world complexities, future research can enhance the predictive power of entropy-based approaches to wealth distribution and conflict analysis, ensuring a more comprehensive understanding of the factors that shape societal stability.

8. Conclusions

Haruki Murakami notes [85]:

> *We are all human beings, individuals transcending nationality and race and religion, fragile eggs faced with a solid wall called The System… Each of us possesses a tangible, living soul. The System has no such thing. We must not allow the System to exploit us. We must not allow the System to take on a life of its own. The System did not make us; we made the System.*

Taking lessons from the past, where our ancestors created social structures with small Gini indices, we note that, although these structures are complex to achieve from an entropic perspective, their existence was vital for the survival of their members. Furthermore, we observe that exponential distribution is the optimal structure for the distribution of wealth and resources. It is easier to achieve from an entropic standpoint (since it maximizes entropy) and is more resilient than the Pareto-type distribution prevalent today. Additionally, Pareto-type distributions have historically been linked to war and conflict.

Therefore, it is crucial to strive for societal structures that embrace balance and stability. The exponential stratification observed in specific historical contexts, such as the Minoan civilization, suggests that stability and peace are attainable when societies prioritize collective progress over domination, which is characteristic of the Pareto distribution. In contrast, the instability inherent in Pareto-type distributions highlights the risks posed by extreme inequalities and resource mismanagement, which can result from a misguided elite leading society toward a death spiral [86].

This "death spiral" manifests during periods of unrest and conflict as there are practical risks to investments in civil infrastructures [87], which are essential for growth. For example, the water supply system in Athens, necessary to support the growth of the metropolis, relied on massive capital investment during a period without significant wars [88]. A military-based society, however, would avoid such investments in favor of prioritizing military technology, particularly during times of war potential [87]. As a result, growth would stagnate (along with investments in civil infrastructure and technology), and military conflict would become inevitable.

Pareto-type distributions, as seen in present-day societies, exhibit low standardized entropy, reflecting internal instability [12]. If the elites in contemporary societies are unable to find ways to foster growth (and increase entropy), they may seek alternative methods to raise entropy, with war being a potential justification for their failure. In addition, the limitation of available resources, reduces entropy, and in a Pareto-type distribution, it places most of the population at risk. Therefore, the elite might prefer to send the plebeians to war rather than face the unrest that could threaten their position.

Humanity stands on the precipice of critical decisions. By recognizing the resilience of the human spirit and drawing on the wisdom of history, we can guide ourselves toward a more optimistic future. By promoting shared resources and balanced wealth-resources distribution, societies can create

environments that prioritize cooperation over conflict, ultimately safeguarding the collective soul of humanity from the ravages of war.

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