campingrovies

3-9 July 2023

Entropy and Wealth_1

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A presentation explaining the paper with the same title published in *Entropy*, 2021, https://doi.org/10.3390/e23101356

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School of Civil Engineering

1. The name entropy

The name "entropy" has been introduced about 150 years ago as a scientific term but later its use became common of everyday language. We can find it in literature in poetry in press, and in web posts, but **often its use is irrelevant to its real scientific meaning**.

The most common use of the word entropy is when a writer wants to describe with an "intellectual" word a kind of disorder.

Expectation: the term "entropy" would more frequently appear in scholar articles in combination with terms such as "physics" or "thermodynamics"—this is the case for the recent years.

Before 1960s the combination of term "entropy" with "society" or "social" was more frequent than the former.

As seen in the figure, in the 21st century "entropy" is also used in combination with ecology and economics.

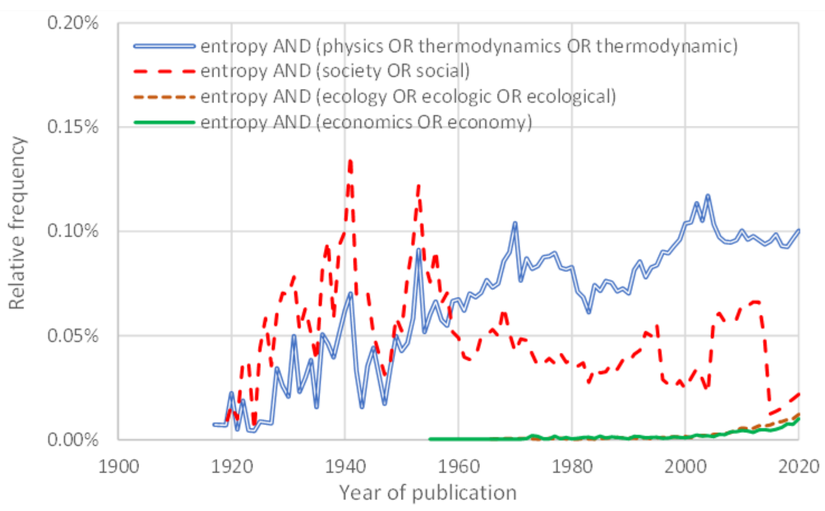
Out of its physical and stochastic context, the term "entropy" is typically used metaphorically and hence its meaning becomes ambiguous or diverse. For example, the term "social entropy", in one of its earliest uses in scholarly publications is equated to "dereliction, pollution and waste", which are created by "economic activity" or by "society as consumers" and has to be minimized.

The dominant view is that entropy epitomizes all "bad things" one can think in the universe, in life, in human societies and in economics.

Our view is quite different.

We **insist that entropy should be used as a mathematical (in particular, stochastic) concept**. We avoid using ambiguous terms such as "social entropy". We claim that any interpretation of entropy should be as close to the mathematical definition as possible.

On the second issue, we believe that the overloading of the concept of entropy with negative properties reflects misunderstanding of the underlying theory, guided by a deterministic world view.



2. Entropy used in a Malthusian perspective

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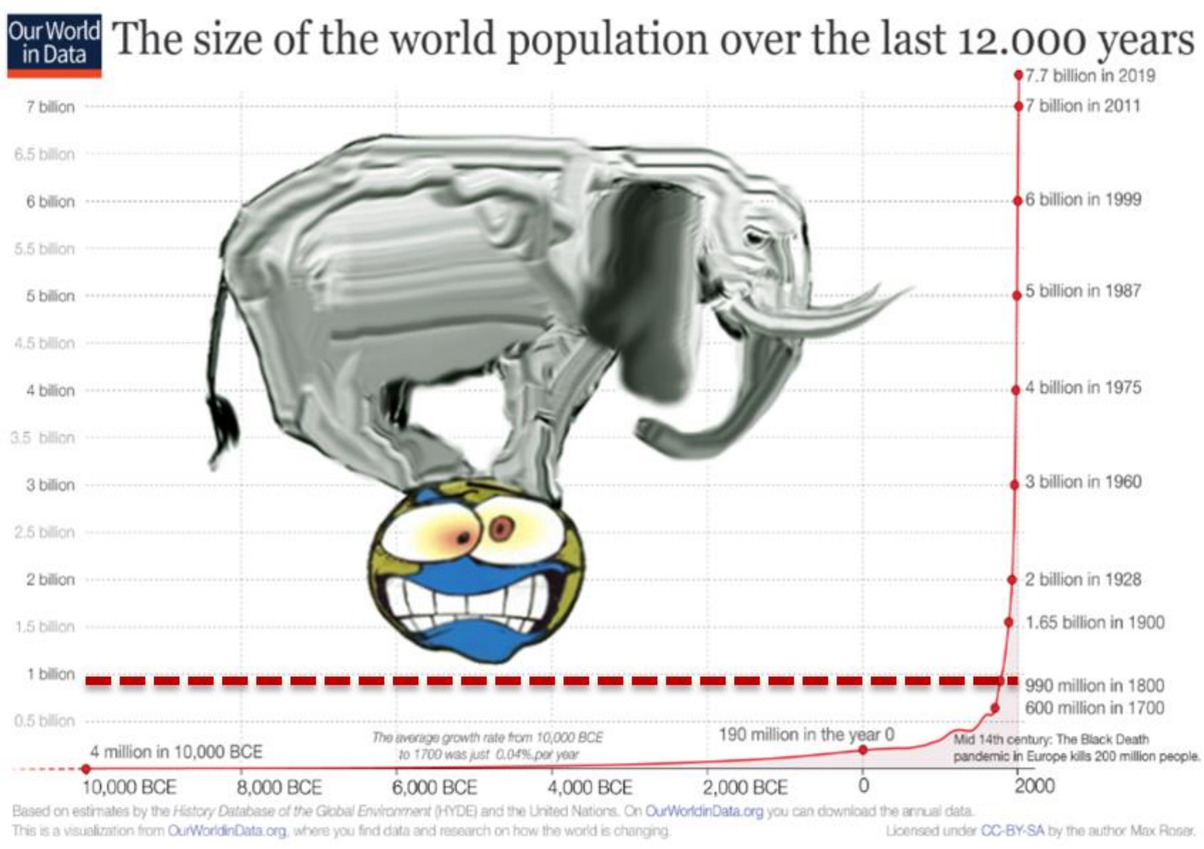


3. The name entropy

More than 150 years after the introduction of the entropy concept, its meaning is still debated. It's important to note that the connection of probabilistic and thermodynamic entropy is clearly implied by its pioneers.

The very definition of entropy is inconsistent with a deterministic world view.

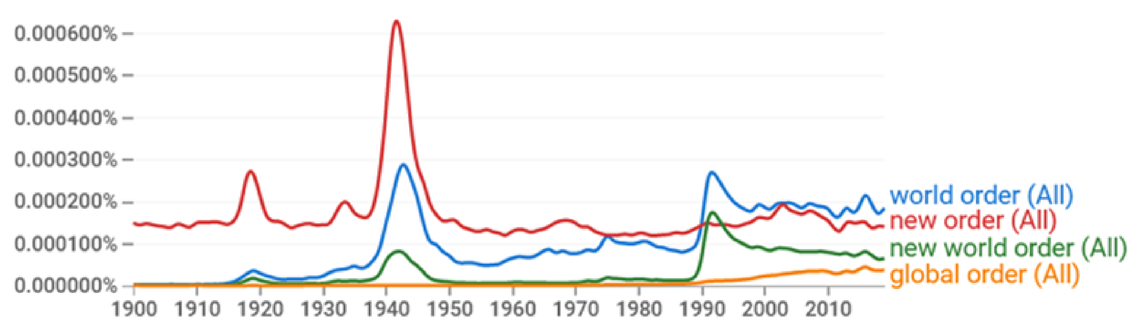
This entails difficulties in understanding entropy because our education is based on the deterministic paradigm.

Indeed, it is difficult to incorporate the clearly stochastic concept of entropy in a deterministic mindset.

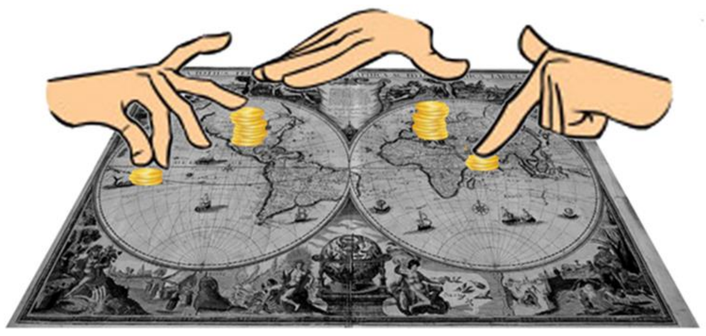
Therefore, many have tried to find analogues more deterministic-friendly, identifying it with disorganization, disorder, deterioration.

All these have a negative connotation in the deterministic mindset.

But they are less appropriate and less rigorous as scientific terms and more appropriate in describing mental states and even more so in describing socio-political states.



- Undoubtedly, elites that want to control the world have the dream of Steyer: "Chaos was the law of nature; Order was the dream of man."
- But this does not necessarily mean that the entire humanity has the same dream with the elites.



4. Entropy as a probabilistic concept

When speaking about entropy, we should have in mind that the scale is an important element and that entropy per se, being a probabilistic concept, presupposes a macroscopic view of phenomena, rather than a focus on individuals or small subsets

Uncertainty is not an enemy of science or of life; rather it is the mother of creativity and evolution.

Without uncertainty, life would be a "**universal boredom**", and concepts such as hope, will (particularly, free will), freedom, expectation, optimism, etc., would hardly make sense.

A technocratic system where an elite comprising super-experts who, using super-models, could predict the future without uncertainty, would also assume full control on the society.

Fortunately, this will never happen because entropy, i.e. uncertainty, is a structural property of nature and life. Hence, in our view, uncertainty is neither disorder nor a "bad thing". How could the most important law of physics (the Second Law) be a "bad thing"?

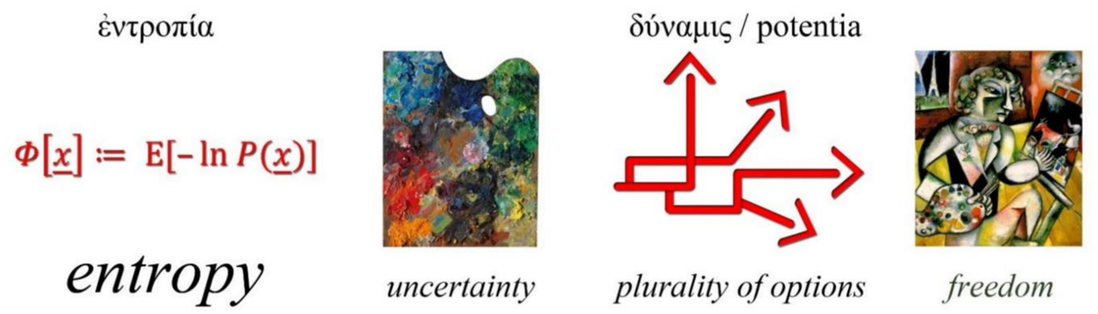


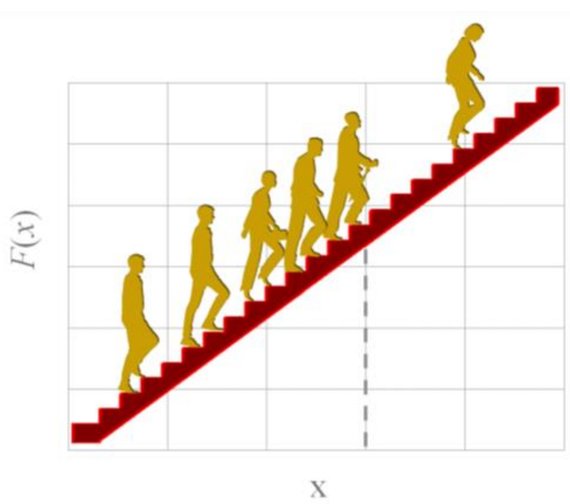
Figure 4. An attempt at an artistic representation of the notion of entropy. Uncertainty is depicted by Marc Chagall's Palette (adapted from [105]) and freedom by Marc Chagall's *Self-Portrait with Seven Fingers* [106]; δύναμις (Greek) or *potentia* (Latin) is the Aristotelian idea of potency or potentiality.

If we see **entropy as uncertainty, we also understand that life is fully consistent with entropy maximization.**

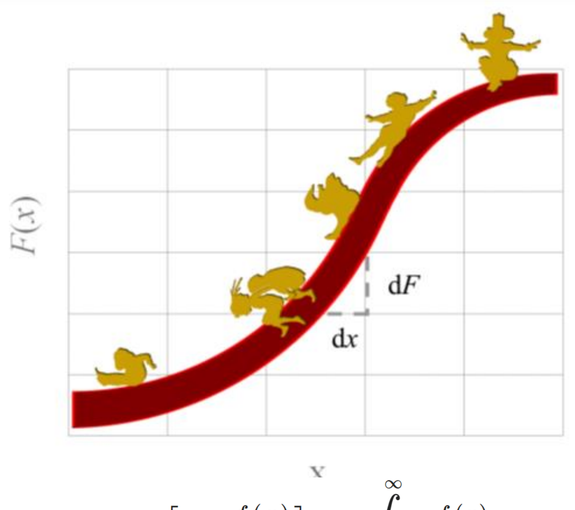
The human-invented steam engines (and other similar machines) increase entropy all the time, being fully compatible with the Second law, yet they produce useful work.

Likewise, the biosphere increases entropy, yet it produces interesting patterns, much more admirable than steam engines. **Life generates new options and increases uncertainty.**

5. Mathematical formulation



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



$$\Phi[\underline{x}] \coloneqq \mathrm{E}\left[-\ln \frac{f(\underline{x})}{\beta(\underline{x})}\right] = -\int_{-\infty}^{\infty} \ln \frac{f(x)}{\beta(x)} f(x)\mathrm{d}x$$

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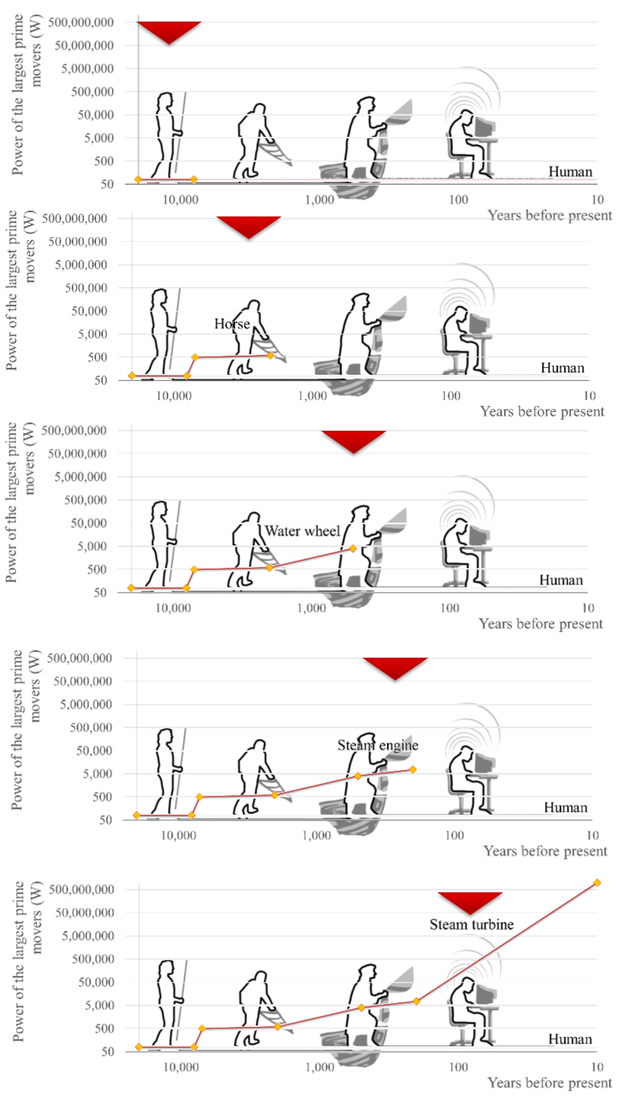
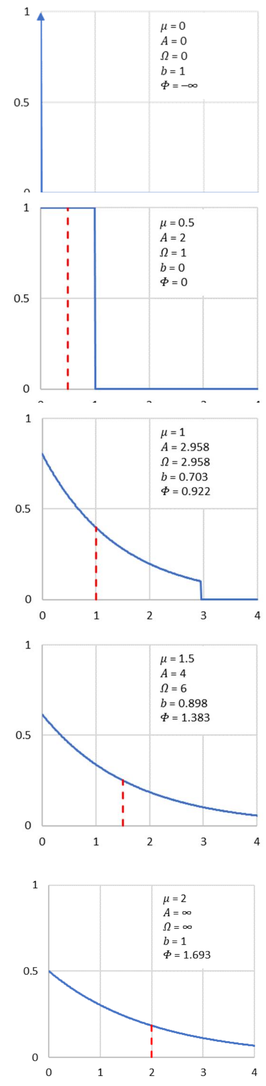
1. Entropy: From the ancient classless society to modern stratified societies





2. Introduction to empirical investigation

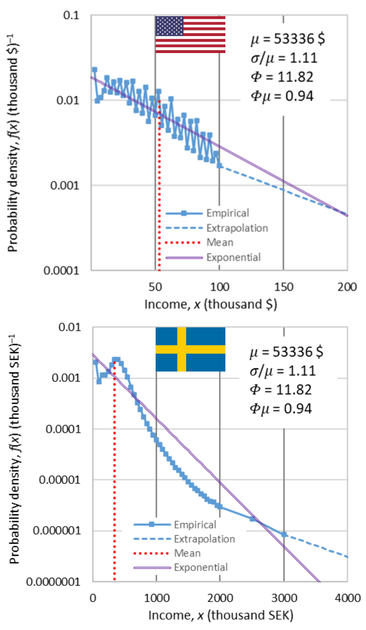
Two opposite forces modify the natural (exponential) distribution:

An organized society redistributes income and wealth through their transferal from the richer individuals to the purer by means of several mechanisms (e.g. taxation).

On the other hand, the actions of economic elites, pursuing a greater share of the community's wealth, tend to modify mostly the income distribution tail, converting it from exponential to power-law (Pareto).

At the same time, the elites advance both the technological limit and the average wealth. Naturally, the advancement of technology and average wealth are the positive side of elites' action.

In the retrieved data, the information about the tail (the very rich people) is missing as the data values end at some level c with the last bunch of data given as "c and over".



3. The failure of "80/20 rule"

In both cases, the income distribution is consistent with the principle of maximum entropy, and in particular with exponential distribution.

Yet the effect of the elites is visible, as the distribution tails exceed those of the exponential.

On the other hand, the **data do not support the well-known "80/20 rule"**, which is consistent with the Pareto distribution (with a specific value of the tail index).

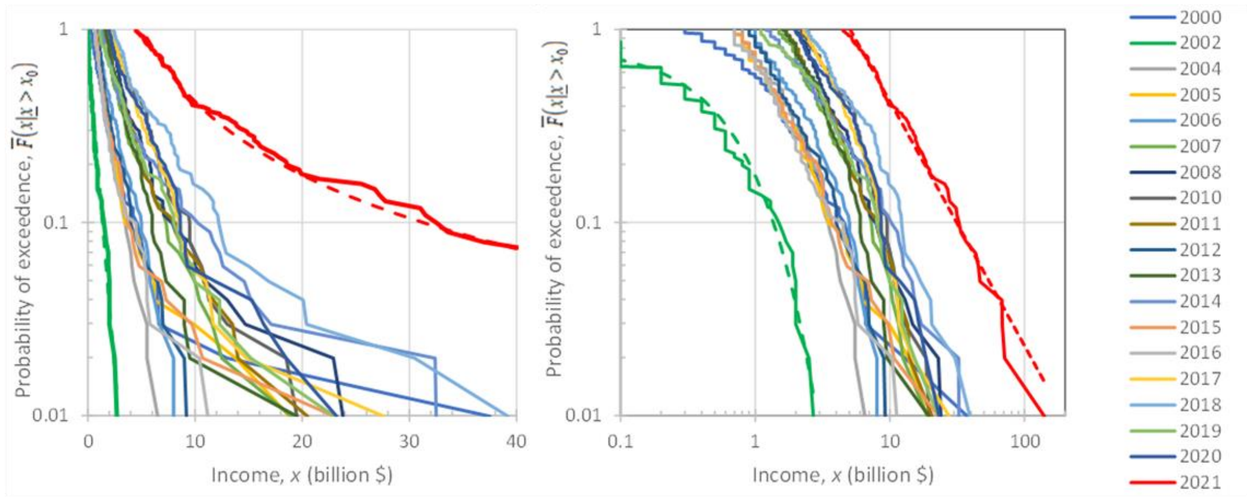
Specifically, 80% of the income is not generated by 20% of the population, but by more than 40% thereof, which is fully consistent with the exponential distribution. Interestingly, the "80/20 rule" is often called the "Pareto rule", but the historical investigation performed reveals that the Italian economist Pareto did not suggest that, but later authors loaded him with things that he never said.

The most telling evidence about the type of the distribution and, hence, the appropriate background measure, is obtained by studying the distribution tail. To study the tail, we do not need to examine the entire population, i.e. the entire range of the variable x.

4. Study of the elites (1)

The means to increase elites' profits certainly include political power and, more recently, an attitude to control the world. Their endeavor becomes more efficient and acceptable by the society by several means they use, such as by overstating existing or non-existing threats, and then by presenting themselves as philanthropists (e.g. by funding nongovernmental organizations dealing with these threats) and world saviours.

5. Study of the elites (2)



Figures: Conditional probability of exceedance of the annual income of the richest persons in the world. The income per person was found by subtracting the total net worth of a year from that of the previous year.

Based on these data and with focus on the distribution tail, we concluded that the exponential tail is not uncommon, while the Pareto tail appears particularly in anomalous periods.

Impressively, the latest period of pandemic resulted in unprecedent profits of the richest, with a clear Pareto tail.

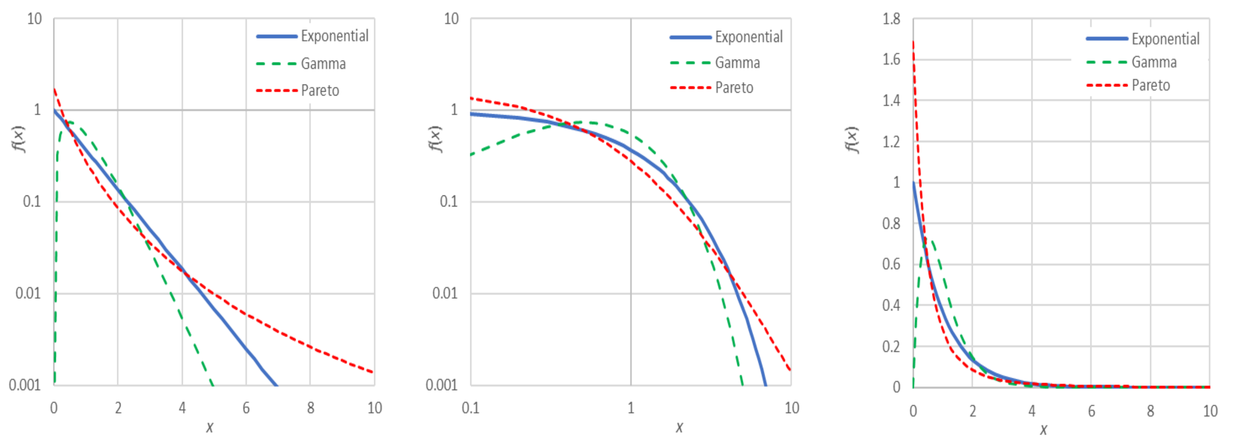
Entropy maximizing distribution emerges when the background measure has constant density, while if a hyperbolic background measure is used, the resulting distribution is Pareto. Based on real-world data, and in particular, those of the world's richest, in order to give a better idea on the distribution tail, we conclude that **the exponential tail is not uncommon, while the Pareto tail appears particularly in anomalous periods.** Impressively, the latest period of the pandemic resulted in unprecedent profits of the richest, with a clear Pareto tail.

The entropy maximizing under a constant density, leads to an **exponential distribution and it is connected to a stable economy.**

Furthermore, we examined two different factors (both **decrease entropy**):

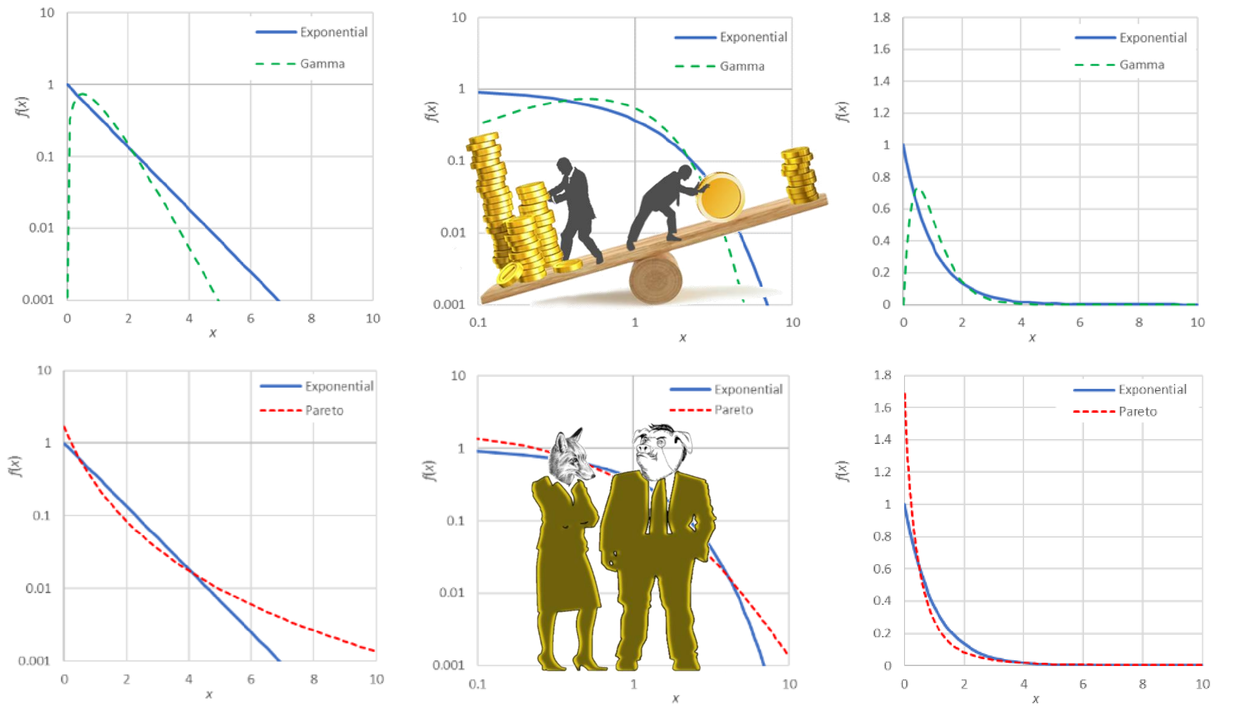
- The organized societies use mechanisms of income redistribution in order to minimize poverty and enhance the middle class.
- Politico-economic elites try to increase their profits, thus pointing toward a Pareto distribution, which populates more the poor and the very rich and reduces the middle class.

6. Discussion and conclusions



A graphic comparison of the **exponential distribution (entropy Φ = 1)** with Pareto density and the two-parameter gamma density, the behaviour of which is opposite to Pareto.

Note that, in **Pareto distribution and gamma distribution, entropy Φ = 0.884.**



- Furthermore, we examined two different factors, both leading to reduction of entropy and modification of the stable exponential distribution, but in different directions.
  1. The **organized societies use mechanisms of income redistribution** in order to **minimize poverty and enhance the middle class**.
  2. Politico-economic **elites try to increase their profits**, thus pointing toward a Pareto distribution, which **populates more the poor and the very rich and reduces the middle class**.

  At the same time, **the elites advance both the technological limit and the average wealth**.
- **Social sciences are often contaminated by subjectivity and ideological influences**, which become apparent when examined from distance, in the light of history.
- Here **we explore whether the maximum entropy, applied to economics** and, in particular, to the distribution of a wealth-related variable, namely the annual income, can give an objective description.
- We show that under plausible constraints related to the mean income**, the principle of maximum entropy results in exponential distribution,** bounded from above if we consider an upper technological limit, or unbounded otherwise.
- Historically, **technology has played a major role in development and increase of the entropy of income**. Under current conditions, technology no longer imposes a bounding condition on the economy, yet it remains an important factor in increasing wealth.