From thermodynamics to civilization to economic bubbles

I. Thermodynamics

According to the 2nd Law of Thermodynamics, heat tends to flow from hot to cold. We'll call the temperature difference between hot and cold a potential. Consequently, entropy is produced and potential entropy gets consumed.

According to the 2nd ½ Law of Thermodynamics, heat tends to flow as quickly as possible. Consequently, entropy is produced as quickly as possible and potential entropy gets consumed as quickly as possible. The 2nd ½ Law of Thermodynamics is also called the Principle of Fast entropy.

Heat engines use heat flows can to produce work. Efficiency is proportional to temperature difference between hot and cold a potential. No heat engine is perfectly efficient. Consequently, all heat engines produce entropy when they perform work.

Since of the work performed by a heat engine can be used to produce more heat engines, heat engines can beget additional heat engines. Consequently, the quantity of heat engines can grow exponentially. Therefore, entropy production and potential entropy consumption can grow exponentially.

II. History from Big Bang to Today

The Big Bang occurs, spreading a relatively fixed amount of light energy across an expanding volume of space. As the density of light energy decreases, the universe dims and cools. Matter forms and congregates in clouds and clumps, giving rise to stars and planets.

Stars condense and heat up enough to undergo fusion. They illuminate planets such as the Earth. Many planets such as the Earth become brighter and hotter than the cool space that surrounds them. A potential exists between hot planets and cold space. In accordance with the second law, heat flows from the planets into space.

In accordance with fast entropy, complex structures form to maximize the heat flow and entropy production. Some of those complex structures can reproduce and form life; they essentially become heat engines able to beget heat engines. Such structures continue increase in complexity in accordance with fast entropy. Cells form, then multi-cellular animals and plants. Intelligence develops as a means to figure out how to increase the rate of entropy production, and highly intelligent creatures such as humans develop.

Yet, greater complexity can still increase entropy production even further. In accordance with fast entropy, intelligent creatures engage in highly organized collective efforts and form civilizations.

III. Economic Bubbles

Heat engines begetting heat engines results in exponential growth in both quantity of heat engines and entropy production. Where the magnitude of potential is fixed, as entropy is produced, the potential decreases. As potential decreases the efficiency of the heat engines decreases. This decrease in efficiency comprises a limiting factor.

This decreased efficiency decreases the ability of heat engines to do work. Eventually, the total amount of both work and entropy production will decrease. Less work will be available to beget heat engines. If the heat engines require work to be maintained, the number of functioning heat engines will decline. Irreplaceable potential entropy continues to decrease as it gets consumed. Eventually, the potential entropy will be completely consumed, and both work and entropy production will cease.

As this scenario begins, proceeds and ends, a thermodynamic “bubble” forms, grows, possibly shrinks and eventually disappears. Entropy production versus time can be graphed as a roughly bell-shaped curve.

<u>Bubbles involving life</u>: Populations of living organisms can experience thermodynamics bubbles. A bacteria colony placed in a media dish full of nutrients faces a potential of fixed magnitude. Each bacterium fill the role of a heat engine, producing both work and entropy. The bacteria reproduce exponentially, increasing the consumption of potential entropy exponentially. Eventually, it becomes increasingly difficult for the bacteria to locate nutrients, decreasing their efficiency. As efficiency decreases, the bacteria will reproduce at a slower rate and eventually stop functioning.

<u>Bubbles involving dynasties</u>: A human civilization can experience thermodynamics bubbles. A new dynasty within a civilization faces a potential of good will and other physical and social resources of fixed magnitude. The society governed by the dynasty fills the role of a heat engine, producing both work and entropy. Prosperity expands exponentially, increasing the consumption of potential entropy exponentially. Eventually, it becomes increasingly difficult for the dynasty to rely upon its store of goodwill and physical and social resources, decreasing its efficiency. As efficiency decreases, the dynasty will experience social crises and will eventually stop functioning.

Bubbles involving business: Businesses can also represented as heat engines (or collections of heat engines). A business faces a new market opportunity of fixed magnitude. Businesses exploit the market opportunity, producing both work and entropy. The business or its industry reproduces exponentially, increasing the consumption of potential entropy exponentially. Eventually, it becomes increasingly difficult for the business or industry to locate new customers or orders, resulting in increased competition and decreased margins, hence lower efficiency. As efficiency decreases, the business will expand at a slower rate and eventually stop functioning.

Bubbles involving macro-economic business cycles: All of the businesses in an entire economy can also represented as a collection of heat engines. If there has been a build-up of thermodynamic potential within an economy (such as during a recession), that economy faces an opportunity of fixed magnitude. Businesses recognize and exploit the opportunity, producing both work and entropy. Competition and pressure to increase profits drives businesses to expand exponentially, increasing the consumption of potential entropy exponentially. However, as potential entropy gets consumed, the potential diminishes in magnitude, and the efficiency of the economy drops. Yet, businesses do not immediately recognize this, but still expand exponentially, resulting in economic overshoot. Eventually, revenue growth stops just as efficiency collapses (as evidenced by inflation). The overshoot results in substantial financial losses. Businesses cut back their operations, and the bubble ends. After a few years pass, this pattern will then repeat itself.

IV. Bubbles and Flows

Ultimately, all potentials are fixed in magnitude. Possibly, the entire Big Bang and its progression could be viewed as a bubble. In practice, many potentials are renewable to a limited extent. For example, as long as the Sun shines upon the Earth in cold space, a potential will exist there. Therefore, potentials can be modeled in terms of flows and bubbles. A flow involves a potential that gets replenished. A bubble involves a potential with a fixed magnitude.

In the case of a flow, heat engines will exponentially grow until they reach a limiting efficiency. Heat engine population and entropy production will reach a limit called a carrying capacity.

Yet even in the case of a flow, the rate of replenishment will be limited. Yet the rate of engine reproduction may have continued beyond carrying capacity. This can be called overshoot, a systematic "momentum" in a sense. In this case, even the flow can be treated as a substantially fixed (or "conserved" in the physics sense) quantity. A thermodynamic bubble will form.

As long as a system maintains the ability to produce new heat engines, then instead of a single bubble, there will be a series of bubbles over time. There are several reasons that systems form bubbles instead of maintaining a single flow. Chaos (in the mathematical sense) provides one reason. Another reason is that a series of bubbles may provide for an overall higher entropy production rate than a more steady, consistent rate of production. Heat engines in a bubble may be able to obtain much higher efficiency during a bubble than during steady state, so that the average production in a series of bubbles may be much higher than during a steady flow, despite the below average production between bubbles.

Another case such as predator-prey cycles can also form where overshoot occurs, where the population of a predator overshoots the available prey, reducing both the population of the predators and the prey, so that there are cycles where the population of the predator is always “reacting “ to the population of the prey. Predator-prey cycles can also be expressed in terms of flows, bubbles and efficiencies.

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Note on references:

The author independently conceived the statements made in this essay, with the exceptions, of course, of the 2nd Law of Thermodynamics and its application to heat engines, and the Big Bang, the formation of matter, the fusion of stars, the formation of planets and evolution. However, so many people have written on thermodynamics, that the author does not claim the statements are new. Nevertheless, to the author’s knowledge, the author is the first to synthesize all of these statements into an integrated whole. The author has subsequently been introduced to relevant the prior work of J. A. Burt, M. K. Hubbert, Meadows, and I. Prigogine.