The structural origin of the current crisis in capitalism

Economic entropy and fractal depth, as a metric for synthetic growth

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1 Introduction

The article provides a rigorous reduction of economic dynamics, by defining 'economic entropy', to illustrate that transactional infrastructure has become the main driver of economic dynamics. It is imperative to understand how current capital allocation dynamics have changed in the last few decades. Efforts in redirecting this dynamic to curb growing inequality and skewing concentration dynamics of capital are destined to fail, if we misattribute its causality.

2 Supply and demand

In economics one of the key concepts is economic utility. It is this concept that is subject to supply and demand dynamics, which in turn drives pricing-dynamics. In the last few decades, economic markets have witnessed the advent of so-called 'market-makers' that provide 'liquidity', in most asset-classes. High Frequency Trading is perhaps the most notorious example, certainly the most excessive example, and their place in a healthy financial market is highly debatable.

3 Economic entropy

In order to define economic entropy, we first have to properly define the system and it's statespace. We define an economic system of size n, meaning that there are potentially n transactions between supply and demand that can be settled. The (macro-)state of this system can then be defined as the number (or proprotion) of settled transactions, so any transactional settlement is a 'state-transition'.
A micro-state is any possible combination of settled transactions: this allows for the macro-state of 'k settled transactions' to be represented by many micro-states.

We consider any transaction definitive (it cannot be undone), so this system is a so-called 'non-ergodic' system: any occurring transaction reduces the solution space for remaining supply and demand. A TV can only be sold once.
Below is a table that illustrates a single permutation of 3 consecutive transactions. The first trx was between C and Y, the second between B and Z, and the final between A and X.
The first trx has 3^2 possibilities, the second trx has only 2^2 possibilities, and the third trx finally has 1 option left.

		supply		
		X	Y	Z
demand	A	3		
	B			2
	C		1	

A macro-state of 2 settled transactions, for example, has 9 + 4 possible microstates, times a factor of 2! for ordering permutations (CY first, or BZ first).
From this it can be inferred that for a system of size n, the macro-state of k

settled transactions amounts to the sum of the squares up to n minus the sum of squares up to $n-k$, times $k!$.
First, the sum of the squares from 1 to n is given by:

$$\sum_{k=1}^{n} k^2 = \frac{n(n+1)(2n+1)}{6} \tag{1}$$

If we call this expression $\sigma(n)$, then we can express the number of microstates as

$$W_n(k) = k!\Big(\sigma(n) - \sigma(n-k)\Big) \tag{2}$$

Plugging in the expression for $\sigma(n)$ yields:

$$W_n(k) = k!\left(\frac{n(n+1)(2n+1)}{6} - \frac{(n-k)(n-k+1)(2(n-k)+1)}{6}\right) \tag{3}$$

which simplifies to:

$$W_n(k) = k!\left(\frac{k^3}{3} - k^2 n - \frac{k^2}{2} + kn^2 + kn + \frac{k}{6}\right) \tag{4}$$

Since the entropy is defined as the log of the number of micro-states, we get:

$$S_n(k) = \ln\left(k!\left(\frac{k^3}{3} - k^2 n - \frac{k^2}{2} + kn^2 + kn + \frac{k}{6}\right)\right) \tag{5}$$

4 Increase of economic entropy

The increase of entropy (as the number k of transactional settlements increases) is demonstrated by determining the positivity (or at least the non-negativity) of entropy-production from $S_n(k)$ to $S_n(k+1)$. This is true if $W_n(k+1) > W_n(k)$, or

$$W_n(k+1) - W_n(k) \geq 0 \tag{6}$$

This translates to:

$$\left(\frac{(k+1)^3}{3} - (k+1)^2 n - \frac{(k+1)^2}{2} + (k+1)n^2 + (k+1)n + \frac{k+1}{6}\right) - \left(\frac{k^3}{3} - k^2 n - \frac{k^2}{2} + kn^2 + kn + \frac{k}{6}\right) \geq 0 \tag{7}$$

which luckily simplifies to:

$$(k-n)^2 \geq 0 \tag{8}$$

which is clearly true for any k, n with $k \leq n$.

This shows that an *increase* in transactional settlement *increases* the defined economic entropy.

4.1 Maximum settlement

If all supply and demand has settled, the ultimate level of entropy is

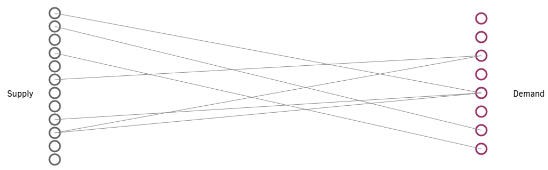
$$S_n(n) = \frac{n!}{6} n(n+1)(2n+1) \tag{9}$$

4.2 State transitions

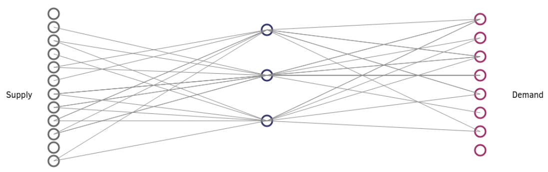
One could allow for state-transitions that settle more than 1 instance of supply and demand. That allows for even more permutations per macrostate, and it does not change the direction of the entropic gradient.

5 Fractal depth of the transactional topology

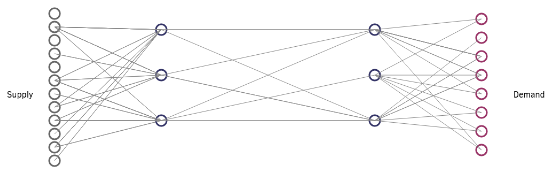
We all understand that a supermarket is economically viable. It actually sits in between primary supply and demand of food and other daily needs. From the perspective of this 'primary' supply and demand, a supermarket introduces intermediary supply and demand.
Supermarkets themselves make use of intermediary suppliers, procurement organizations and wholesalers. Every 'intermediate' layer introduces it's own supply and demand, in between existing supply and demand. Eventually there is some 'optimum' in the number of intermediate levels, given the scale, lead-times, liquidity-aspects and other aspects of the specific market.
In financial markets, the number of intermediate levels is typically much higher. Financial engineering has led to myriads of derivatives, covering most asset classes.
This level of 'intermediacy' is better characterized by 'fractal depth'. After all, every intermediate layer will, in principle, introduce more new supply and demand than its surrounding layer introduced. But not only the added liquidity increases per layer, the 'distance' for settlement also reduces. It is more liquidity in volume and in settlement-time. This is illustrated by the following diagrams.



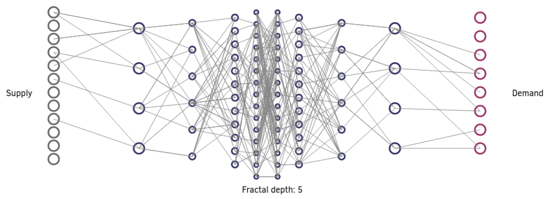
Fractal depth: 0



Fractal depth: 1



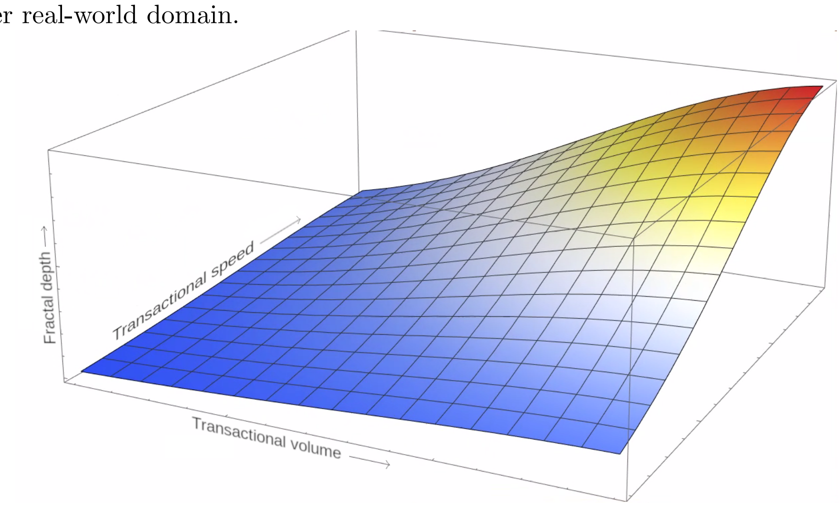
Fractal depth: 2



In the financial sector High Frequency Traders currently sit in the center, at the deepest level of this fractal structure. And as stated above, at this depth it takes the biggest transactional volumes, at the shortest settlement-times. Every added intermediate layer allows for higher volumes and shorter transaction times. This is the fractal aspect.

5.1 Measuring fractal depth

In the real world, intermediate layers are not always discrete. Especially in IT-environments the transactional topology will show a much more 'networked' layout than the discrete, hierarchical one that can be seen in the supermarket example.
For domains that display discrete intermediate settlement-layers the fractal-depth can be read from the above diagrams. For 'continuous' topologies fractal depth can be quantified through the distribution of (some measure of) network-centraiity against both transactional volumes and settlement-times: the centraiity is then a metric for fractal depth. Of course the actual distribution varies per real-world domain.



This should allow for a fundamental framework for empirical, comparative research in many economic subdomains.

6 Maximization of economic entropy production

Given that economic entropy will always increase (it will even increase as fast as possible), it is clear that increasing fractal depth allows for an excessive increase in economic entropy. It is another typical example of 'exponential growth', for which we currently have *not a single* empirical framework, to be able to 'diagnose' the current state of our financial-economic system. We have no clue of the power of these undercurrent dynamics, and its effects on the surface dynamics, but one could imagine that it easiliy outweighs any policy put out by a government or central bank. One could also imagine that the introduction of 'decentralized' crypto-currency is not able to counter these dynamics at all: at best, they add a layer of fractal depth, amplifying existing dynamics.

7 Dissocation of transactional momentum from primary supply and demand

In the history of the economic discipline, the debate about 'economic value' has never been settled. If anything, conceptual conflation concerning this 'hyper-object' has only increased, in the last few decades. (Talking about increase of information entropy..) This article is not going to add fuel to this debate, but will only argue that, in an economic system, you can determine the proportion of capital that is being injected and extracted from the economic system at any fractal depth.
To make this more specific: increasing fractal depth allows for increasing volumes of capital allocation and extraction at that depth. High frequency traders extract huge amounts of capital only by inserting a level of extreme fractal depth. QE-programmes of central banks inject huge amounts of capital at a level of extreme fractal depth. One can argue that, at this fractal depth, it does *not* serve the settlement of supply and demand at the most shallow region of this fractal landscape: primary supply and demand that originate from real-world economic utility in a society. It will even harm it because of all kinds of skewing dynamics and obfuscation of price-discovery and all kinds of feedback-loops, etc. In other words, one could determine a *qualitative tipping point* in fractal depth from which it does not really serve the real-world economy anymore. But since fractal depth does takes up a significant part of real-world economic resources, it is blatantly obvious that, beyond this tipping point, any existing infrastructure will cause more harm than good.
Another way to frame this is:

Increasing fractal depth allows for synthetic growth of GDP.

Growth itself cannot be qualified as good or bad in a consistent or sensible way. But economic growth can be qualified as organid or synthetic.
This allows for a re-framing of the de-growth debate. This debate is currently extremely obfuscated, and it misses the point that growth is an emergent aspect that cannot be tamed. One can only reduce the facilitating infrastructure. And fractal depth is a fundamental aspect of this infrastructure.
Synthetic growth originates at fractal depth.

7.1 Nonlinear transactionality

Unfortunately it is not possible to determine when deep transactionality starts to significantly distort primary transactionality, because it concerns a highly nonlinear, chaotic system. But it is obvious that the current globalized, IT-driven economy suffers greatly from fractal depth.

So given our current situation, where we can clearly agree that we are far beyond this tipping point, the most pressing policy-measure would be to signficantly reduce fractal depth of financial-economic infrastructure.