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Econophysics - related Remarks in Considering the Necessity of a Distribution Adjustment in the Eurozone Real Economy and Re-modeling its Financial System and Markets. Thermodynamics and Statistical Physics Approach

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The term "Econophysics" was used for the first time by Eugene Stanley (physicist) in 1995 and represents the name of a rather new research domain that tries to apply the modeling standards in statistical physics to the more complicated world of economics and finance. This approach seems to be kind of appropriate and that because Economics is about people and refers to individuals. In this kind of respect we have to say that in a certain economic environment there are a lot of individuals existing, working and making commerce, so they may very much be assimilated with a system composed of a really big number of "particles" and obey to the same mathematical laws used to describe the time-behavior of such a system. In this article we use thermodinamics and statistical physics approach to describe some economic processes.

Keywords: *econophysics, thermodynamics principles, GDP, money, central banks*

Preliminaries

The term "Econophysics" was used for the first time by Eugene Stanley (physicist) in 1995 and represents the name of a rather new research domain that tries to apply the modeling standards in statistical physics to the more complicated world of economics and finance. This approach seems to be kind of appropriate and that because Economics is about people and refers to individuals. In this kind of respect we have to say that in a certain economic environment there are a lot of individuals existing, working and making commerce, so they may very much be assimilated with a system composed of a really big number of "particles" and obey to the same mathematical laws used to describe the time-behavior of such a system (Stanley, 1996). Assessments concerning the status of an economic environment can be made only by analyzing economic and financial data (and, usually, there are a lot of data) and Econophysics as a quantitative science, actually proposes a refined and sophisticated analysis of those indeed large amounts of data. It may seem kind of surprising but Econophysics represents somehow a return of Physics to its origins: it is well known that the famous J. C. Maxwell was inspired by the immense popularity social statistics had during his researches on the random distribution of molecular speeds in a gas [4]. A little bit later (1905), the also famous L. Boltzmann and J. W. Gibbs found this approach as being correct and gave it the mathematical fundamentals we still use nowadays.

The basis in studying the systems with large number of particles consists in three simple laws:

- *The law of defined proportions*: in case of whatever compound, the composing basic elements always combine themselves by a rigorously determined mass ratio. Indeed, when two or more individuals get involved in a trade or exchange relation, they are usually backed, besides money (cash currency), by different amounts of *assets*. Each and every pair of those asset amounts determines a single and rigorous ratio.
- *The law of multiple proportions* (J. Dalton, 1803): when two basic elements can make more than one single compound, then, the ratio between whatever two quantities of the second element combining

with the same quantity of the first one is a rational number. In economic terms it means that an individual can economically relate only with an integer and rather small number of other individuals which is kind of common sense.

- *The law of identical volumes* (Avogadro, 1811): a basic element (gas) can combine with himself and materialize this way in a more stable form (molecules). In such a case, two different basic elements but having the same number of molecules and occupying identical volumes will have the same pressure. In economic terms it does mean that in identical economic areas the same number of individuals will economically meet each other with the same random interaction speed.

Analogies between statistical approaches in studying molecular chaos and Economics

Sophisticated experiments proved that while studying a molecular (molecule is a really stable micro-system) system is not necessary to study the behavior of each and every molecule [18]. When a really big number of molecules reach to form, as a whole, a macroscopic and rather stable system – this system always turns out to be quite different, in terms of physical properties, from its molecules. Such a macro-system simply cannot be studied using classical Mechanics laws but can very well be studied using statistical laws.

In whatever macro-molecular system the molecular motion is proved to be kind of chaotic and this motion can be described using the so called medium average values of the parameters describing this motion. The key issue in studying the properties of the macro-system consists in the fact that a unilateral dependence really exists between the micro-motion medium parameters and the macroscopic parameters of the macro-system. However, it’s not to play down that – because the statistical laws are sort of probabilistic – any outcome in statistically studying a certain macro-system should be judged as being “the most possible” and not the “only one possible”. In the same kind of respect we have to add that statistical approaches effectively do work only in cases of macro-systems containing a

really big number of stable particles. Assessments on the limits in covering the economic phenomena by Econophysics could be found in [5] or [6].
Not the only one ([12], [13], [14]), but the best known physical model that fits all requirements we've been mentioned is the so called perfect gas model. Indeed, such a model satisfies the following conditions:

- Such a gas has a really large number of identical molecules.
- the dimensions of each and every molecule are rather small comparing with the distance between whatever two of them
- all molecules are experiencing continuous and chaotic motions while each and every one molecule is moving under the classic Mechanics laws
- Inter-molecular forces are present only during the specific time period when whatever two particles clashes; otherwise each and every particle is accepted as being free.
- Clashes (impacts) between whatever two molecules are only of perfectly elastic kind.

Studies like [1], [2], [3], [20], [21] seem to confirm that economic behavior of individuals living in really big economic spaces fits nicely with the conditions we've just mentioned. Indeed, a large majority of empirical data analysis concerning wealth and (or) income made on populations living in important economic areas like United States of America or United Kingdom of Great Britain revealed actually two distinct categories of population existing [17]. A vast majority of people belongs to the so called "lower class" and the distribution of wealth and income for this category of population is kind of exponential (thermal), fitting this way quite well with the perfect gas statistical model. The (small) rest of the population represents the so called "upper class" and the distribution at this level is kind of power-law (super thermal). While the "lower class" is rather stable, time-stationary let's say in its economic behavior, and allowing us to assume that any process it suffers kind of quasi-static, there is no reason to consider the "upper class" as being in equilibrium.

As we'll show in this paper, some equilibrium exit of "lower class" might occur and we'll try to explain why.

The way the thermodynamic pressure is introduced in Kinetic Theory of Gases:

$$p = \frac{1}{3} n m \overline{v}^2 = \frac{2}{3} n m \frac{m\overline{v}^2}{2} \qquad (1)$$

where n is the molecular concentration, m is the mass of a single molecule and $\overline{v}^2$ is the so called medium squared average velocity (speed) of molecules – the same way we will introduce what we call the "economic pressure" of a certain economic space (area) p_e having the same calculus formula like (1) but where we will have:

- m will be the entire quantity of assets of each and every individual. As long as we deal with the "lower class", this quantity might be considered as being pretty much the same or something close, at individual level. For example we may choose for m the whole $GDP/capita$ produced in the specific economic area since 1945 and expressed in current money (Euro, for example)
- n will be the so called population density in the specific economic area, and
- $\overline{v}^2$ will be the classic year-measured money velocity (speed)

In the Kinetic Theory of Gases, in order to explain how thermodynamic temperature is related with kinetic molecular energy (meaning with pressure), the following description of an ideal experiment became famous. Let's consider two different ideal gases (gas 1 and gas 2) having the following medium average molecular kinetic energies:

$$\frac{m_1\overline{v_1}^2}{2} > \frac{m_2\overline{v_2}^2}{2} \qquad (2)$$

We will make this example even more simple and intuitive considering $m_1 > m_2$ and $\overline{v_1}^2 > \overline{v_2}^2$ which make our case even more obvious; indeed we might have the relation (2) still in place with the same order relation between molecular masses and the opposite order relation between medium squared average velocities or vice versa. We will next consider that somehow we manage to get contact between those two gases. This contact will result into a lot of clashes (impacts) between the gas 1 particles and gas

2 particles. This large indeed number of clashes actually means a macroscopic transfer of energy from the gas 1 to gas 2. When the equilibrium will be reached the energy transfer cease meaning that the following equality will be reached:

$$\frac{m_1 \overline{v_1}^2}{2} = \frac{m_2 \overline{v_2}^2}{2} \qquad (2')$$

We have to pay a lot of attention and that because the equality (1') only means that those two gases have reached the same temperature T , the way that:

$$T_1 > T > T_2 \qquad (3)$$

This ideal experiment helps us to conclude that the thermodynamic temperature hides a statistic face and, someway, the medium average kinetic energy and temperature could be linked. Indeed, the following relation is in place:

$$\frac{2}{3}\frac{m\overline{v}^2}{2} = kT \qquad (4)$$

Where:

$$k = 1{,}38054 \cdot 10^{-23} \frac{J}{K} \qquad (5)$$

Is the well-known Boltzmann constant *for ideal gases*.

In economic terms all that means that we also have to deal with an "economic temperature" as a status parameter of the studied economic area and with a pseudo-Boltzmann constant which has *to be adapted in terms of value and units of measure*. Unlike the case of ideal gases where the constant stated by relation (5) is the same for each and every ideal gas, *in case of economic environments* we have to deal with different *pseudo-Boltzmann constants*.

Very much like in case of an ideal gas where the well-known internal energy is given by the following relation:

$$U = N \cdot \frac{3}{2} \cdot kT \qquad (6)$$

where N is the number of molecules of the ideal gas that is studied. In economic terms we might interpreted as being the existing potential of creating economic growth while maintaining economic equilibrium – in other words creating economic growth as a quasi-static process; of course k will be the specific pseudo-Boltzmann constant of the economic area and T its specific economic temperature.

Since we simply cannot discuss as we can do in Thermodynamics, in economic terms, of an "absolute zero economic temperature", we can adopt a certain one country economic area (Germany for example) as reference and agree for a standard economic value of k. In such a case, the German economic temperature could be considered as reference economic temperature and the economic temperature of each Eurozone country would tell us how healthy its economy is.

For ordinary thermodynamic systems which are composed, of course, of a large number of inanimate small particles, the 1st principle of Thermodynamics is:

$$dU = \delta Q - \delta L \qquad (7)$$

where δQ is the elementary heat exchange and δL is the elementary mechanical work made by the system. The sign convention is "+" for Q and "–"for L when the system receives both of them. For an economic system receiving heat means receiving investments from outside while delivering heat means making investments outside – also, receiving mechanical work means exporting goods and services while delivering mechanical work means importing goods and services. Bottom line is that, accepting the 1st Thermodynamics principle as working in a certain economic space, we actually accept that this economic space is an *open one*. Looking at the relation (7) we simply find out that it gives an empirical view on how the gross domestic product (GDP) is formed in a certain economic environment:

$$GDP = C + G + I + TB \qquad (8)$$

Investment spending I and trade balance TB have been somehow quantitatively explained by (7), but consumption C and expenditures related to the government activities G seem to find no place in (7). The fact of the matter is that relations (1) to (7) are referring, as we've mentioned, to systems made of inanimate particles while any economic system means first human beings and, as consequence, means *work* and *innovation*. The measure of work is largely accepted as being the so called "labor productivity" which is quite suggestive for rather short periods of time, but innovation is hard to quantify. Relations (7) and (8) are really hard to put together in terms of mathematics despite the fact that, empirically, they tell us the same thing. But a short look at them reveals that the key issue for a healthy economic growth is that both U and GDP are doing far better off when they increase slowly in other words when they are experiencing quasi static processes.

The human nature needs security and predictability in order to innovate. Only innovation keeps U increasing *by itself*. Far from disrupting economic growth and, in high productivity conditions, innovation is quickly absorbed by system. This quick absorption creates investment (Q rises) while the system is relaxing through international trade due to its competitiveness given by innovation (L also rises) the way that the entire economic growth process remains kind of quasi static. In this respect, we dare to assess that only lack of innovation could lead to loss of competitiveness and to economic stagnation or, even worse, to recessions. Consumption C remains specific only to human kind. It also contributes to the relaxation of system: when innovation does exist the labor productivity is almost assured and a strong consumption – which is possible due to higher wages – only increases the money velocity.

Conservation of money and central banks actions

Any economic space could be considered as being a really huge system of statistic kind and having millions of participants: individuals and agents, as well.

While the central bank of the specific economic area takes no action in printing additional money [8], [9], [10], [11]. Rightfully assessed that money M could be considered as a conserved quantity.

Indeed, at least at local level, some sort of "conservation money law" [11] seems to work. Let's consider ([8] or [16]) two economic agents or individuals A_1 and A_2 having at their disposal the quantities of money M_1 and M_2 respectively. Let's also consider they make some transaction the way that A_1 pays the amount of money M_3 to A_2 for a corresponding amount of goods and/or services. A transaction of this kind becomes possible without debt [7] only when we have:

$$0 < M_3 < M_1$$

$$0 < M_3 < M_2 \qquad (9)$$

At the end of the transaction, A_1 and A_2 will hold these new amounts of money:

$$M_{1f} = M_1 - M_3$$

$$M_{2f} = M_2 + M_3 \qquad (10)$$

It's easy to see that:

$$M_1 + M_2 = M_{1f} + M_{2f} \qquad (11)$$

So, the money behaves really conservative at least at "local level".

We have also to tell that relation (11) is to stay even when transactions take place in a wide open economy with the local currency having undoubted international status (USA and US Dollar, for example).

Relation (11) is also enforced by the fact that money today is purely fiat money [10]. It is to be said that relation (11) keeps the track of money and keeps not the track of goods and services provided for the specific money. The reason, according to the specified authors consists, beside that services are not kind of tangible, in the fact that many goods, like food for example. Far from denying in any respect these affirmations, we have to add to the picture that, in any transaction, someone win and the other one lose and that because it's not possible to get measured the quantity of work, innovation and risk of investment a certain sold good is actually carrying.

Relation (11) works properly only in a closed economy and this kind of common sense. Extending relation (11) to an entire economy means actually that we'll have, considering (8), that $C = I$. In other words, all that means that *debt* is, somehow, unavoidable.

In our days, the existing money is *fiat*, meaning that money carries no intrinsic value. This money is declared to be money by central banks and is asset-backing guaranteed by governments. So, any central bank has a monopolistic power – and behaves this way – in printing money. The main reason why a central bank does print money is to increase its velocity during recessionary times, but that creates debt, also. In fact, under the existing fiat money regime debt has become a living-way, and relation (8) simply cannot work. The fiat money regime simply biased the trading balance in favor of sellers and decreased the saving propensity.

Under this kind of state-centralized monopoly in printing money regime, the only solution seems to consist in re-thinking the role the work and innovation are really playing in modern economies and how much the risk *directly* related with them is prized. And this means politics and regularization.

Conclusions

Let's cover once again the Physics-related example involving the relations (2), (2') and (3) and let's further consider that $m_1 >> m_2$ and $\bar{v}_1^2 >> \bar{v}_2^2$. It becomes easy to figure out that all the particles of the gas 2 will be tremendously accelerated and its temperature will increase sharply while the particles of the gas 1will experience only small decrease in their velocities and its temperature will decrease only by a small fraction. A process of this kind could imply heat transfer or mechanical work or both. In economic terms we may consider as a good example Germany as being gas 1 and Greece as being gas 2. The example is not tendentious at all: Germany's citizens are rich indeed and enjoy a nice money velocity while Greece's citizens experience quite the opposite. When the Euro currency started to circulate de facto (2002), those two economies ("gases") got actually contact. The outcome was that the money velocity (molecular velocities) increased sharply in Greece [15] while its citizens simply weren't able to get rich (molecular mass remain small) instantaneously. Adding to the picture the fact that Germany was and still is a big exporter and Greece was a big importer, the energy transfer was actually consumption-based: Greece received new strong Euros on its capital account (received "heat") and, of course, its imports accelerated (loss of "mechanical work") and, simultaneously, got worse in terms of competitiveness of their produced goods and services. In real economies, as in thermodynamic systems, increasing consumption (receiving heat) and deteriorating trade balance (delivering mechanical work) is the most natural (irreversible) way to rich equilibrium [7]. Also, the efficiency has to be taken into consideration: no natural system in this world can increase its internal energy receiving heat without delivering mechanical work. In this specific economic case (and many others like that) the mechanical work delivering (deteriorating the trade balance due to sharp increase in consumption – the human nature being the way it is)) reached to become far much faster than heat (investment) receiving. In terms of Physics all that means, in the aftermath, a sharp decrease in U , meaning, in economic terms, a sharp slowdown in GDP (recession) and a lot of debt due to the withdrawal of money from the capital account.

Everybody, right now is very much aware that situation has become really serious. What the cure could be? Two distinct situations seem possible. The first one could be that Greece will drop the Euro. A situation like this will lead to a complete loss of economic equilibrium in the whole Europe and, according to politicians, does not seem likely.

The second situation consists in keeping the Euro in the whole so called Eurozone. In this respect we have to remind that introducing Euro was nothing but a political decision. All reasons found by European governments, concerning exchange and customs costs are simply not consistent. If, in early 2000, governments would have been accepted competition in paying for goods and services in no matter where (in Europe) issued currency, then the re-distribution would have been made by itself and the European economic transformation would have been a process of quasi static kind. Of course, one currency would have been prevailed (Deutsche Mark, probably). A process of this kind could have been adjusted, by itself and out of “beggar-thy-neighbor” policies, trade (im) balances and investment and could have been lead to more pressure on governments in realizing some sort of fiscal unification. Of course, in such a case the redistribution of wealth would have been naturally reached and, probably, a situation of this kind simply wouldn’t have been agreed by the “big ones” of Europe. Introducing Euro wasn’t an economic mistake, or a political one. But it was mostly a political decision and haven’t had yet benefited from political support of any kind. A simple centralized budgetary planning from the very beginning would have been enough to prevent the actual mess. But this is history.

The urgent need for the Eurozone consists in a rapid resumption of investment and trade in Europe (in Physics terms to raise U). And the first step is monetizing the Greece (and, eventually, all so called PIIGS) debt (in Physics terms to add energy to the system). Choosing austerity to create cash (energy) was not a choice for European leaders – in fact was *the only choice*.

Here is an example to understand. Technically speaking, the fundamental problem is that the euro does not qualify for a sufficiently high worldwide demand so that the ECB does not have the possibility to operate some sort of “European quantitative easing”. See the opposite side of the dollar. The dollar is the main reserve currency worldwide, and precisely for this reason the Fed can print trillions, with minimal effect on the Forex market and inflation in US. Europeans feel frustrated that they cannot make the same thing like US. The solution is to increase global demand for euros finding new clients, public or private. China, for instance. Or Brazil. Or admitting new European countries to join the Eurozone – even the poorer ones – they will bring their low cost labor. Any of these solutions could be successful in igniting some redistributing process “without tears”, the same way US enjoys “budget deficits without tears”.

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