Maxwell's Demons in Brains and Politics

Formulating the evolution of needs and values as dialectics of entropy

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Abstract

The evolution of capitalism in the last 300 years can be characterized as (i) an evolution of productive forces mirrored in a long-run decrease of labour value of commodities, (ii) an evolution of needs reflected in a permanent, even accelerating growth, reshuffling – emerging elements and disappearing elements - of the vector of possible commodities itself, and (iii) by the evolution of a rich structure of institutions. It is telling that mainstream neoclassic theory takes the non-existence of these evolutionary processes, namely given technologies and given preference orders over a fixed set of commodities in an institution setting consisting only of competitive markets as its axiomatic starting points. On the other hand, the smallest denominator of current definitions of evolutionary economics is their opposition to mainstream neoclassical theory, thus implying that any positive definition of an evolutionary political economy of capitalism should build on specifications of the above-mentioned basic evolutionary processes.

The central thesis presented of this paper is that it is useful to frame such specifications in the language borrowing that borrows concepts from physics and information science.

Introduction: The Demon

In 1867 James Clerk Maxwell, the eminent physicist, in a letter to a friend mentioned an idea about the possibility that the second law of thermodynamics – the tendency towards an ever-increasing disorder (entropy) - might be circumvented. Physics just was on the way to be transformed into a science developing probabilistic laws and Maxwell was one of the major contributors. In particular he was able to formally describe the elements of a set (of gas molecules) not by making an assumption about a hypothetical representative element and then simply aggregating, but rather by looking at distributions of heterogeneously acting elements

and solving the much more complicated system. This new procedure clearly leads to conclusions different to the representative agent approach, and provided more adequate descriptions of what actually happened in laboratory experiments. One – formally reproducible - consequence of this discovery was that in the course of the dynamics of that system a certain measurable system property, expected entropy, necessarily increased. Roughly speaking, every initial order of elements, i.e. elements with a similar property building clusters, would more and more vanish, in the long-run a state where every element has the same average property would be approached. This was the famous Second Law of Thermodynamics. Of course, the starting point of the theory, probabilistic distribution functions, implied that in any actual processing of such a system there was some non-zero probability that entropy decreases, that order emerges. In 1871 he published his book 'Theory of Heat', where in a section called 'Limitations to the Second Law of Thermodynamics' he repeats the idea mentioned above:

"One of the best established facts in thermodynamics is that it is impossible in a system enclosed in an envelope which permits neither change of volume nor passage of heat, and in which both the temperature and the pressure are everywhere the same, to produce any inequality of temperature or of pressure without the expenditure of work. This is the second law of thermodynamics, and it is doubtlessly true as long as we can deal with bodies only in mass, and have no power of perceiving or handling the separate molecules of which they are made up. But if we conceive of a being whose faculties are so sharpened that he can follow every molecule in its course, such a being, whose attributes are still as essentially finite as our own, would be to do what is at present impossible to us. For we have seen that the molecules in a vessel full of air at uniform temperature are moving with velocities by no means uniform, though the mean velocity of any great number of them, arbitrarily selected is almost exactly uniform. Now let us suppose that such a vessel is divided in two portions, A and B, by a division in which there is a small hole, and that a being, who can see the individual molecules, opens and closes this hole, so as to allow only the swifter molecules to pass from A to B, and only the slower ones to pass from B to A. He will thus, without expenditure of work, raise the temperature of B and lower that of A, in contradiction to the second law of thermodynamics.

This is only one of the instances in which conclusions which we have drawn from our experience of bodies consisting of an immense number of molecules may be found not to be applicable to the more delicate observations and experiments which we may suppose made by one who can perceive and handle the individual molecules which we deal with only in large masses.

In dealing with masses of matter, while we do not perceive the individual molecules, we are compelled to adopt what I have described as the statistical method of calculation, and to abandon the strict dynamical method, in which we follow every motion by the calculus."

Later the being was dubbed ***Maxwell's demon***. Its significance for theoretical physics was hotly debated. While some found it trivial to mention that probabilistic laws lead to

probabilistic results, others argued that there is more to Maxwell's story. Richard Feynman, the notorious genius of theoretical physics in the 20th century, considered the second law of thermodynamics because of its introduction of time (only via this law the notion of time enters the world of laws of theoretical physics at all) as something quite different from the rest of laws discovered so far. He links this peculiarity, i.e. that the common observations of irreversibility, of asymmetry between past and future, of neg-entropy seem to contradict the law, to a problem of abstraction level. Only our abstraction, our ignorance of micro-dynamics – and a whole lot of them are not even known today – misleads us to perceive the mentioned contradictions. He implied that it is our own time horizon, the extremely short period mankind exists within the long-run build-up of neg-entropic living systems on earth, that makes us consider neg-entropic processes as so natural (compare [R. Feynman, 1967, chapter 5]). That perception, in particular ***partial ignorance*** plays a crucial role for the understanding of structure building living entities was an idea that in many contexts later on reappeared again and again[1]. In the course of the rediscovery of the importance of Maxwell's demon in the last decade – compare the most instructive collection of Leff and Rex [Leff H.S. and Rex A.F., 2003] – a central idea crystallized, namely that information loss plays a central role: Memory erasure feeds entropy to the environment, this is called Landauer's principle after the scientist who first wrote about it [R. Landauer, 1961]. Indeed, what currently is explored, namely how a richer incorporation of information in a world view based on quantum theory can produce a consistent theory, seems to be in line with Feynman's earlier intentions – there is something special that drives theoretical progress, but the latter will only lead to a better understanding of the second law of thermodynamics.

Political Economy

Why should economists care about such debates in theoretical physics at all? ***One evident reason*** is that the nowadays overdue theoretical foundation of mainstream economics, i.e. general equilibrium theory, in its formal properties is just a copy of the old mathematical treatment of theoretical physics[2] – some hundred years in delay[3]. Of course, there always have been exceptions to the rule (e.g. Wei-Bin Zhang has beautifully applied Haken's synergetic approach to a variety of economic problems [Wei-Bin Zhang, 1991]). But many of the critics of mainstream economics remained quiet with respect to the methods that should replace what they correctly accused. Some even went so far to deny the usefulness of formal methods at all, thus profoundly confusing a certain subset of tools and applications, namely those used by GET, with formal methods in general. In fact, the latter provide an enormous potential for

[1] A prominent example is Hermann Haken's (nobel price winner in chemistry) science of synergetics that heavily rests on the principle of abduction, i.e. applied ignorance (compare [H. Haken, 1977]).
[2] The most detailed treatment of this very strong and surprising issue can be found in a recent paper by E. Smith and D. Foley [Smith E. and Foley D., 2002]
[3] That economics not even take notice of the transformation to *statistical* mechanics in physics is a major argument in [Farjoun E. and Machover M., 1983].

further developments in economics. So why not learn from ***contemporary*** methodological debates in physics?[4]

The ***second, deeper, reason*** why this debate is so important for evolutionary economics is the content of this debate. The following analogies are rather evident:

1. As Maxwell did away with the representative micro-unit, replacing it by assumptions on the distribution of heterogeneous features so is evolutionary economics laying emphasis on heterogeneous traits of social micro-entities. And as Maxwell needed a substantially new formal apparatus to deal with this more complicated starting point, so will evolutionary economics be forced to apply the most advanced new tools. On the other hand, economics will even have to solve a much more difficult problem: its micro-units entertain heterogeneous individual models on which they base their heterogeneous actions.
2. From Maxwell to Ludwig Boltzmann (and finally to Schrödinger) theoretical physics did take on board large parts of another science, of probability theory. This changed the whole character of the discipline, lead to methodological crisis and deepening gaps between schools, but finally to a highly successful result in terms of predictive power. For evolutionary economics a similar merger with new modelling sciences can be predicted. In particular, if information is described as an element of thermodynamics (Maxwell), if observation is part of the observed process (evolutionary economics), then this can be interpreted as an attempt to bridge the long-standing scientific divide between mind and matter, between humanities and natural sciences[5]. This also shows why it is economics, and not the social sciences in general, that has to be addressed to take this big leap forward: Economics is the discipline that tries to embed the biological growth process of the human species, its primary metabolism, in a broader framework of intended actions of an ensemble of model-building social entities – or vice versa[6]. Economics is necessarily evolutionary, because in this continuing interdependent process between learning of preliminary models and biological evolution, the classical vision of discovering economic principles is replaced by an (meta-) evolutionary theory that allows for informed and welfare increasing intervention[7].
3. Maxwell's demon used his observations to increase neg-entropy, i.e. order. Evolutionary economists, at least part of the variety mentioned in the last footnote, try

[4] Physicists are already out to conquer and redefine economic theory, they call this area econophysics. And this is a good thing! It forces economists to defend their terrain that is to learn the most advanced tool from the formally better equipped, thus superior aggressor. In the end, this will advance political economy.

[5] As a side issue: Note that the old view is not just a special case embedded in a broader more developed new theory. It is an extremely ***implausible*** case; its probability is close to zero.

[6] The still fashionable models of the rational expectations school in this perspective are just a helpless attempt to exorcize model building (the process) of social entities completely, a price that clearly is paid to save the quasi-physical treatment of units. Instead of learning, a state where the mental models of entities perfectly mirror the actual physical state (including the identical mental models) is described.

[7] This last conclusion surely still is a matter of hot debate between evolutionary economists. The scope reaches from evolutionary defeatists to evolutionary social interventionists and is the basis for a fruitful dialectics.

to consult economic policy to enable welfare increases. In other words, they advice to allow or to prevent actions of observed social units – just like the demon opens or closes the hole after having observed the velocity of the molecule. They are increasing order with respect to an endogenously emerging welfare vision, a fundamentally more demanding 'decrease in entropy'.

The strength of an evolutionary approach in economic theory along these lines will have to be proven by its ability to describe the essential features of actual developments, and to design effective intervention. So what where essential features of political economy in the last 200 years?

Evident for every economic historian, but embarrassingly neglected by mainstream theory[8], three developments can be singled out in the developed world:

- Productivity, more precisely, labour productivity exploded[9].
- New utilities of households (and the individuals in these households) emerged permanently – driven by firms as well as by changing social and environmental circumstances.
- A constantly increasing set of social institutions – sub-national, national and super-national – has emerged, a network of relations that teaches societies what the concept of democracy can mean.

To describe the first feature, labour productivity increase, evolutionary economics recently has concentrated on empirically informed, theoretical descriptions of the disequilibrating force of innovators[10]. A wealth of interesting issues has been unravelled, including strategic behaviour, the dependence on the macroeconomic and the political environment, the influence of financial institutions, and expectation building processes providing forecasts about all the formerly mentioned items. None of these elements is dominated by a clear-cut market process. What rather can be observed, in particular in the last 30 years, is an increasing role of direct (sometimes only expected) coercive power[11]. Markets, on the contrary, have proven to be restricted to those special situations where the power relations allow for interaction between participants of approximately similar force. For the innovation process their role is further diminished, since it is the very characteristic of the new product, service or institution that the demand side does not yet know it. The role of innovations with respect to market

[8] In the standard neoclassical model technical progress is exogenous, preference orders are fixed and the only set of fixed institutions consists of markets, which are cleared with infinite speed. Loosening of any of these counterfactual assumptions - recent attempts to do so are telling - leaves this type of theory in deep trouble.

[9] Even the more empirically oriented mainstream has noted that this feature is decisive for capitalism (e.g. [W. Baumol, 2002]).

[10] As one example within a broad field of wok compare [Cantner U. and Hanusch H., 2000].

[11] Even the more empirically inclined mainstream theorist Jack Hirshleifer acknowledges the returning importance of power [Hirshleifer J., 2001]. Remember Karl Marx' famous dictum stating that power is an extraordinarily strong economic force ('Sie selbst (die Gewalt, H.H.) ist eine ökonomische Potenz').

dynamics clearly is that of a disturbance, curbing effective demand in other output markets, raising prices in some input markets, etc. From a macroeconomic point of view, large economies with large production units, a well developed financial system and either strong domestic demand or high export potential (or both) seem to breed these disturbances of market forces particularly well.

Maxwell's evolutionary demon in political economy (decision-making entities, social institutions) in some countries clearly managed to install a rule system which let innovative firms survive better than in other countries: Large ones certainly get larger, and exports can extend the limits set by domestic demand[12]. In this perspective the increasing gap in R&D between the USA and the rest of the world surely makes sense. Add a falling US Dollar as exchange rate policy and the export initiative since the collapse of Bretton Woods fits perfectly to the exploding inequality in income distribution in the United States. Indeed, the European Union in its euphoric initiative to conquer 80% of world markets by its newly introduced (falling) Euro just tried to imitate the US success story. After three years this second devil probably can be said to have failed. Shifting the income distribution towards more inequality proved to be substantially more difficult and slower than in the United States. Moreover European exporters found an already poorer middle class in the USA, while their predecessors, i.e. US exporters in Europe 25 years before, could sell to a still relatively wealthy middle class in Europe. Nevertheless the USA felt hurt by the short European counter attack, and it is only straightforward that a shift in direct power relations between the United States and the rest of the world had to follow. After 9/11 the strategic power game was accelerated: Investing primarily in military productivity growth, the sector where US lead was already largest, promised to increase dominance most. The European Union - partly still caught in the useless and outdated imitation game and trying hard to break the resistance of some social entities that fight income losses of their members – will be forced to react on the military challenge. Therefore markets will play a less and less important role in the near future – quite contrary to contemporary privatisation propaganda.

But remember that one of the most important lessons learned by Maxwell's metaphor is that the demon first has to observe micro-units correctly, only then the being can play its sorting job. To some extent this observation is easier in political economy since their behaviour can be monitored and influenced by the increasing ICT capabilities of the demon. Moreover the primary metabolism of households does not play the role of a tight restriction in Europe or the United States[13]. But still the behaviour of micro-units, of the members of households, has become extremely volatile and hard to predict. This leads to a discussion of the second essential trend: utility dynamics.

[12] The problem with domestic effective demand is that a large part of it appears as wage cost on the balance sheet of potentially innovative big firms.

[13] A treatment of global economics, where this constraint is probably one of the closest bottlenecks goes beyond the scope of this paper.

Increase of labour productivity implied lower social values[14] of the inputs of the primary metabolism too. Together with a trend to increasingly intensive work, in many cases even increasing daily working hours (multiple jobs, after hours, weekends) and lifetime schedules (pension reforms), this produced a tremendous increase in output. Despite exploding profits in a shifting income distribution cheap standard means of subsistence were possible. This left middle class consumers with some freedom to stroll into the spaces of possible new utilities. The structure building force of an evolutionary demon is not completely clear right now; yet there seems to be a growing share of utility derived from the consumption all sorts of information and communication goods and their related services. But information goods pose serious problems with respect to property rights, as is the case with infrastructure services, another candidate for utility attraction. The emerging continental political unit in Europe will have the difficulty to deal with such large scale suddenly arising shifts in utilities. E.g. the surprising wave of communication demand (mobile phones) in the 90-ties implies long-lasting behavioural changes with hard to predict repercussions. On the other hand this extremely flattering type of demand, at least in Europe, can be channelled into a much smoother flow of effective demand by a well-developed and powerful financial system (credits). So indeed, compared to the USA, Europe with its more developed social culture might have more room to manoeuvre with respect to utility exploration and innovation of political units – perhaps restructuring those parts of the production side for which the old-fashion property rights relation of private firms is inadequate. Emerging aggregate utility focussed by political processes, not by markets, might provide the necessary drive and legitimating for such (r)evolutions. The evolutionary demon of political economy in this respect looks like a rather progressive being.

Trend number three: The innovation of social institutions, i.e. the emergence of new social entities, is a rare event. They sometimes are milestones of social progress that after a long period of struggle finally come into existence. Sometimes they are the product of quick and dirty power handling of more powerful social institutions, invented just as an additional tool in the fight for additional rents. They may exit quietly because their reason for being has vanished, or they may explode with a big bang because a group of enemies suddenly has gained control and destroys them. From the perspective of evolutionary economics a well developed structure of institutions is a necessary part of modern society, not just the caricature often found in mainstream textbooks: A bunch of lazy people eating away the hard earned surplus of firms, doomed to be kept as small as possible (e.g. lean state management). In fact, the evolution of this political side of society, what makes the economy to a ***political*** economy, carries the vision of evolutionary political economy, a better and more democratic society. Only by testing envisioned institutions the members of society learn what democracy might

[14] There still seems to be a role to be played for a new version of a fully dynamic labor theory of value. A detailed discussion of this issue cannot be included in this paper, but compare [Hanappi H. and Hanappi-Egger E., 2003].

mean and how it interacts with the economy. In no other domain the evolutionary demon jumped around so wildly, seemingly moving left in former monarchies after World War 1, then jumping right with the institutions of fascism in Europe, somewhat to the middle after World War 2, and so on. Perhaps this is the point in this argument where the nature of this mysterious being, as far as evolutionary political economy is concerned, reveals itself: The demon is nothing but the self-organized mankind that struggles for its consciousness.

Brains

One very queer feature of economics is its enduring insistence on methodological individualism. The human individual is its starting point, and even if it focuses on families [Becker G., 1981] or firms [Ricketts M., 2002] these are always conceived as some more or less intentional groupings, of outcomes of strategic actions of individuals, equilibrium points so to say.

In the real world most of the time individuals act on the basis of the models they entertain in their brains. These models are far from being copies of the actual dynamics they sometimes refer to. The overwhelming majority of them has been acquired in the course of communication processes that are more or less continuously are taking place between individuals. Existing sets of models, traditions, are thus usually transferred to new members of social groups, making them talk and act in the same way as their peers - at least as long as no shock of inconvenience hits them off the trail. To some extent the common worldview is what constitutes a social entity, its split into physically different biological individuals becomes rather unimportant, at least from an economic perspective.

The link between individuals within the same social entity to a large extent works via their perception and communication, including self-communication (e.g. memory, model-building), physically located in their brains. As a consequence, it is clear that evolutionary economics must be interested in brain processes. They are the physical basis of the micro-dynamics that – if properly disentangled, remember Maxwell – make a sound description of social entities possible. And if evolutionary economists follow this advice, then they will find an old friend at work in human brains: Maxwell's demon.
As recent brain research shows, several important brain processes can be described by Lotka-Volterra dynamics, equations well known to economists by Richard Goodwin's work on business cycles and capitalist dynamics in general [Goodwin R. and Punzo L., 1987]. With two types of elements, activators and their counteracting silencers, oscillating systems in human brains can be traced back to their molecular chemical properties. So we start to understand the build-up of patterns, of some ordered structures in the brain, initiated by a stimulus from outside, by perception. Of course, the way up to full-fledged communication processes still is long, but there are already elements in work that could help. Not only

linguistics contributes, but also modern network analysis was able to show that several languages posses the small-world property. This might shed some light on the evolution of language, not only in every single brain but also in general. The evolutionary demon seems to work by starting to select nodes with preferential attachments (nodes with many links have higher probability to be selected again) leading to exploding scale-free distributions – a pattern also found in the population sizes of cities, in that context called Zipf's law. But as this process in some of the dimensions in which it works hits a limit that cannot be exceeded, and if this event changes the sign of the formerly stimulating feedback to other dimensions, then an oscillation of states occurs. And oscillation simply means that certain states are periodically revisited – time and memory have emerged in the brain. Of course, this brief sketch misses all necessary detail; it only should ventilate the idea that the demons evolutionary selection is not as mysterious as one might first guess. As Maxwell's demon never contradicted the second law of thermodynamics, it only provoked quantum theory to provide better microdynamics, so our evolutionary demon hopefully will do similar work in political economy. But evolutionary economics does not posses an analogue[15] to the second law of thermodynamics! The concluding paragraphs will give my short and extremely speculative best guess for a candidate.

Conclusion

Contradictions[16], caught in time as spiralling (exploding oscillations) movements, hit limits and transform their force. The speculation is that the total force of contradictions in the human society remains constant – analogue to the conservation of energy in a closed physical system. The transformation of this force into different forms manifests itself in the emergence and exit of social entities, which therefore can best be understood as spiralling - or over shorter time horizons oscillating - systems. At least, this is a working hypothesis.

In this paper the strategy was to reach this conclusion from both ends, the long-run macroeconomic topic of political economy and the short-run molecular topic of an individual brain. In between, further developing evolutionary political economy[17] will play a demon's game.

[15] In his monumental last work the biologist Stephen J. Gould tries to give a kind of negative upshot of evolution, namely that there is no progress to be found, there just is evolutionary drift [S.J. Gould, 2002]. But this impression probably is too vague to be counted as a law.
[16] The concept of contradictions as creative force is also dealt with in [E. Egger and H. Hanappi, 1995].
[17] My view on the research program of evolutionary economics can be found in [H. Hanappi, 2003].

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