Observing productivity
What it might mean to be productive when viewed through the lens of Complexity Theory

Manfred Füllsack

Working paper (Oct. 2011)

Abstract: *The paper tries to clarify the epistemological background of what in economical terms is referred to as productive. It does so in respect to insights from Complexity theory, therewith taking up charges about the contradiction of economic productivity and the Second Law of Thermodynamics. In respect to epistemological consequences of contemporary levels of productivity however, a seemingly paradox constraint is put forward: the constraint that productivity is conditioned on being observed as such, with the observer in its turn being conditioned on productivity.*

While theoretically quite simply defined, the economic conception of productivity poses problems on practical grounds. Today, various growth and well-being indices compete for an unambiguous definition of what exactly it is that can be considered productive.[1] The experience seems to becomes common that what counts as productive in one respect must not be productive in others (cf. Füllsack 2008). The fact that the pride of Victorian labor for instance, the massive output of material industrial goods, mainly produced by male manual labor and huge machinery, today often is accounted for its vast exploitation of raw materials, its wasteful effects on the environment, or its long-term effects on gender-inequality - to name just three aspects -, seems apt to fundamentally shake the longtime unquestioned category. The clear-cut distinction of productive and unproductive labor with which Adam Smith tried to explain the causes of wealth, and which Marx momentously passed on to Socialism to make it a core principle of administered labor, seems to dissolve in the plurality of perspectives modernity provides. The epistemology of modern society - allowed for by its "productivity", as we shall see - obliges to specify to whom and in regard to what productivity is considered productive. As a consequence, speaking about productivity today necessitates to specify its *observer*.

This seems to call for a philosophy of science at first, for to clarify the conditions of observation. But as we shall see, observing the observer is difficult without having the observer observing *something*. The observer simply is no observer without any observed. It has to be related to something in order to "be". And since one would like to conceptualize the observer in terms of productivity as well, it turns out that productivity might be the most basic "something" that an observer can be thought of observing.

So, as this paper actually in a sense is meant to analytically grasp what might be meant when speaking about productivity, it focuses on observing the observer as observing productivity. It therefore starts out and ends in reference to respective conceptions of economic theory and to the epistemology of these conceptions. In between however, it draws on insights from complexity theory, from philosophy and from computational science in order to do what it intends to do, that is, to observe the observer, and only therewith to gain a better understanding of what it might mean to be productive.

[1] See for example the *Report of the Commission on the Measurement of Economic Performance and Social Progress*, headed by Joseph Stiglitz, Amartya Sen and Jean-Paul Fitoussi, retrievable at http://www.stiglitz-sen-fitoussi.fr/en/index.htm (22.9.2011). See also Easterlin 1974, Cobb 1995, World Bank 1997, Kahneman/Krueger 2006.

I. Productivity in economic theory

To speak about the difficulty of grasping a value that obviously is (- or has become?[2] -) observer-dependent, first of all necessitates to specify one's own perspective. In order to do so, I will draw upon Daniel Dennett's (1987) distinction of a "physical" and an "intentional stance"[3], with the former, in short, referring to a level of abstraction at which scientific explanations focus on physical causes (and therewith at least implicitly on the project of reductionism), and the later referring to a level of abstraction which is said to be common in every-day-explanations ("folk psychology"), but often also is the base of what academia calls "the humanities". Both stances are conditioned on what Dennett calls "computational power". As we shall see, there is reason to assume that at least classical economics implicitly take in the "intentional stance" when talking about productivity.

The textbooks of this classical economics usually define productivity as the ratio of what is produced to what is required to produce (Davis 1955, Samuelson/Nordhaus 2004). An activity hence is productive if its output-input-quotient is larger than one. Since input and output often are considered compounds, an economic process counts as productive if by doubling input factors output is *more than doubled.* In this case, economy speaks of "increasing returns to scale" (Eatwell 1987, Buchanan/Yong 1994), and in general of "economic growth" (Jones 2002, Helpman 2004, Weil 2008). The concrete causes of this growth, however, often remain somehow vaguely defined.[4] In this regard, productivity just seems to refer to something "*more* than the sum of its parts", with the mysteriousness and attractiveness of the "more" entailing an ongoing quest for its causes. Famous historical candidates for these causes include: land (physiocracy), trade (mercantalism), labor (Locke), its division (Smith, Ricardo), its exploitation (Rodbertus, Marx), its sedimentation in the form of capital (Marx, Boehm-Bawerk, Clark) inducing interests (Fisher), technical progress (Solow), innovation (Coase), knowledge (Romer, Jones) and various combination of the former (Schumpeter) with further differentiations being suggested in the form of organizational, cultural, social and human capital for instance.

As all of these factors leave out on measurability - a highly valued aspect in economics - , efforts continue to concretize and to quantify them, and meanwhile seem to have driven the search for the ultimate productive factor into the realm of information theory, with disciplines like bibliometrics and scientometrics occupying the rather applied side of the spectrum and entropy-oriented physics - as for example claimed by Georgescu-Roegen (1971) - marking its fundamental side. In respect to this fundamental side, it seems legitimate to classify respective endeavors as turning away from the "intentional stance" and taking in what could be called a "physical stance".

2. Productivity and the Second Law of Thermodynamics

At the abstraction level of the "physical stance", productivity (or economic growth) appears to contradict the physical principle known as the Second Law of Thermodynamics. In broad terms, this law states that - statistically seen - entropy inevitably increases and order decays in the universe. With productivity implying an increase of order and hence a *de*crease in entropy, it thus poses a challenge to scientific explanation. Physical suggestions for to explain this contradiction, such as the conception of "dissipative structures" for instance (Prigogine/Nicolis 1977, Prigogine/Stengers 1984), expanded by assumptions about a

[2] This refers to historical changes in social structure as have been highlighted by Niklas Luhmann (1995). Due to space restriction I will not discuss this aspect at length in this paper.
[3] I will neglect Dennett's "design stance" here.
[4] With the probably most cited example being the "residual" in Solow's (1956) conception of *Total Factor Productivity*.

relation, if not equivalence, of energy and information (of *bits* to *ergs*) (Landauer, Bennett 1982), seem to allow to reformulate this contradiction in terms of improbability and informational uncertainty, and to investigate into the apparently contra-intuitive increase of order by way of computation. Meanwhile, this has entailed a wide spectrum of investigations in emergent structures based on suggestions to conceptualize the world in terms of a huge Cellular Automaton (Dennett 1991, 2003, Wolfram 2002) and subsequently to redefine (and redesign) scientific research in terms of information theory and respective methods. Currently, these investigations range from fundamental research work as the one on "universal computation" (Wolfram 2002) or on "order at the edge of chaos" (Langton 1991, Kauffman 1993) - trying to grasp what could be called the minimal preconditions of "productivity" -, up to complex and far-reaching endeavors into A-Life-research (Fellerman et al. 2010). And it also entails fiercely fought disputes about reductionism and the possibility of a "Theory of Everything" (Weinberg 1987, Dennett 2003: 68).

3. Entropy-decrease through increase

Within the realms of this research work, findings like the one of Parunak and Brueckner (2001) might be interpreted as a kind of answer to the contradiction of increasing returns and the Second law of Thermodynamics. As Parunak and Brueckner showed on the example of simulated ants coordinating their foraging activities with the help of artificial pheromones, the decrease of entropy (hence increase of order, or growth) has to be seen as *coupled* to a micro-level-order *de*crease. The macro-level-order of coordinated ants seems to arise from an increase in disorder on the micro-level of pheromone-diffusion. In other words, ants seem to "pay" for the productivity gain of coordinated foraging with the loss of order through entropic diffusion of pheromones. The productivity on *n*-level-order appears to be compensated by "unproductivity" on a *n*-1-level-order. As Parunak and Brueckner could show by way of statistics, the increase does not just outweigh the macro-level-decrease but seems to increase entropy in the overall system, so that the Second law is fully satisfied.

As seen from the "physical stance", this might be a universal principle, as other examples of entropy decreases through coupled increase can be easily found. Parunak and Brueckner themselves mention the dissemination of a common currency ("money") for example, in order to facilitate the exchange of (otherwise incompatible) goods and services. Georgescu-Roegen 1971) emphasized pollution as the downward aspect of productivity. Analogously, the institution of highly dynamical scientific communications (publications, congresses) in order to enable cognition, or, may be more to the point, the provision of fecund economic environments for the start of businesses in order to let some of them prosper seem to draw on respective possibilities. The most general example in this regard might provide evolution itself, with a few "fittest" individuals eventually representing order and growth, and a huge fraction of "unfit" having been sacrificed on the way in order to enable the survival of the few.

Hence productivity, as seen with the "physical stance", does not seem "really" productive. At best, it could be regarded as a temporal or spatial shift or a "bias" in the concentration of order, that is a bias towards the entropy-*de*creasing side of the process.

However, a bias it is, albeit an elusive and transient one. So the question remains as to where the bias comes from. And this suggests to draw the *observer* into the game. What is more, it urges to regard the observer on a level of abstraction at which it[5] can be conceptualized in terms of entropy-decrease as well.

[5] The observer, as it is conceptualized here subsequently to Spencer-Brown, Foerster, Luhmann etc. (see below), is a formal entity. To ascribe gender to it would be misleading.

As a preliminary, it should be noted that this endeavor - obviously - leads into a *circular*, that is, a *self-referential* conception. It tries to clarify its preconditions while using them. However, as insights from mathematical and computational theory suggest, such an endeavor does not necessarily run dry in the infinite regress that classical philosophy dreaded so much. As it seems to find analogy in what in mathematics is called Gödel's encoding ("Gödelisierung") and in computational theory is known as Turing machines, that is, as machines that allow for a concurrency of program and programmed, for a computation of data that is enacted by other data provided in the same medium, it seems to be formalizable and simulatable. It therewith might allow to say something useful, maybe even "productive" about the observer.

4. The observer - and its observer

The first feature that springs to mind when regarding the above examples of entropy-decrease through increase is the fact that the observer is a "result-seer". What it gets to see are results, rather than the processes that lead to these results. When observing ants for example the observer tends to see readily coordinated insects rather than the process of coordination, (which in this case would imply to see the diffusion of pheromones). The same applies to evolution. What is usually[6] seen, is the result of natural selection, but not evolution itself. Hence, what the observer perceives as productive conforms to the *ontology* of productivity and not to its *ontogenesis*, or with Prigogine (1980), to its Being and not its Becoming. Alluding to William James' sculptor[7], we might say that what is perceived as productive - a (temporarily) stable decrease of entropy - appears to be a "cutout" from the overall picture - a cutout generated by the one who perceives it as order, that is, by the observer.
Calling the observed a "cutout" however, entails an irritating philosophical consequence which could have been thought to be abrogated already by the fundamentality of constructivism: namely the necessity to assume something (a Kantian "Ding an sich") *behind* the observed. "Cutting out" or "selecting" implies a plurality of instances *from which* something can be selected. On the abstraction level of the "physical stance" however, the observer is an abstract entity which has no whatsoever conception of an overall world from which it selects or cuts something out. This observer is thought to observe what it observes, and nothing more. So when speaking of a "cutout", one obviously implies an observer of the observer, a second (-order-) observer[8], who can see that the first (-order-) observer cuts something out.
Although eventually observing the observer - as will be discussed below - can induce "self-observation", for the time being, in order to keep to the "physical stance", we should regard this second (-order-) observer as having no other abilities or qualities than the first (-order-) observer. This means that this second observer necessitates an observer in its turn for to be conceivable, and this applies to any further observer as well. Considering the resulting chain (or network) of observations into some depths, it turns out that observation needs observation in order to *be* and therewith implies the above mentioned infinite regress. In the realm of complexity theory and related disciplines however, such reciprocal dependency is not considered a tragedy. The mutual provision of possibility, or, as it might be termed in regard to the conception of Bayesian networks, the mutual provision of probability is known to run

[6] „Usually" refers to the every-day-commonness of the "intentional stance" as distinguished from the highly abstract, and therefore unlikely, "physical stance". I come back to this in section 10.
[7] In James' (1890/1983, I: 288) picture, this sculptor initially faces thousand different statues in the block of stone from which he eventually extricates the one that finally will be observable as his oeuvre. He does so "by simply removing portions of the given stuff", that is, by increasing entropy in his studio.
[8] This, of course, refers to "observing systems" in the sense of Heinz von Foerster (1981), that is, in the double-sense of the English *-ing* form, as systems observing observing systems.

up to *attractors* which might be “strange” at times, but stabile enough for to provide footing to further dynamics (Abraham/Shaw 1984, Strogatz 2001, Füllsack 2011a). I come back to this in section 9.

5. Regularities

For the moment let’s turn to the “results” of order generating processes again. The reason for the observer observing *results*, and (usually) not processes, can be seen in the fact that only results possess the *regularity* on which the observer can *capitalize*. What do we mean by this?
In order to explain the phrase “capitalizing on regularities”, I suggest to follow considerations of Francesco Varela (1992: 7) and to regard the most general “reason” to observe something as an act of emerging and maintaining existence, meaning that an observer observes something which it can use as a “resource” for its existence. Note, that this implies to regard the observer as taking an “intentional stance” towards the “resource”. With the “physical stance” however, it should be possible to regard a “resource” not immediately as nourishment or fuel or any other mean an observer might aim its actions at, but to take it most abstractly as a kind of advantage or leverage which the observer can deploy to emerge as such and to persist, and be it only for a tiny moment in time.
May be the most basic form of such a “resource” can be seen in *regularities*. The reason for this is best explained with a short excursion to the attempts to find measures for complexity. As two among many of such measures (see Lloyd 2001 for a list, Mitchell 2009 for an introduction), *predictability* (aka Shannon-entropy) and *compressibility* (aka algorithmic complexity) have been suggested. A highly regular process - like for example the one which would generate the sequence {101010101010101010101010 ...} - allows for a pretty save prediction about the next coming event, the binary 1 in this case. The tossing of a fair coin on the other hand seems to impede any such prediction (if not just statistical). Thus, a process which is predictable in its outcome can be compressed. The above sequence could be represented by the rule <print 12 times “10”> for instance. Compression thus economizes on computational power. It provides a predictive leverage. One might say, it provides a possibility to do the same with less input. It thus allows for to be *productive*.
If an entity can emerge which can use this possibility, it might gain an advantage against the entropy of its environment. It can *capitalize* on this possibility. Therefore, on the condition of the emergence of such an entity, a regularity can be considered a “resource” to capitalize on. If one assumes this possibility to be one of many, that is, if one is ready to concede that such an entity in its existence itself might provide a regularity on which a next-order-entity again finds a chance to capitalize on (see to this section 7 and Füllsack 2011b), one could say that such regularities conform to an abstract form of what in the Marxian sense of “frozen labor” has been termed *capital*.[9]
On first view, “high” regularity might seem easier to capitalize on than “lower” regularity, as for example the sequence {10101010111010101010...}, which seems to hold a little “error” after the first four 10s. This in mind, the reason for the observer being a “result-seer” might be seen in the fact that an evolutionary process, or a system of foraging ants coupled to pheromone diffusion, appears to be most regular when it is “finished”, that is, when initial fluctuations have cooled down and the process seems to have found a state from which it does not deviate too much anymore. One might assume that this steady state provides more, or at least sufficient regularity for an observer to capitalize on, that is, to gain a productive advantage with which to maintain its existence. However, in the fundamental simplicity of the “physical stance”, the observer has to be thought of existing *not earlier* than a regularity on

[9] However, as one might want to add here in regard to the topic of this paper, “frozen labor” differs from what Murray Gell-Mann (1995) has called a “frozen accident” by nothing else than *observation*.

which it might capitalize. The observer is not prior to observing regularity. It does not wait somewhere out there pre-given for an evolutionary process to "finish". And this in its turn implies that the "finished" (or steady) state an evolutionary process might run up to, depends on the observer's ability to capitalize on its regularities. In other words, the "end" of such a process is no absolute but a *relative* state that depends on the observer. The end is where the observer starts from - to paraphrase a phrase of Mihai Nadin (2003). The end is brought forth by the observer, which in its turn is brought forth by it. This end is "enacted", in the sense of Varela, Thompson and Rosch (1991). And this means that it depends on the observer's *complexity*, on the degree of regularity that the observer itself possesses, with the complexity of the observer in its turn depending on the complexity of its world. In its most abstract form therefore, the observer is a regularity that emerges by capitalizing on other regularities, with these regularities being the result of an evolutionary process which is "enacted" (i.e. interactively generated) by the observer. The result and the regularity, that is, the observed and the observer, *mutually determine each other*. They reciprocally provide footing to each other.

The principle at issue repeats on this level: it needs regularity for an observer to emerge, and it needs an observer for to observe regularity. Or in short, it needs order to induce order. What to classical analytic attempts might seem paradox and impossible - to conceive such a "bottomless" mutual provision of possibilities -, is currently finding practical investigation in a rapidly broadening spectrum of computer-based methods relying in particular on multi-agent-simulations and Genetic Algorithms (cf. Holland 1995, Jaeger 2000, Füllsack 2011a).

6. Distinct and indicate

As we have seen, regularity implies compressibility and compressibility saves computational power. One thus might see the core condition of productivity in regularities - with the constraint however, that productivity therewith is conditioned on an observer which is conditioned on it. Hence, the condition for an observer to "be", and therewith at the same time the condition for productivity, is a world with regularities, and a mechanism with which to "compress" regularities. A theoretical conception of these two conditions can be seen in the suggestion of George Spencer-Brown (1969) to define observation as the dual operation of "distinction and indication". As mentioned above, this definition, when deconstructed, necessitates not just one but two observations. On a first order-level, the *distinction* (as the first aspect of the dual) might be brought forth by a multitude of random differentiations (*distinctions*) of which one (eventually) is observed (by a second (-order-) observer) as "successful" or "final" and therewith *indicating* a certain state, for example the "result" of an evolution. This state therewith becomes the "observed" state, however, only as being a "result" in itself - a "result" which is brought forth by another observer.

The observer thus, *if observed*, appears to observe by differentiating its world into bisections and indicating one of them as the one relevant for further operations (i.e. for further observations). An air-con for example observes its world by differentiating warm and cold temperatures and indicating one of them as reason for sending an on-signal to a heater. A computer differentiates binaries and indicates one of them as the state from which to start the next computation. An organism distinguishes usable resources from unusable and indicates usable as the ones relevant for maintaining existence.[10]

On the abstraction level of the "physical stance" however, the observer might also be thought of simply "observing by being", that is, by *embodying* a "distinction and indication" with its

[10] On a hardly less abstract level than Spencer-Brown, Niklas Luhmann (1984/1995) uses this formula to explain the emergence of a system by being distinguished by an observer from its environment and indicated as the relevant observable entity. The clue in this conception, however, is the fact that *complex systems* are considered *self-observing* and therewith might maintain the distinction from their environment *themselves*.

emergence. A plant for instance distinguishes sunlight from eternal darkness by indicating sunlight with its existence. The famous *Game-of-Life*-Glider (see Dennett 1991 for an explanation) distinguishes and indicates - hence “observes” - the 25 GOL-cells and their particular rule-based interrelations which provide those regularities that enable its persistence in time and in space. If one dares to strain wording even more, one might say that these specific 25 GOL-cells and their interrelations are the “resource” on which the Glider emerges and exists. More generally thus, one might formally define observation as a distinction that turns out to be capitalizable and therewith is indicated by the emergence of an entity that uses the neg-entropic advantage it gains from this observation to maintain its existence for the next given moment in time.

7. Productive upgrades

This emergence however, might be momentous for the observer itself, since it alters the “initial” regularity on which it emerged. The “initial” regularity becomes, so to speak, suspended (“aufgehoben”) in the triple meaning of Hegelian German. It *lives on* as manifested in the internal complexity of its observer. At the same time it is *abolished* since altered by the existence of the observer. The world changed with its existence. And it is also sort of *lifted to a new level*, at which it again might provide sufficient regularity for a new - and arguably a bit more complex - observer as well, who, if successful, repeats this suspension on the next level of order again.

In its own complexity, this *n*+1-level-observer therewith might be thought of as *building on* the complexity of the *n*-level observer. For the *n*+1-level-observer the *n*-level-observer serves as a “resource” which sort of *hands on* a part of the neg-entropic advantage that itself could gain. This passing-on of neg-entropy seems to allow for increasingly effective attempts to capitalize on “self-made” regularities. *Observed* productivity thus, might drive itself into an ongoing process of productive upgrades (cf. Füllsack 2011).

In detail, these upgrades can be explained by what William Ross Ashby (1956) has called the “Law of requisite variety”, which, in short, states that variety is needed to cope with variety. For to observe a regularity which is in a simple way regular (as for example the sequence {1010101010...}), a simple observation might suffice to unfailingly predict the next coming event and thus to safely compress the sequence. A regularity however, which is just *statistically regular*, that is, one that contains “errors”, might still be compressible and provide a predictive leverage. But this leverage depends on how much “noise” its observer can take. And this in its turn depends on the existence and complexity of a sort of controlling mechanism which observes the *regularity of the regularity*, that is, the “noise”, or the amount of “errors” in the regularity.

One might conceive this controlling mechanism as a sort of *internal* second-order-observer, an observer with the task to observe the observations of the (internal) first-order observer in respect to “dangerous” deviations from regularities, - an observer, so to speak, that observes the regularity of *irregularities*. And as these irregularities might occur to be just statistically regular too, one could conceive of yet another (internalized) observer who observes the observations of the controlling mechanism, and so on, constituting a “requisite variety” of distinctions and indications that build on each other. Depending on the environment in which these observations take place, this “requisite variety” of mutually observing “control-levels” might refine and therewith significantly enhance the system’s possibility to capitalize on regularities.

Since the operations of such a system generate noise on their own, it might seem conceivable that eventually such a system appears to spend more attention on observing its internal operations, than on observing its world. Such a system seems to shift its observational operations from its environment to itself. It seems to *observe itself*, that is, to capitalize on self-generated regularities. In the terminology of Spencer-Brown (1969), such a system performs a *re-entry* of its own operations. Maturana and Varela (1987) suggested to refer to such systems as autopoietic.

8. Intentionality

At this point, Dennett's "intentional stance" comes back into the picture. Remember, that we spoke about intentionality in regard to the GOL-Glider, however in an overly metaphoric way. A composite system however, with several control-levels observing each other's operations and therewith *internalizing* the distinction and indication of productivity into itself, might be regarded as operating with an amount of intentionality that exceeds metaphority. In 2006 Josh Bongard and his colleagues (2006) presented the by now famous "continuous self-modeling machine", a starfish-shaped robot, which uses a model of itself and its environment in order to "virtually" pre-test combinations of movements that its limbs allow to perform. From this multitude of test-movements, the machine than "cuts out" those that appear to be productive in terms of motion. If one of the limbs of the machine is removed, it repeats the search for a productive combination of actions until it finds a new way to walk.
As seen with a "physical stance", this machine works (and also emerges[11]) on the above mentioned principle of "entropy decrease via increase". The machine performs, so to speak, an opulent waste of virtual motions in order to carve those ones out from its space of options that eventually might prove productive. However, this machine would hardly raise any interest, if it is just observed in regard to its physics. What makes it a "productive" result of scientific endeavors is the apparent *autonomy* with which it seems to *intentionally* look for ways to maintain motion. The machine is observed - and presented - with an "intentional stance".
Its autonomy thereby stems from the fact that we, the (second-order-)observers, observe the principle of "entropy decrease via increase" as an *integral* process of the robot itself. We observe the machine as a whole with an autonomous intention to walk. And we do this even in spite of our physical-stance-knowledge (i.e. our scientific knowledge) of the robot being just a machine.

At this point, the reason for deploying the distinction of "physical" and "intentional stance" in this context should become clear. As said before, the distinction denotes levels of abstraction and has an economical implication in Dennett's conception. By itself, it is not free for decision, but determined by the costs of computational power. As a consequence, we usually cannot simply choose to take in the one or other stance, or to deliberately oscillate between its perspectives. As with every observer, our stance is determined by the capacity to capitalize on the regularities at hand, that is, by our possibility to cope with complexity. And as this complexity might be quite overwhelming at times, it does not make sense to account for it in each and every context. In every-day-life for instance, it would be quite stupid to consider the myriads of neurons and their connections that our brain lavishly deploys for guaranteeing an optimal level between stabile and flexible behavior (between *exploitation* and *exploration*, as evolutionary theory calls it). In this context, we would be helplessly overburdened if we would act and observe with a "physical stance". Or in the words of Dennett, on this abstraction level the "intentional stance" makes sense because it saves computational power. It provides the needed predictive leverage while minimizing computational efforts.[12] In every-

[11] Which becomes visible if one considers the abundant mass of trials and errors producing less effective robots and other predecessor machines from which finally the self-modeling starfish-robot was "cut out".
[12] In this regard, I dare to predict that in the extent that our interactions with artifacts like the starfish-robot increase in daily life, we will start to ascribe intentionality to them - simply *for economical reasons*. Already

day-life it simply *suffices* to account for the *effect*, for the “result” of the lavish deployment of neurons in our brain. And it suffices to call its adaptation *learning* rather than *evolution*. At this level, we are not driven by the “blind teleology” (Dawkins) of evolutionary selection. We are *intentionally planning* our actions.

9. Bottomlessness

However, intentional planning can be quite efficient, as we know. In some sense, it can increase productivity severely. The current state of the world with all its order and dynamical growth would hardly be conceivable without the effectiveness of plans and intentions. In this state far from thermodynamic equilibrium, productivity seems enhanced to an extent at which our capacities to cope with complexity allow for an unprecedented level of capitalizing on regularities. However, the enormous productivity gain effected by intentionality entails a paradox consequence. It allows for, and eventually institutionalizes a level of abstraction at which a systematic questioning of what it means to be productive is incited. This is the highly unlikely abstraction level of the “physical stance” and its institutionalized manifestation called *science*.

One might pin down the reason for this seemingly strange twofold dynamic at first to a simple temporal shift that the “intentional stance” seems to entail, a shift from backward-oriented to forward-oriented processes. In this regard, the “intentional stance” acts like an observer itself. It shifts the temporal bias from the past to the future. While triggering a dramatic increase in productivity on the one hand, it therewith “virtualizes” productivity on the other hand as well.

As we have seen, the “blind teleology” of evolutionary processes builds on a plurality of instances that seem to exist *at first* in order to only *then* distill a productive result from them. In contrary, the “explicit teleology” of intentional activities can *advance* a “result” which only *then* tries to find amortization by spreading costs over a plurality of instances. A simple hammer might exemplify both cases. A hammer can be bought in respect to the (past) experiences of repeated necessities to drive in nails. But it also might be bought on the (future) expectation to once have driven in so many nails that the costs of the hammer eventually pay off.[13] This second possibility seems more momentous, since it includes the chance to repeat this advancement *even before* the costs of the first investment have been paid off. One might not have done enough hammering for to let the purchase of the hammer become reasonable, but one can start to think about buying pliers as well for the (future) possibility of once having to remove so many nails that the pliers pay off.

In short, intentionality, and the expectations and anticipations it enables, can trigger chains of next-order-investments that in their turn again entail expectations to once eventually pay off. As a result, the probability of - and also the need for - anticipating activities seems to increase. With the possibility for activities that postpone their amortization further and further into the future, anticipations begin to drive anticipations, with the actual pay-off sliding more and more out of view. Amortization itself becomes irrelevant, and one might ask if *this* is the true reason for the unprecedented upswing of productivity in modern times.

Asking this question in this way, of course again implies something like a transcendental truth *behind* what can be observed, that is an *unobserved truth* of vague and unclear definition. If one sticks to the decision to consider productive whatever an observer can capitalize on, - and therewith can emerge and maintain its existence -, one should accept the possibility of an economy in which advances are continuously and increasingly refinanced with other

---

today, “discussions” with language operated GPS devices for instance, when believing to know the way better, seem to provide illustrative examples.

[13] To this example: Leroi-Gourhan (1993), and its influence on Derrida’s “future anterior”.

advances, and the actual pay-off eternally backtracks into the future.[14] Of course one could stress that observers of this sort live on continuous debt. And in regard to environmental issues, this indeed is a fact to consider. On theoretical grounds however, insights as those into the physics of complex networks for instance (and its currently may be most well-known example: the Page-rank-algorithm, cf. Brin/Page 1998 and Füllsack 2001a for a respective interpretation) show that such "bottomless" systems of reference are no metaphysical chimera, but on the opposite are able to provide footing for momentous next-order-dynamics to emerge. Such systems tend to run up to at times "strange" but stabile attractors, to "Eigen-values" with far-reaching and at times self-undermining effects.

10. Epilogue

In his seminal book on the Origin of Wealth, Eric Beinhocker locates modernity's productivity take-off[15] at about the year 1750 (2006: 9) and suggests to see the reason for it in what he calls "rational deduction" (cf. 2006: 258f). Contrasted to the blind "experimental tinkering" of evolution, as Beinhocker calls it, "rational deduction" relates to what we here call "intentional stance". It builds on a systematic use of analysis, of concepts and plans, and needs organisms or mechanisms which are complex enough to use self-models in order to deploy generalized principles from which productive options and activities can be deduced. In human contexts of course, the institutionalized form of "rational deduction" is *science*, which took off at approximately that time. Following Dennett again, we might say that science needs a good deal of computational power in order to maintain its high level of abstract problem solving activities (or in other words, in order to take in the "physical stance"). And it gains this power through the suspension of a part of every-day-life-necessities, above all the need for an immediate applicability of its problem solutions. In its turn, of course, this suspension is "paid for" by modern society's productivity, which is enacted and enforced by "rational deduction". Hence, one might say that the highly abstract level of the "physical stance" as taken in by many modern sciences, emerges and "lives" on the productivity of the "intentional stance", which in its turn supports and enforces science and therewith the "physical stance".
The "physical stance", however, as this paper tried to demonstrate, is not unambiguous in its enhancement of productivity. It also tends to undermine its own enabling conditions. Modern science's particular Eigen-logics of measuring its output in terms of its own *internal* criteria, allow for a level of abstraction at which productivity itself can be questioned for its productivity. In other words, science indeed seems to incite a reductionism which can do no other than leave the question whether itself is productive open to an observer which might emerge by finding capitalizable regularities in it.

References

Abraham, Ralph H. / Shaw, Chris D. (1984): Dynamics. The geometry of behavior. Santa Cruz, CA: Aerial Press.

Ashby, Ross (1956): Introduction to Cybernetics. London. Chapman and Hall.

Beinhocker, Eric D. (2006): The Origin of Wealth. Evolution, Complexity and the Radical Remaking of Economics. London. Random House.

Bennett, Charles H. (1982): The thermodynamics of computation - a review; in: International Journal of Theoretical Physics 21, pp. 905-940.

[14] A respective view on economy has been suggested by Böhm-Bawerk as early as the 19th century. With his "time-consuming production roundabouts" ("zeitaufwändige Produktionsumwege"), or shortly "roundaboutness", as the actual cause of productivity gains, he clear-sightedly indicated interests as triggering other interests, and not labor exploitation, as the decisive mean of capitalism. More recently, and also more explicit as to the effects of this logic, Niklas Luhmann (1984) suggested to consider the closure of dynamics mutually providing footing to each other, as the central characteristic of contemporary social conditions.

[15] Which Beinhocker (2006: 9) suggests to account for in terms of the *store keeping units* of modernity's consumer world.

Böhm-Bawerk, Eugen von (1894): Zum Abschluß des Marxschen Systems; in: Böhm-Bawerk, Eugen von, / Hilferding, Rudolf / Bortkiewicz, Ladislaus von (1975): Zum Abschluss des Marxschen Systems. Clifton [N.J.]: A. M. Kelley.
Bongard, Josh / Zykov, Victor / Lipson, Hod (2006): Resilient machines through continuous self-modeling; in Science vol. 314 (17. Nov 2006), p. 1118-1121.
Brin, Sergey / Page, Lawrence (1998): The anatomy of a large-scale hypertextual Web search engine; in: Computer Networks and ISDN Systems 30: pp. 107–117.
Buchanan, James M. / Yong J. Yoon, (eds.) (1994): The Return to Increasing Returns. University of Michigan Press.
Cobb, Clifford W. / Halstead, Ted / Rowe, Jonathan (1995): The Genuine Progress Indicator: Summary of Data and Methodology. Redefining Progress, Washington DC.
Davis, Hiram S. (1955): Productivity Accounting. University of Pennsylvania.
Dennett, Daniel C. (1987): The Intentional Stance. Cambridge, Massachusetts: MIT Press.
Dennett, Daniel C. (1991): Consciousness explained. Cambridge, Little Brown and Co.
Dennett, Daniel C. (2003): Freedom Evolves. London: Pinguin.
Easterlin, Richard A.: (1974): Does Economic Growth Improve the Human Lot?; n: Paul A. David / Melvin W. Reder (Eds.): Nations and Households in Economic Growth: Essays in Honor of Moses Abramovitz. Academic Press, New York, pp. 89–125.
Eatwell, John (1987): Returns to scale, The New Palgrave: A Dictionary of Economics, v. 4, pp. 165-66.
Fellermann, Harold et al. (eds) (2010): Artificial Life XII Proceedings of the Twelfth International Conference on the Synthesis and Simulation of Living Systems. MIT-Press.
Foerster, Heinz von (1982): Observing systems. Seaside (CA): Intersystems Publications.
Füllsack, Manfred (ed.) (2008): Verwerfungen moderner Arbeit. Zum Formwandel des Produktiven. Bielefeld transcript.
Füllsack, Manfred (2011a): Gleichzeitige Ungleichzeitigkeiten. Eine Einführung in die Komplexitätsforschung. Wiesbaden (VS).
Füllsack, Manfred (2011b): Complexity and its observer, Does complexity increase in the course of evolution? Paper presented at the 11th Congress of the Austrian Philosophical Society (OeGP) 2.-4. 6. 2011, at the University of Vienna.
Gell-Mann, Murray (1995): What is Complexity?; in: Complexity Vol. 1, no.1.
Georgescu-Roegen, Nicholas (1971): The Entropy Law and the Economic Process. Harvard University Press: Cambridge, Massachusetts.
Helpman, Elhanah (2004): The Mystery of Economic Growth, Havard University Press.
Holland, John (1995): Hidden Order. How Adaptation builds Complexity. Reading, MA.
Jaeger, Heinz (2000): Observable operator models for discrete stochastic time series; in: Neural Computation 12, pp. 1371–1398.
James, William (1890/1983): Principles of Psychology. Boston, Harvard UP.
Jones, Charles I. (2002): Introduction to Economic Growth. 2nd ed. W. W. Norton & Company: New York, N.Y.
Kahneman, Daniel / Krueger, Alan B. (2006): Developments in the Measurement of Subjective Well-Being; in: The Journal of Economic Perspectives, vol. 20, No 1, pp. 3-24.
Kauffman Stuart A, (1993): The Origins of Order. New York, Oxford UP.
Leroi-Gourhan, André (1993): Gesture and Speech. Cambridge MIT-Press.
Langton, Christopher G. (1991): Computation at the Edge of Chaos: Phase Transitions and Emergent Computation; in: Forest, Stephanie (ed*.): Emergent Computation.* The MIT Press, pp. 12-37.
Lloyd, Seth (2001): Measures of Complexity: a nonexhaustive list; in: IEEE Control Systems Magazine, August.
Lloyd, Seth (2006): Programming the Universe. A Quantum Computer Scientist takes on the Cosmos. New Yoek: Vintage Books.
Luhmann, Niklas (1995): Social Systems. Stanford: Stanford University Press (quoted after German edition 1984).
Maturana, Humberto R. / Varela, Francesco J. (1987): The Tree of Knowledge: The Biological Roots of Human Understanding, London, New Science Library, Shambhala.
Mitchell, Melanie (2009): Complexity: A Guided Tour. Oxford, New York: Oxford University Press.
Nadin, Mihai, (2003): Anticipation: The end is where we start from. Baden: Lars Mueller Publishers.
Parunak, Van Dyke H. / Brueckner, Sven (2001): Entropy and Self-Organisation in Multi-Agent Systems; in: Proceedings of the International Conference on Autonomous Agents (Agents 2001), 124-130.
Prigogine, Ilya / Nicolis, G. (1977): Self-Organization in Non-Equilibrium Systems. Wiley.
Prigogine, Ilya (1980): From Being To Becoming. Freeman.
Prigogine, Ilya / Stengers, Isabelle (1984): Order out of Chaos: Man's new dialogue with nature. Flamingo.
Samuelson, Paul A.; William D Nordhaus (2004): Economics, McGraw-Hill.

Solow, Robert M. (1956): A Contribution to the Theory of Economic Growth; in: Quarterly Journal of Economics, 70(1), pp. 65-94.
Spencer-Brown, George (1969): Laws of Form. London.
Strogatz, Steven H. (2001): Non-linear Dynamics and Chaos. With Applications To Physics, Biology, Chemistry, And Engineering (Studies in Nonlinearity). Westview Press.
Varela, Francisco / Thompson, Evan / Rosch, Eleanor (1991): The Embodied Mind: Cognitive Science and Human Experience. Cambridge, MA: MIT Press.
Varela, Francesco (1992): Autopoiesis and a Biology of Intentionality, in: McMullin, Barry (ed.): Proceedings of a Workshop on Autopoiesis and Perception, p. 4–14.
Weil, David N. (2008): Economic Growth. (2nd ed.) Addison Wesley.
Weinberg, Steven (1987): Newtonianism, reductionism, and the art of congressional testimony; in: Science 330, p. 433-437.
Wolfram, Stephen (2002): A New Kind of Science. Wolfram Media.
World Bank (1997): Expanding the Measure of Wealth: Indicators of Environmentally Sustainable Development. Environmentally Sustainable Development. Studies and Monographs Series No. 17. Washington, DC: World Bank.
Wright, Robert (2000): Non-Zero. The Logic of Human Destiny. New York. Pantheon Books.