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Manfred Füllsack

► **To cite this version:**

Manfred Füllsack. Observing productivity: what it might mean to be productive when viewed through the lens of Complexity Theory. *Journal of Philosophical Economics*, 2012, Volume VI Issue 1 (1), 10.46298/jpe.10637 . hal-03705677

**HAL Id: hal-03705677**

**<https://hal.science/hal-03705677>**

Submitted on 27 Jun 2022

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THE JOURNAL OF  
PHILOSOPHICAL ECONOMICS

Volume VI Issue 1 Autumn 2012

ISSN 1843-2298

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

**Manfred Füllsack**



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

*Manfred Füllsack*

**Abstract:** The paper tries to explore options and preconditions for a theoretically thoroughly grounded conception of productivity that is able to account for its observer-dependency and thereby meets the needs of a dynamic and highly differentiated modern society. It does so in respect to insights from Cybernetics and Complexity theory, thereby 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, a seemingly paradoxical 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. The assumption is that this paradoxical constitution helps to keep productivity adaptive to the changes it itself incites in economy.

**Keywords:** productivity, complexity, observer-dependence, cybernetics, economic theory, computation, anticipatory systems

## Introduction

While theoretically quite simply defined, the economic concept of productivity, as referring to value-adding processes [1], poses problems on practical grounds. Statisticians concerned with national accounting for instance, as well as politicians concerned with social and financial issues, and ordinary people worrying about their economic future no longer agree about what it is that counts as productive [2]. The modern world's economic upswing seems to be paradoxically accompanied by a

differentiation of perspectives. Is it land, labor, material goods, technical progress, knowledge and whatever can be measured in money, or is it happiness, democratic freedom, less labor, overall wellbeing, the chance for self-determination, fresh air, clean water, health, longevity that drives economy? While most national and supranational accounting systems still focus on money, a growing number of wellbeing indices is suggested and competes for an unambiguous definition of wealth. Furthermore, with rich nations discussing "degrowth" and "a-growth" concepts (Van den Bergh, 2011) while developing countries try to replicate their material output, it appears that what counts as productive in one context may not be productive in others (Füllsack, 2008).

The clear-cut distinction of productive and unproductive labor with which Adam Smith tried to explain the causes of wealth, and which Marx momentarily passed on to Socialism as a core principle of administered labor, has dissolved in the plurality of perspectives that modernity provides. In short, the epistemology of modern society – conditioned on and embedded into its productivity, as we shall see – seems to oblige us to specify to whom, and in regard to what, productivity is considered productive. Hence, I argue in this paper that speaking about productivity today necessitates specifying its *observer*:

This argument seems to call for a philosophy of science to clarify the conditions of observation. Attempts to analytically observe these conditions however, lead into the dreaded circle of using these conditions while trying to clarify them, and produces the insight that the observer is paradoxically constituted (Foerster, 1981; Luhmann, 1995, and below). What is more, conceptualizing the observer in terms of productivity - or at least in terms of a condition that defies entropy, as we shall see -, reveals that productivity is a much more complex conception than is usually conceded in economic textbooks. In respect to this insight, I assume that the aforementioned problems could be alleviated to some extent with a more fundamentally grounded conception of productivity.

Even with such a conception however, the central problem addressed in this paper, that is, the problem that productivity is observer-dependent, cannot be evaded. In this text, I try to express this point not only in terms of content, but to some extent also in terms of its own demeanor. By not claiming to present a clear-cut result or solution, this paper might deviate slightly from the usual terms of scientific reports; At least partially I will leave it to the reader to decide if it can be considered productive. However, since writing inevitably implies to propagate a viewpoint, namely the one of the author, the paper in hand will nevertheless try to

bring something forth. Drawing on insights from Cybernetics, Complexity theory and computational science it explores the options and preconditions for a more thoroughly grounded, but thereby necessarily also more complex (and thereby maybe not in every respect productive), conception of productivity.

## Productivity in economic theory

To speak about the difficulty of grasping a value that is obviously (or has become?) [3] observer-dependent, first necessitates that one specifies one's own perspective. In order to do so, I draw upon Daniel Dennett's (1987) distinction of a "physical" and an "intentional" stance [4], 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 which also frequently serves as the basis for what academia calls "the humanities".

Whereas the physical stance roughly conforms to what is known as objectivism, the intentional stance accounts for the subjective intentions and needs of humans. Its explanations tend to assume qualities in human activities which cannot (completely or directly) be reduced to physical causes. For Dennett, both stances are conditioned on what he calls "computational power". The assumption is that for lastingly taking the "physical stance" a lot more "computational power" is needed than is usually available in everyday-life. It needs special spheres, such as science, in which activities and insights are suspended from immediate application. The possibility of taking the "physical stance" is thus conditioned on an economic productivity which is able to pay for such spheres. In this respect, science is seen as a (by itself highly unlikely) subsystem of modern society that, on the one hand, is paid for by its productivity and that, on the other hand, provides a sort of aloofness with which productivity can be questioned to an extent which cannot but irritate classical economics. However, this paper builds on the assumption that this paradoxical setting also provides explanative possibilities, which allow for a conception of productivity that is more in line with the conditions of modern society.

The textbooks of classical economics usually define productivity as the ratio of what is produced to what is required for production (Davis, 1955; Samuelson and Nordhaus, 2004). As we understand it here, an activity 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 and Yong, 1994), and, in general, of “economic growth” (Jones, 2002; Helpman, 2004; Weil, 2008). In economic theory however, the concrete causes of this growth often remain somewhat vaguely defined.[5] In this regard, value-adding productivity seems to refer simply to a process that generates “*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 (mercantilism), 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 lack measurability (a highly valued aspect in economics), efforts continue to concretize and 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 suggested 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 what could be called a “physical stance”. Mainstream economics so far does not associate with this line of research. It seems appropriate, therefore, to see what this research could add to the understanding and conceptualization of productivity and what problems it might entail.

## Productivity and the Second Law of Thermodynamics

At the level of abstraction of the “physical stance”, (value adding) 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. If we follow the assumption that a productive process generates something that is “*more than the sum of its parts*” and hence implies an increase in order, respectively a *decrease* in

entropy[6], we pose a challenge to scientific explanation. What on the level of the "intentional stance" might be explained as an effect of a specific arrangement of inputs, becomes a fundamental problem in the realm of physics.

However, at this level of abstraction, there are many theoretical and methodological conceptions which seem apt to answer this challenge. The conception of "dissipative structures" for instance (Prigogine and Nicolis, 1977; Prigogine and Stengers, 1984), expanded by assumptions about a relation, if not equivalence, of energy and information (of *bits* to *ergs*) (Bennett, 1982), seems to allow us to reformulate it in terms of improbability and informational uncertainty, and to investigate the apparently counterintuitive increase of order by way of computation. Meanwhile, this has entailed a wide spectrum of investigations in emergent structures based on suggestions that we conceptualize the world in terms of a huge Cellular Automaton (Dennett, 1991, 2003; Wolfram, 2002; Fredkin, 2003) and subsequently redefine (and redesign) scientific research in terms of information theory and respective methods. Currently, these investigations range from fundamental research, such as the one on "universal computation," (Wolfram, 2002) or the one on "order at the edge of chaos," (Langton, 1991; Kauffman, 1993) which tries to grasp what could be called the minimal preconditions of "productivity," to complex and far-reaching endeavors into A-Life research (Fellermann et al., 2010). This research also entails fiercely fought disputes about reductionism and the possibility of a "Theory of Everything" (Weinberg, 1987; Dennett, 2003: 68).

## Entropy-decrease through increase

Within the realm of this research, findings like those 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 in 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 *decrease*. 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, for example, mention the dissemination of a common currency, “money,” 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 dynamic scientific communications (publications, congresses, etc.), which enable cognition, or, maybe more to the point, the provision of fecund economic environments for the start of businesses, seems to draw on respective possibilities. The most general example in this regard might be evolution itself, with a few “fittest” individuals eventually representing order and growth, and a huge fraction of “unfit” being sacrificed in order to enable the survival of the few.

This brings up a new problem for our considerations: productivity, as seen with the “physical stance”, does not seem “really” productive. Only if we *pre*-decide to focus our interest on the entropy-decreasing aspect of this process, that is, on the side of the gain of order, can we consider it productive. According to the “physical stance” however, we should either not pre-decide, or we should account for each pre-decision in terms of a consistent conception. Since we are interested in productivity, and are hence pre-decided, we draw the *observer* into the game. What is more, we regard the observer on a level of abstraction at which it [7] can also be conceptualized in terms of entropy-decrease.

As a preliminary, it should be noted that this endeavor obviously leads into a *circular*, that is, a *self-referential* conception, a conception that, from a conventional point of view, seems to run aground by clarifying 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 in the case of what is called Gödel’s encoding (“Gödelisierung”) in mathematics or Turing machines in computational theory (that is, machines, which allow for a concurrency of program and programmed, for a computation of data that is enacted by other data provided in the same medium), this endeavor seems to be formalizable and simulatable. It therewith might allow for saying something useful, maybe even “productive” about the observer.



## 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 is the diffusion of pheromones. The same applies to evolution. What is usually [8] 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 as Prigogine (1980) writes, to its Being and not its Becoming. Alluding to William James' sculptor[9], we might say that what is perceived as productive - a (temporarily) stable decrease of entropy - appears to be a "cutout" from the overall picture, and moreover, 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 may be considered abrogated by the fundamentality of constructivism: namely the necessity of assuming 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 being which has no conception whatsoever 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[10], who can see that the first (order) observer cuts something out.

Although the process of observing the observer might eventually induce "self-observation" - as will be discussed below -, 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 in turn necessitates an observer in order to be conceivable; this applies to any further observer as well. In-depth considering the resulting chain (or network) of observations, 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 up to *attractors* which might seem "strange" at times, but which are stable enough for to provide the footing of further dynamics (Abraham and Shaw, 1984; Strogatz, 2001; Füllsack, 2012b). I come back to this later on.

## Regularities

For the moment let's return to the "results" of order generating processes. 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 following the considerations of Francesco Varela (1992:7) and regarding 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 regarding 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 means 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 brief moment in time.

Maybe the most basic form of such a "resource" can be seen in *regularities*. The reason for this is best explained with a short excursion into the attempts to find measures for complexity. Among many such measures (see Lloyd 2001 for a list, Mitchell 2009 for an introduction) are *predictability* (Shannon-entropy) and *compressibility* (algorithmic complexity). A highly regular process, for example the one which would generate the sequence {1010101010101010101010101010 ...}, allows for a pretty safe 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 allows being *productive*.

If an entity that uses this possibility can emerge, 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, regularity can be considered a "resource" on which to capitalize. 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 might itself provide a regularity on which a next-order-entity again finds a chance to capitalize on (Füllsack 2012a), one could say that such regularities conform to an abstract form of what, in the Marxian sense of "frozen labor," has been termed *capital*.<sup>111</sup>

On first view, "high" regularity might seem easier to capitalize on than "lower" regularity; for example, the sequence {101010101110101010...} 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 with 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 no longer deviates significantly. 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 must *not* be thought to exist *earlier* than a regularity on which it might capitalize. The observer does not exist prior to observing regularity. It does not wait somewhere out there pre-given for an evolutionary process to "finish". This, in its turn, implies that the "finished" (or steady) state which 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 not absolute but rather a *relative* state dependent upon the observer. The end is where the observer starts from - to paraphrase Mihai Nadin (2003). In other words, the end is brought forth by the observer, which in turn is brought forth by the end. This end is "enacted", in the sense of Varela, Thompson and Rosch (1991). This means that it depends on the observer's *complexity*, on the degree of regularity that the observer itself possesses, while the complexity of the observer depends 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 resulting from an evolutionary process that 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: there needs to be regularity for an observer to emerge, and there needs to be an observer to observe regularity. In short, there must be order to induce order. What to classical analytic attempts might seem

paradoxical 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 (Holland, 1995; Jaeger, 2000; Füllsack, 2011).

## 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 paradoxical constraint that productivity therewith is conditioned on an observer, which is conditioned on it. Hence, the condition for an observer to "be", and therewith 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 George Spencer-Brown's (1969) suggestion that we define observation as the dual operation of "distinction and indication". As mentioned above, this definition, when deconstructed, necessitates not just one observation but two. On a first-order level, the *distinction* (the first aspect of the dual) might be brought forth by a multitude of random differentiations (*distinctions*) of which one is eventually observed (by a second-order observer) as "successful" or "final", and thereby *indicating* a certain state, for example the "result" of an evolution. This state thus becomes the "observed" state, but only by 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, that is for further observations. An air conditioning system, 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 ones as those that are relevant to maintaining existence<sup>12</sup>. On the abstraction level of the "physical stance," this process might be thought of as simply "observing by being", that is *embodying* a "distinction and indication" via existence. A plant, for instance, distinguishes sunlight from eternal darkness by indicating sunlight with its existence. The famous *Game-of-Life*-Glider (see Füllsack 2011 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 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 one might formally define "observation" as a distinction that turns out to be capitalizable and is therefore 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.

## Productive upgrades

This emergence, however, might be momentous for the observer itself, since it alters the "initial" regularity through 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 it is altered by the existence of the observer; the world changed with its existence. Furthermore, it is *lifted to a new level*, at which it again might provide sufficient regularity for a new, and arguably a bit more complex, observer, which, if successful, repeats this suspension on the next level of order.

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 *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 (Füllsack, 2012a).

These upgrades can further 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. If a regularity is uncomplicated (for example the sequence {10101010...}), a simple observation might suffice to unfailingly predict the next coming event and thus to safely compress the sequence; however, a regularity which is just *statistically regular*, that is, one that contains "errors", might still be compressible and provide predictive leverage. But this leverage depends on how much "noise" its observer can take. This, in 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 of observing 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*. Since these irregularities might also be statistically regular, 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 thereby significantly enhance the system’s possibility to capitalize on regularities.

Since the operations of such a system generate noise of their own, it might seem conceivable that eventually such a system would appear 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 that we refer to such systems as “autopoietic.”

## 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, although in an overly metaphoric way. A composite system however, with several control-levels observing each other’s operations and thus *internalizing* the distinction and indication of productivity, might be regarded as operating with an amount of intentionality that exceeds metaphoricity. In 2006 Josh Bongard and his colleagues (2006) presented the now famous “continuous self-modeling machine”, a starfish-shaped robot, which uses a model of itself and its environment to “virtually” pre-test combinations of movements that its limbs are able to perform. The machine then “cuts out” those movements from the multitude of test-movements 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)[13] on the aforementioned principle of “entropy decrease via increase”. The machine performs,

so to speak, an opulent waste of virtual motions in order to carve out from its space of options those that might eventually prove productive. However, this machine would hardly be of interest, if it is considered only 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) that the robot is 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 to decide, but is determined by the costs of computational power. As a consequence, usually we cannot simply choose to take one or the other stance, nor can we deliberately oscillate between their perspectives. As with every observer, our stance is determined by the capacity to capitalize on the regularities at hand, that is, by our potential to cope with complexity. Because this complexity can 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 senseless to consider the myriads of neurons and their connections that our brains lavishly deploy to guarantee an optimal balance between stable and flexible behavior (between *exploitation* and *exploration*, as evolutionary theory calls it). In this context, we would be helplessly overburdened if we acted and observed with a “physical stance”. On this abstraction level, the “intentional stance” makes sense because, in the words of Dennett, it saves computational power. It provides the needed predictive leverage, while minimizing computational efforts.[14] In every-day-life it *suffices* to simply account for the *effect*, for the “result” of the lavish deployment of neurons in our brains. 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 *intentionally plan* our actions.

## Bottomlessness

As we know from everyday life, intentional planning can be quite efficient. In some sense, it can increase productivity dramatically. The current state of the world, with its order and dynamic growth, would hardly be conceivable without the effectiveness of plans and intentions. In this state far from thermodynamic equilibrium, productivity seems enhanced to such an extent that our capacities to cope with complexity allow us to capitalize on regularities at an unprecedented level. The enormous productivity gain evoked by intentionality, however, entails a paradox consequence. It pays for, and eventually institutionalizes, a level of abstraction at which what it means to be productive is systematically questioned. This is the highly unlikely abstraction level of the "physical stance" and its institutionalized manifestation called *science*. In its sphere of influence productivity is not only considered an intended and desired goal of human activities; its preconditions and possibility are also investigated "objectively."

One might, at first, attribute this seemingly strange twofold dynamic to a simple temporal shift that the "intentional stance" entails, 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 one hand, it also "virtualizes" productivity.

As we have seen, the "blind teleology" of evolutionary processes builds on a plurality of instances that seem to exist *at first* in order only to *then* distill a productive result from them. On the 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 hammer exemplifies both cases. A hammer might be bought because of (past) experiences in which one has need to drive in nails. But, it also might be bought on the (future) expectation that once one has driven in a certain number of nails, the hammer will be worth its costs.[15] The latter seems more momentous, since it includes the possibility of repeating this advancement *even before* the costs of the first investment have been paid off. One might not have done enough hammering to make the purchase of the hammer reasonable, before one starts to think about also buying pliers on the assumption that once one has removed so many nails, the pliers will also be worth their purchase cost.

In short, intentionality, and the expectations and anticipations it enables, can trigger chains of next-order-investments on the expectation that the investments



will eventually pay for themselves. As a result, the probability of, as well as 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 that a transcendental truth lies *behind* what can be observed, that is, an *unobserved truth* of vague and unclear definition. If one decides 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 advances, and the actual pay-off is eternally delayed.[16] Of course one could stress that observers of this sort live in continuous debt; in regard to environmental issues, this is indeed a fact to consider. On theoretical grounds however, insights, such as those into the physics of complex networks for instance (and its currently most well-known example: the Page-rank-algorithm, cf. Brin and Page (1998) and Füllsack (2011) for a respective interpretation), show that such "bottomless" systems of reference are not metaphysical chimeras, but rather 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" (Foerster, 1981) with far-reaching, and at times self-undermining, effects. However, in their plasticity and reactivity such systems can show quite high adaptivity to changes which they themselves bring about. Since productivity, as I have conceived it in this paper, is a paradox and self-undermining conception, it might need this seemingly strange constitution in order to continually adapt to the developments that it incites.

## Epilogue

In his seminal book on the Origin of Wealth, Eric Beinhocker (2006: 9) locates modernity's productivity take-off [17] at about the year 1750 and suggests that the reason for it lies in what he calls "rational deduction" (cf. 2006: 258f). Contrasted to what Beinhocker calls the blind "experimental tinkering" of evolution, "rational deduction" relates to what I have called the "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”). We might also say that it gains this power through the suspension of some every-day-life-necessities, particularly the need for an immediate applicability of its problem solutions. This suspension, in turn, 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 turn, supports and enforces science and therewith the “physical stance”.

The “physical stance”, however, as this paper has 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 (e.g. citation impact instead of market value), 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 of whether itself is productive open to an observer which might emerge by finding capitalizable regularities in it, thereby once again re-defining what it means to be productive.

## Endnotes

[1] The meaning of the term productivity in this paper deviates slightly from textbook definitions referring to a formal output-to-input ratio which can be positive as well as negative. What is at stake here is the somehow less neutral notion of “productive” as opposed to “unproductive” processes.

[2] 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 et al. 1995, World Bank 1997, Kahneman and Krueger 2006.

[3] 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.

[4] I will neglect Dennett's "design stance" here.

[5] With the probably most cited example being the "residual" in Solow's (1956) conception of *Total Factor Productivity*.

[6] Which slightly deviates from regarding productivity as a general category or a measure, of which only one aspect refers to a positive ratio of output to input (cf. Fn. 1).

[7] 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.

[8] "Usually" refers to the every-day-commonness of the "intentional stance" as distinguished from the highly abstract, and therefore unlikely, "physical stance".

[9] 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.

[10] 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*.

[11] 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*.

[12] On a hardly less abstract level than Spencer-Brown, Niklas Luhmann (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*.

[13] This 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".

[14] 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 economic reasons*. Already today, "discussions" with language operated GPS devices for instance, when believing to know the way better, seem to provide illustrative examples.

[15] To this example: Leroi-Gourhan (1993), and its influence on Derrida's "future anterior".

[16] 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 (1995) suggested to consider the closure of dynamics mutually providing footing to each other, as the central characteristic of contemporary social conditions.

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

## References

Abraham, Ralph H. and Chris D. Shaw (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', *International Journal of Theoretical Physics*, 21, pp. 905-940.

Böhm-Bawerk, Eugen von (1894), *Zum Abschluß des Marxschen Systems*, reprinted in: Böhm-Bawerk, Eugen von and Hilferding, Rudolf and Bortkiewicz, Ladislaus von (1975), *Zum Abschluss des Marxschen Systems*, Clifton, N.J.: A. M. Kelley.

Bongard, J. and V. Zykov and H. Lipson (2006), 'Resilient machines through continuous self-modeling', *Science*, 314, pp. 1118-1121.

Brin, S. and L. Page (1998), 'The anatomy of a large-scale hypertextual Web search engine', *Computer Networks and ISDN Systems*, 30, pp. 107-117.

Buchanan, James M. and Yoon J. Yong (eds) (1994), *The Return to Increasing Returns*, Michigan: University of Michigan Press.

Cobb, Clifford W. and Ted Halstead and Jonathan Rowe (1995), *The Genuine Progress Indicator: Summary of Data and Methodology. Redefining Progress*, Washington DC.

Davis, Hiram S. (1955), *Productivity Accounting*, Pennsylvania: University of Pennsylvania Press.

Dennett, Daniel C. (1987), *The Intentional Stance*, Cambridge, Massachusetts: MIT Press.

\_\_\_\_\_ (1991), *Consciousness explained*, Cambridge, Massachusetts: Little Brown and Co.

\_\_\_\_\_ (2003), *Freedom Evolves*, London: Penguin.

Easterlin, Richard A. (1974), 'Does Economic Growth Improve the Human Lot?', in Paul A. David and Melvin W. Reder (eds), *Nations and Households in Economic Growth: Essays in Honor of Moses Abramovitz*, New York: Academic Press, pp. 89-125.

Eatwell, John (1987), *Returns to Scale*, The New Palgrave: A Dictionary of Economics, vol 4, pp. 165-166.

Fellermann, Harold et al. (eds) (2010), *Artificial Life XII Proceedings of the Twelfth International Conference on the Synthesis and Simulation of Living Systems*, Cambridge, Massachusetts: MIT-Press.

Foerster, Heinz v. (1981), 'Objects: Tokens for (Eigen-) behaviors', in H.v. Foerster (ed), *Observing Systems*, Intersystems: Salinas CA, pp. 274-285.

Fredkin, Edward (2003), 'Introduction to Digital Philosophy', *International Journal of Theoretical Physics*, 42(2), pp. 189-247.

Füllsack, Manfred (2008) (ed.), *Verwerfungen moderner Arbeit. Zum Formwandel des Produktiven*, Bielefeld: transcript.

\_\_\_\_\_ (2011), *Gleichzeitige Ungleichzeitigkeiten. Eine Einführung in die Komplexitätsforschung*, Wiesbaden: VS-Verlag.

\_\_\_\_\_ (2012a), 'Complexity and its observer. Does complexity increase in the course of evolution', in Dunshirn, Alfred, Nemeth, Elisabeth and Unterthurner, Gerhard (eds.), *Crossing Borders. Thinking (across) Boundaries*, Vienna: Phaidra, pp. 379-392.

\_\_\_\_\_ (2012b), 'Information, Meaning and Eigenforms: In the Light of Sociology, Agent-Based Modeling and AI', *Information* 3(3), pp. 331-343.

Gell-Mann, M. (1995), 'What is Complexity?', *Complexity* 1, pp. 1-17.

Georgescu-Roegen, Nicholas (1971), *The Entropy Law and the Economic Process*, Cambridge, Massachusetts: Harvard University Press.

Helpman, Elhanah (2004), *The Mystery of Economic Growth*, Cambridge, Massachusetts: Harvard University Press.

Holland, John (1995), *Hidden Order. How Adaptation builds Complexity*, Reading, MA.

Jaeger, Heinz (2000), 'Observable operator models for discrete stochastic time series', *Neural Computation*, 12, pp. 1371-1398.

James, William (1890/1983), *Principles of Psychology*, Boston: Harvard UP.

Jones, Charles I. (2002), *Introduction to Economic Growth*, New York, N.Y.: W. W. Norton & Company.

Kahneman, D. and A.B. Krueger, Alan B. (2006), 'Developments in the Measurement of Subjective Well-Being', *The Journal of Economic Perspectives*, 20 (1), pp. 3-24.

Kauffman, Stuart A. (1993), *The Origins of Order*. New York, Oxford UP.

- Leroi-Gourhan, André (1993), *Gesture and Speech*. Cambridge, Massachusetts: MIT-Press.
- Langton, Christopher G. (1991), 'Computation at the Edge of Chaos: Phase Transitions and Emergent Computation', in Forest, Stephanie (ed), *Emergent Computation*, Cambridge, Massachusetts: The MIT Press, 12-37.
- Lloyd, Seth (2001), 'Measures of Complexity: a non-exhaustive list', *IEEE Control Systems Magazine*, 8.
- Luhmann, Niklas (1995), *Social Systems*, Stanford: Stanford University Press.
- Maturana, Humberto R. and Francesco J. Varela (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, V.D.H. and S. Brueckner (2001): 'Entropy and Self-Organization in Multi-Agent Systems', *Proceedings of the International Conference on Autonomous Agents* (Agents 2001), pp. 124-130.
- Prigogine, Ilya and Nicolis, G. (1977), *Self-Organization in Non-Equilibrium Systems*, New York: Wiley.
- Prigogine, Ilya (1980), *From Being To Becoming. Time and Complexity in the Physical Sciences*, San Fransisco: Freeman.
- Prigogine, Ilya and Isabella Stengers (1984), *Order out of Chaos: Man's new Dialogue with Nature*, Bantam: Flamingo.
- Samuelson, Paul A. and William D Nordhaus (2004), *Economics*, McGraw-Hill.
- Solow, Robert M. (1956), 'A Contribution to the Theory of Economic Growth', *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.

Van den Bergh, Jeroen C.J.M. (2011), 'Environment versus Growth – A criticism of “degrowth” and a plea for “a-growth”', *Ecological Economics*, 70, pp. 881-890.

Varela, Francisco and Evan Thompson and Eleanor Rosch (1991), *The Embodied Mind: Cognitive Science and Human Experience*, Cambridge, Massachusetts: The MIT Press.

Varela, Francesco (1992), 'Autopoiesis and a Biology of Intentionality', B. McMullin (ed), *Proceedings of a Workshop on Autopoiesis and Perception*, pp. 4–14.

Weil, David N. (2008), *Economic Growth*, Addison Wesley.

Weinberg, Steven (1987), 'Newtonianism, Reductionism, and the Art of Congressional Testimony', *Science* 330, pp. 433-437.

Wolfram, Stephen (2002), *A New Kind of Science*, Wolfram-Science.

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.

Manfred Füllsack is Professor of Systems Sciences at the University of Graz (Austria) (manfred.fuellsack@uni-graz.at)