The Integrative Analysis of Economic Ecosystems: Reviewing labour market policies with new insights from permaculture and systems theory

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Reviewing Labour Market Policies with New Insights from Permaculture and Systems Theory

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Abstract

This paper explores new ways of applying ecological knowledge to solve economic problems in a manner that suits the complexity of society and environmental challenges. This is done by developing the integrative analysis method. The integrative analysis uses systems ecology in order to characterize economic systems with their energetic properties and model them as ecosystems. This makes it possible to assess them with the design principles of permaculture. Through a process that adopts the main characteristics of the "Soft Systems Methodology" incremental changes can be found to make economies increasingly resemble the natural functioning of healthy and stable ecosystems. To show the capabilities of the integrative analysis, it is applied to three different perceptions of the labour market and its surrounding actors, starting with the viewpoint of the European Commission. In conclusion, many EU proposals to meet labour-related challenges can be refined and complemented with existing alternative proposals. This way the integrative analysis makes it possible to enhance economic strategies with integrated solutions for a widened problem scope. As a consequence, single problem interventions also address the far-reaching environmental and social challenges of declining resource and energy supply.

Keywords: emergy, entropy, systems ecology, permaculture, labour

Journal of Economic Literature Classification: Q57, Q01, D85, J48

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1 Introduction

The world economy, fueled by the paradigm of unlimited growth, risks to exceed its ecological boundaries without being aware of it. On the other side, system ecologists already envisioned a new integrative discipline of transdisciplinary science that would not only integrate the latest findings from different fields of ecology but extend them with new approaches to social sciences (Barrett, 2001, p. 79). This way new ways towards a truly sustainable society can be conceived of. In the past, various new fields emerged within economics such as bioeconomics, ecological economics and evolutionary economics that all somehow employ biological notions. Nevertheless, there is still a need for a better understanding of the underlying relations between energy, resources, information as well as the behaviour of living actors within the biosphere and complex socio-economic systems. Based on the fact that our economy is embedded in our earth's ecosystem, this paper determines how principles observed in sustainable ecosystems can be applied to solve economic problems. Acknowledging that the complexity of living systems cannot be engineered externally, I develop an integrative analysis method that complies to the "Soft Systems Methodology" (cf. Checkland, 2000). It seeks to create new insights by viewing economic problems macroscopically, from a systems perspective. The search of another concept that elegantly unifies soft system thinking and ecological engineering leads to the discipline of permaculture. Permaculture is a management approach that aims at designing and maintaining agriculturally productive ecosystems based on the patterns and relationships found in natural ecosystems (Holmgren, 2011, p. 9). During its almost 35 year long history, permaculture transformed from an agricultural centred application of ecological principles to a powerful system design methodology relevant to many different fields of problem solving.

Based on research on the metabolism and energy management of self-regulating ecosystems, general principles have been formulated to describe their functioning

(Tilley, 2004, p. 121). The first part of this thesis shows their role in the practical design of ecosystems, e.g in permaculture. I translate these practical guidelines into the context of economics and assign a set of ten questions that enhances the inquiry of economic policies and models. Together with the modelling method of "energy diagrams" they are useful devices for grasping hidden dynamics and building new insights for better ecosystem oriented functioning. This way they become resourceful tools for resolving economic problems.

In the second part, I apply the elaborated method to the economic problem of unemployment. The labour market is a fitting research subject for an integrative systems analysis due to its immense complexity and fragility. Ongoing discussions and political debate about the effectiveness of proposed solutions suggest that there are numerous non-market factors influencing the outcome of the labour market. Not yet fully recognised are for example the role of intrinsic motivation, the effects of the informal economy, incomplete information, income distribution as well as ecological influences (cf. Frey and Jegen, 2001; Costanza, 2008). I put the current conventional approach based on the considerations of the European Commission (2010) about reforming the EU labour market into the context of a widened ecological viewpoint. It is shown how the integrative analysis of all underlying processes can bring new hints for relationships with undervalued potential. Eventually, I discuss resulting proposals regarding labour market challenges. In closing, it is argued how the integrative analysis can generally enrich economic debate.

2 Theory and methodology

Since the beginning of ecological economics as a scientific discipline, its most common and influential notion has been that the economy is embedded within its supporting ecosystems. This challenges the paradigm of unlimited growth and leads to the recognition that the economy cannot outgrow its material basis (cf. Meadows et al., 1972). Economists acknowledge that it rather has to evolve within the carrying capacity of its surrounding ecosystems (Costanza, 1989, p. 2). Otherwise, effects like climate change and resource depletion threaten to cause an unprecedented and transversal crisis (Heinberg, 2007; Schlauch and Palmisano, 2013). The dangers and risks that come from not tackling these issues have caused scientists to claim for a scientific paradigm shift (Costanza, 1989, p. 1). Meanwhile, proposals for solutions currently range from a mere emphasis on sustainable development, green jobs and a steep increase in resource productivity (cf. von Weizsäcker et al., 1995) to a non-growing steady-state economy (cf. Daly, 2010) and degrowth (cf. Paech, 2011). They diverge in their assumptions about the nature of economic development and the feasibility of necessary technological progress. However, all of them share the conclusion that measures of wealth other than the gross domestic product are needed to make appropriate decisions in consideration of ecological effects. Thus, we can say that there is a vast spectrum of theories involving both ecological and economic aspects. The starting point of this section is not to solve ecological problems caused by the economy, but rather to use ecological notions specifically for the examination of economic problems. Therefore, I proceed by specifying the necessary requisites of a suitable method and introduce transdisciplinary and systemic aspects of permaculture. Then I develop the concept of economic ecosystems and its characteristics as a general category to which any economic system can adhere. Finally, I introduce a conceptual modelling technique for economic ecosystems and elaborate criteria for the evaluation of these models.

2.1 Developing an integrative approach for complex ecology and economics

Having learned that the economy is embedded in the greater ecological system of the earth, we can characterise economies by processes that are in common with natural ecosystems. Energy flows and resource processing, selection due to competition and cooperation, self-regulation and adaptation are common foundations upon which ecological knowledge can build new insights. We may refer to economies that are viewed from that perspective as *economic ecosystems*. The literature about these kinds of economic ecosystems exhibits a great variety of conclusions and conflicting arguments when it begins to treat the details of how to resolve related economic problems. Whereas neoclassic exponents, defending the idea of the substitutability of ecosystem services, tend to portray the ecological debate as ideological and "very hard to argument with rationally" (Solow, 1997, p. 267), others question the scientific premises for motivating both economic and qualitative growth (Paech, 2009). Bioeconomicst Nicholas Georgescu-Roegen (1975, p. 367) discusses Hermann Daly's concept of the steady state economy with respect to its reliance on irreversible processes and physical laws, concluding that "a steady state may exist in fact only in an approximated manner and over a finite duration". As this was not enough divergence, even attempts to integrate energy-related concepts of biophysics into economics risk the fallacies of reductionist natural science. This is the case if they are used as means to "engineer society" in a technocratic manner as it was pointed out with respect to social considerations within Howard T. Odum's work on system ecology (Hammond, 1997, p. 200).

It seems that the fundamental problem at hand is the enormous complexity of social and ecological systems. Traditional approaches are accustomed to cope with closed systems that have defined boundaries, measurable performance indicators and actors with foreseeable rational behaviour. This is simply not possible with more complex social systems because these properties are either out of reach or vary depending on the observer's expectations, his world-view and the scale of the examined system. In order to obtain conclusions that are closer to reality, there is a need for an analysis method that takes into consideration different assumptions and perspectives on systemic, economic and ecological dynamics. We can refer to a similar analysis as an *integrative analysis* and additionally distinguish it from an integrated analysis that rather concentrates on the processing of a large amount of information and data from different origins under a single viewpoint.

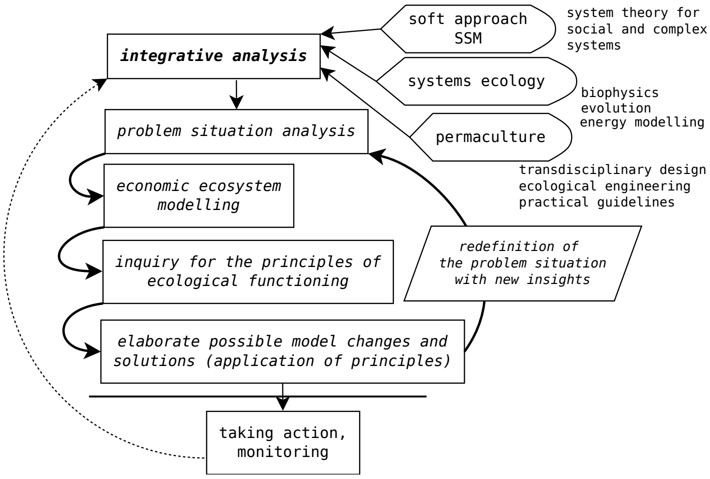

Figure 1: Overview of the integrative analysis - this graphic shows the strategy of the integrative analysis and its various steps that are analogue to the four-activities model of the SSM. Additionally, it displays the theoretical framework that has been adopted in order to make conceptual models of economic ecosystems. This way resulting proposals are inspired by the functioning of healthy and stable ecosystems.

The "Soft Systems Methodology" (SSM) put forth by Peter Checkland attempts to avoid reductionism of natural science and offers useful practical guidance to develop such a method (Checkland, 2000, p. 36). The purpose is to avoid the limitations that come from assuming systems as real and describing resulting models and modifications from one supposed external viewpoint. Instead, it concentrates on finding a "systemic process of inquiry" that helps to build conceptual models as "devices to stimulate, feed and structure" debate (Checkland, 2000, p. 26). The latter produces new insights to act upon. Systems are then referred to as "purposeful activity systems", i.e. systems that consist of human actors that take purposeful actions. These are not taken as real, but as continually changing perceptions from different points of view. Models are "working models" not claiming any "permanent ontological status" (Checkland, 2000, p. 20). Resulting solutions are valid for the observed situation and may not be purported as universal laws. In its recent form the SSM consists of 4 contemporary and iterative activities: a problem situation analysis, the drafting of relevant conceptual models, debate for changes and solutions as well as taking action (Checkland, 2000, p. 21). Hence, the constituting rules of a method that adopts the SSM are that it has to assume systems as mere "social constructions" instead of real entities, use "explicit intellectual devices to explore situations" and create holistic "purposeful activity models" based on declared world-views (Checkland, 2000, p. 38).

An integrative analysis of economic ecosystems would adopt the SSM in order to fulfil its goals adequately. But it has to be modified by supplying an additional framework through which economic ecosystems understood as merely perceived systems can be viewed macroscopically. This way an emphasis on underlying evolutionary and biophysical dynamics can be given.

2.2 Permaculture viewed as a systems science

Permaculture is important for our analysis as it is an ecosystem management methodology that shares many characteristics with the SSM. It copes with open systems that interact continuously with their surrounding environments and have no defined boundaries. It is often argued that permaculture offers no universal solutions. They rather depend on the individual evaluation of the local situation. The design process is characterised by an iterative circle of action and learning which conveys a large importance to the role of nature which continually adjusts itself (Holmgren, 2011, p. 16). The "birds-eye-view" often mentioned in permaculture textbooks summarises the concept of the interconnectivity and the functioning of ecosystems on a very large scale. That scale is not visible from a usual human viewpoint (Mollison, 1988, p.95). In ecology, a "macroscopic" view "rises above" and shifts from finding mechanistic explanations among parts of systems to grasping the big picture of systemic ecological dynamics (Odum, 2007, p. 2).

It should not be surprising that the shortcomings of a reductive scientific approach centred around the optimization of single performance indicators devised by humans became first evident within forestry and agriculture. These are the branches of production that are most exposed to ecological disturbances. In fact, the aim to preserve "permanent" characteristics and functioning of an ecosystem is not new. The idea of a "permanent forest" introduced by Alfred Möller (1922) challenges the forestry practice of that time. The latter was marked by vast woodland clearings succeeded by the growing of tree monocultures. Soon this idea was not only applied to wood production, but also considered as a new possibility to grow food with "permanent tree crops" in agriculture (cf. Smith, 1953). Inspired by other pioneers that have taken this path, among them Masanobu Fukuoka (1978), permaculture, a neologism composed of the words "permanent" and "agriculture", originated with the book "Permaculture One" by Bill Mollison and David Holmgren in 1978 and was developed into a holistic agricultural system with "Permaculture Two" by Mollison (1979). With the training of permaculture designers and its growing worldwide diffusion, permaculture became a community driven project of applied systems thinking that transcends the scientific boundaries of agriculture, leading eventually to a new understanding of the term permaculture as "permanent culture" (Scott, 2007, p. 2). This makes it a very important discipline for the sustainable design of society as a whole. In fact, the effects of ecological disturbances may increasingly go beyond the scope of agriculture and forestry.

Permaculture solutions are characterised by an ethical framework that puts ecosystem health above short-term productivity (Noga, 2012, p. 20). Another peculiarity is its methodological approach that seeks to be holistic and transdisciplinary (Mollison, 1988, p. 11). In consequence, permaculture blends into many other disciplines like civil engineering and construction, urban development and landscape design - a fact that has lead to its important role in preparing cities for "energy descent", the diminishing use of fossil fuels, purported by the "Transition Town Movement" now active in more than 1000 cities worldwide (O'Hara, 2013, p. 7). To a large extend, permaculture can be described as "ecological engineering" in the sense defined by Howard T. Odum (2007, p. 363): whereas environmental engineering "concerns primarily technology and processes before connecting with nature" in order to solve problems, ecological engineering "matches technology with the self-design of connecting ecosystems" with the intend to help them "self-organise a symbiotic interface" with human production systems. This is echoed by the dictum "work with nature, rather than against it" in permaculture (Mollison, 1988, p. 15). Anthropocentric human behaviour thus transforms into behaviour of "enlightened self-interest" which includes ethics of sustainable and sensible application of technology (Mollison, 1988, p. 3).

Although the permaculture movement has gained momentum recently, there is still much potential for its ideas to enter and enrich academic discourse as well as a need to verify its conclusions on the basis of empirical research (Morris, 2012). Until now its most criticised weak points have been lacking peer-reviewed scientific diffusion and missing empirical documentation (Scott, 2007, p. 12). Like any idea that originated from profound theories, popularity and diffusion comprises an increasing simplification which makes it easier to be adopted. But to many practitioners, the popular image of permaculture as a magic set of rules for "gardening plus ergonomics" displays a great amount of confusion and distortion that has come with it (cf. Harper, 2013).

For that reason, another intention of this thesis is to identify the underlying ecological foundations of permaculture as an "energy conscious" methodology (cf. Peeters, 2011, p. 425). I put it into the context of the scientific developments around energetic and evolutionary aspects of ecology during the past hundred years. As a matter of fact, initial permaculture ideas where motivated by the energetic analysis of Odum, connecting system energy flows with principles of good ecologies (Mollison, 1979, p. 3). The relevant theories of system ecology (Odum, 2007) and research about the linkages between the "bioeconomy" and thermodynamic laws (Georgescu-Roegen, 1986) are influenced by the work of Alfred Lotka who first integrated biology with physical laws, drafting the discipline of "biophysics". He thus laid the ground for an embedded economic theory in the beginning of the 20th century (Bobulescu, 2013, p. 3). Influential thoughts of physicist Schrödinger (1945) on life and the emergence of the Society for General

Systems Research during the 1950s are additional inputs. The latter one has been of great importance for the development of the SSM (Checkland, 2000, p. 11).

In summary, it can be said that there are two main branches that we examine in order to develop new conceptual models for the inquiry of economic policies. One basis is permaculture, which, as an influential branch of ecological engineering practises a large set of ecological notions and complies in many ways to a "soft" systemic approach. The other one is the ecological analysis of economic ecosystems from a macroscopic viewpoint as formulated by Odum and other system theorists.

2.3 Elaborating the main characteristics of economic ecosystems

The scope of ecological inquiry is how living systems organise themselves and how they evolve during a longer time scale. Therefore, evolution plays an important role in the analysis of ecosystems. There has been a shift from the original individualistic concept of evolution as "survival of the fittest", as Charles Spencer once worded, to a more complex one. To be named are approaches that concentrate on the biophysical evolution of organs "outside the body", i.e. tools and technology that extend the human range of action (Bobulescu, 2013, p. 6), energy-centred theories of cultural evolution and the theory of multilevel selection that explains the emergence of cooperation through group-level selection (Wilson et al., 2013, p. 23). This made it possible to conceive of selective, long-term optimization and self-regulative processes not only within ecosystems, but in all kinds of economic and social fields, e.g. in evolutionary economics (cf. Lehmann-Waffenschmidt, 2012, p. 1144).

Next to evolution, another key concept in our analysis is energy. The following subsections introduce thermodynamic laws in living systems. After discussing useful qualitative aspects of the embodied energy analysis and the role of the entropy law in economic ecosystems, I analyse the principle of maximum empower as a reference for natural optimization. Later, this becomes the basis for modelling economic ecosystems and the recognition of organisational patterns within them.

Energy and thermodynamics in living systems

Obviously, natural selection has to conform with physical laws as many life supporting processes deal with the transformation of matter within energy constraints. Thermodynamics offers interesting insights when considering its implications not only to inorganic, but to living systems and their evolution (cf. Bobulescu, 2013, p. 6). The second law of thermodynamics explains the manifestation and dissipation of available energy (Odum, 2007, p. 33).

Definition 1. ***The second law of thermodynamics****: the entropy of a "closed system continuously (and irrevocably) increases toward a maximum", that means that the available energy is continuously transformed into unavailable energy until it disappears completely (Georgescu-Roegen, 1975, pp. 351-352). Or: heat flows by itself only from the hotter to the colder body, never in reverse.*

Definition 2. ***Entropy*** *is a measure of the amount of unavailable energy (unavailable energy divided by temperature). It has been defined by Clausius (1864, p. 35) as the transformation-content, i.e. dissipative energy use, of a thermodynamic system.*

All living organisms feed upon available energy to create structures and functional organization. Many energy-related, biophysical theories recognise the fact that every energy transformation requires some of the available potential energy to be dispersed. Therefore, also living beings need surplus thermal entropy, i.e. the emission of unusable heat, in order to continue life (Schrödinger, 1945, note to chaper 6). Only few economists, such as Georgescu-Roegen (1975, p. 352), made efforts in researching how the entropy law applies to the human economic sphere as well. There has been a general lack of attention for the fundamental role of energy transformation in economics. In response, some scientists tried to assess energy with relation to dissipation as quantitative measuring unit with the concept of "embodied energy" (Costanza, 1980, p. 1224).

Definition 3. ***Embodied energy*** *is generally defined as the sum of all the energy required to produce any goods or services.*

Embodied energy represents not the energy physically stored in an object, but the overall energy that systems require to produce objects directly and indirectly. Different energy kinds have different quality levels depending on how much transformation processes and dissipation is needed to create them. The "embodied energy analysis" seeks to take account of that when evaluating the energetic "cost" for the supply of any good or service.

For example, electric energy has a higher quality level than thermal energy because a much greater amount of heat energy is needed to dissipate to produce electricity than vice versa. It has to be noted that calculations that implement different accounting methods can diverge extremely and partial analysis may create underestimated results. Odum and Barrett (2004, chapter 3) extensively analysed energetic processes along all organisms of the ecological pyramid. H. Odum et al. (1983) made an effort to incorporate even social structures, capital, technology, knowledge, human labour, information into embodied energy calculations. The idea is that even socially generated commodities like written scientific papers are ultimately fed on the basis of solar and fossil energy after a long succession of energetic transformations that eventually also include human actions and intellectual work. Unfortunately, too often an incorrect embodied energy analysis treats different kinds of available energy as equivalent, for example when the work done with a calorie of human labour is treated the same as with a calorie of sunlight, electric power, or unprocessed food (Odum, 2007, p. 68).

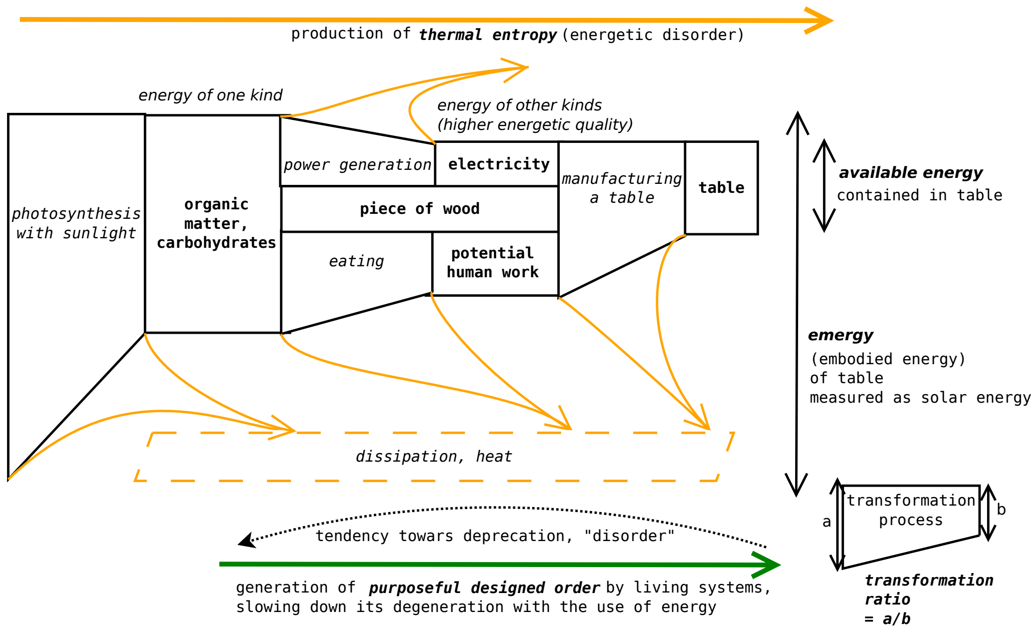

Figure 2: Energy transformations during the fabrication of a table - this graph shows, in a very simplified manner, the natural and artificial production of things from an energy-related perspective. Every transformation process requires a substantial part of the available energy to dissipate. This way thermal entropy increases unless energy constantly enters the system from an external source (sunlight). The available energy is used to create and maintain the order and structures that were purposefully designed by living organisms. The energetic "cost" (emergy) of such commodities can be expressed with the necessary amount of available energy that has entered the system in order to create them. Every energy form is characterised by its solar "transformity", that is the product of all transformation ratios during all processes beginning with sunlight. We can estimate the amount of emergy of a commodity by multiplying the remaining available energy with the solar transformity at a given time period (Odum, 2007, p. 73).

Emergy as a conceptual device for energy-related valuations

To distinguish Odum's approach, which has a more pronounced sensibility towards the differences in energy quality, ecologists coined the term *emergy*, the "energy memory" which "records the available energy previously used up, expressed in units of one kind", usually in units of embodied solar energy ("emjoules", "emcalories") (Odum, 2007, p. 100 note 2). The conventional embodied energy analysis often produces improper results by summing up the energy quantities of different energy kinds. Instead, the quantities first have to be converted to a common energy kind with the use of the respective transformation rations. Hence, in order to calculate the amount of emergy of one commodity as shown in figure 2, there is a need to know all transformation ratios (transformities) along the process chain.

Definition 4. ***The transformation ratio*** *is the quantity of available energy used up during a transformation process divided by the quantity of residual energy contained in the output.*

Definition 5. ***Emergy*** *records the available energy used up for the creation of any good or service, expressed in units of solar energy.*

Definition 6. ***Solar transformity****, often only referred to as (absolute) transformity of an energy kind, is a particular transformation ratio that stands for all solar emergy used up divided by the residual energy contained in the output (Odum, 2007, p. 73).*

Definition 7. ***Empower*** *describes the emergy consumed per time unit, analogue to power which refers to the usage of energy.*

It is almost impossible to measure transformities exactly. For example, it is difficult to assess how much sunlight the earth ecosystem needs to produce one calorie of coal. Hence, emergy values always involve a critical amount of uncertainty. Apart from that, there are two strictly theoretical argumentations against the use of an "energy currency" which stands for the usage of the emergy concept as a mere quantitative measure.

The first one is directed against the tendency to combine energy measures and monetary values in order to add deprecation and generation of "natural capital" into the gross domestic product (cf. Costanza et al., 1997). According to Odum, this results in "double counting" as it adds an additional quantity of "natural values" to the global buying power that has never been purchased by anyone. Instead, it has only been estimated by scientists (Odum, 2007, p. 280 note 3). This produces a melange of ecosystem-centric and market driven values resulting in the illusion of a new economic indicator without the required viewpoint shift. It may be better to consider any currency merely as a social instrument for human organization embedded in the earth ecosystem. Money may be incommensurable with ecosystem services on the practical side, but also intrinsically dependent on the flows and quantities of disposable emergy .

The second, more consequential line of argumentation questions the general applicability of emergy quantities as an objective value indicator. For example, Kenneth Boulding, an important exponent of the general systems theory, remarks in a critique of Odum's book "Energy Basis for Man and Nature" that all values eventually are human values created by human evaluations (Hammond, 1997, p. 202). Odum describes emergy of a product as memory of the available energy used up during its direct and indirect production. However, he doesn't explicitly declare how a mere consumption of a quantity of available energy theoretically suffices to postulate any value. Indeed, it also has to be demonstrated that this consumption served an useful purpose. But in order to establish a concept of utility, it has to be clarified from what subject's perspective this utility is perceived. The same energy kind can be available for one subject and regarded as unavailable by another subject. In ecology, the distinction between waste and useful, i.e "high-emergy", commodities occurs from the observation of the life-supporting functions of balanced natural ecosystems ex post facto. Such observation can be, for instance, that the rainforest contains much more biodiversity than a desert although they have the same latitude and sun exposure. In this case natural observation defines which energy form is waste, e.g. reflected sunlight in the desert, and which is useful, e.g. photosynthetic production in the forest. In compliance with common sense, heated sand would then contain less emergy than forest soil. Nonetheless, Odum misses out on providing the means to assess the energetic value of things when their purpose cannot be clearly deduced from natural functioning. This means, when nature can't define what is useful and what is waste. This happens every time there is a human decision to be made between either one desired and another undesired outcome that would both require the same natural emergy input, let's say for example between an artificial lake or a forest plantation in a future nature reserve on dismissed urban land. So in the end, we inadvertently enter the "soft" conceptual paradigm of SSM: emergy valuations are either influenced on the observer's judgements or depend on empirical observations given by the nature's past and present development. Taking these points into consideration, we can use emergy measures as hints for the further empirical exploration whether an ecological system fulfils its purpose (efficacy), and estimate its efficiency and its effectiveness. The modelling of the "3Es", efficacy, efficiency and effectiveness, belongs likewise to the soft modelling approach in SSM (Checkland, 2000, p. 30). In that sense, the embodied energy analysis is nothing else than a powerful inquiry device.

The important, qualitative aspect of the emergy analysis can be clarified by the following example. Odum calculates that 70% of the annual human emergy intake derives from fossil fuels, only 30% come from renewable photosynthetic production (Odum, 2007, p. 370). On the other hand, it has been calculated by (Smil, 2006, p. 23) that the absolute amount of sun energy that hits the earth yearly is nearly 4 orders of magnitude greater than the total human consumption of primary energy which mostly consists of fossil fuels. These two statements can seem rather contradicting. When we let ourselves deceive by the fact that the overall sun energy that enters earth per day is up to 10000 greater than the energy we consume, we may be optimistic about our energy supply and highly underestimate our dependence on fossil fuels. But sunlight is the energy kind with the lowest energy quality and contains less emergy. The earth metabolism needs hundreds of energy-dispersive transformations in order to supply ecosystem services from sunlight. Fossil fuels, on the other hand, are currently contributing to our wealth as highly mobile, versatile, high-quality energy source that has accumulated from organic matter in the course of millions of years. It is very difficult for human technology to achieve a higher efficiency in capturing sunlight than the earth ecosystem, which has been optimised during millions of years of evolution. The usage of human technology for deviating energy has to assure essential ecosystem services at the same time. It is not clear how the energy supply of our civilization can be maintained without further displacing the biosphere which also depends on sun energy. The neglected detail here is that our economy relies not only on energy. It has a corresponding need for entropy production. To be more specific, it depends on the degradation of higher-quality energy forms into lower-quality forms.

The two kinds of entropy

In evolutionary economics entropy plays a central role for making evolutionary principles applicable to economic systems (Herrmann-Pillath, 2007, p. 1478). Unfortunately, the concept of entropy as disorder has led to the metaphorical conflation of energetic entropy and physical disorder (cf. Corning, 2002, "Thermoeconomics and Economics" para. 2). At first sight, it even seems that live produces order, not disorder, and, thereby, reduces entropy. Living systems seem to be an exception to the universal dissipation process ultimately ending in the famous universal heat death, originally asserted by Rudolf Clausius (1864). This is because life continuously creates structures, order, organisation, information and knowledge out of basic energetic and material input. Schrödinger tried to resolve this paradox with the hypothesis of negative entropy that nature produces and "feeds on" in exchange of heat dispersal, not violating the law of overall entropy production (Schrödinger, 1945, p. 25, "It feeds on negative entropy").

But in detail, ecosystems and living organisms contain "storages with potential" that are capable of releasing available energy when requested. According to Odum (2007, p. 247 note 1) these storages represent "order" away "from equilibrium". In a hypothetical, closed "equilibrium" state, the stored energy would be made unavailable immediately according to the second law of thermodynamics and entropy would be maximised. Thus storages reduce entropy production. Odum admits in his note that the term "order" can be found too generic and confusing compared to "storage with potential". Nevertheless, the existence of "storage with potential" acquires crucial importance within living systems as they aspire to execute as many life functions with less entropy production as possible. The creation of living structures and order happens with the expense of energy degradation. But the discussion about entropy can be extremely confusing as long as we don't differentiate the two notions of disorder we are talking about: disorder as energetic entropy and disorder as absence of purposely designed order.

Definition 8. ***Purposely designed order*** *describes the structure of environments that were adapted by actors in order to fulfil special purposes. The measure of "order", in that case, depends on the perception of the living organism and its respective needs. Purposely designed order is not connected with thermal entropy by definition. However, often the purposes of living organisms coincide with building "storages with potential" (holding back entropy production) in order to be able to release work afterwards.*

When somebody cleans his home with a vacuum cleaner, he may create purposely designed order that is essential for the fulfilling of daily life support functions and complex social organisation (e.g. inviting friends for dinner). But energetically, there has been an entropy production because concentrated electric energy has been transformed to dispersed heat and noise. To put both measures into the same basket would be theoretically problematic and presumes an unknown exchange rate between the two which is difficult to define accurately.

This doesn't mean that living systems in general aren't influenced by a tendency towards the transformation of less probable states (order) into more probable states (disorder), may that happen because of the need of heat dispersion during transformation processes or due to intentional actions of other organisms (in the above example: friends may leave dirty dishes). In consequence, the generation of life is equally conditioned by the laws of thermodynamics as any physical transformation process. In difference to closed systems, living systems have to be open and require external energy inflows in order to create and maintain order of any kind. This means also that we can deduce evolutionary principles from how living systems adapt in order to slow down both, the production of energetic entropy as well as the degeneration of purposely designed order.

Maximum empower within economic ecosystems

With respect to the integration of available energy as a quantitative physical principle of biological evolution, one influential discovery has been the hypothesis of the *maximum power principle* by Alfred Lotka (1922). It laid the foundations for the formulation of Georgescu-Roegen's bioeconomic theory (Bobulescu, 2013, p. 8) and was updated with scientific developments from ecology by Odum. In its original form, the principle states that organisms that best capture and direct available energy to the preservation of their species are advantaged. This means that the quantity of processed energy is a criterion for natural selection (Lotka, 1922, p. 147).

Definition 9. ***The principle for maximum power*** *states that, under the assumption of no input constraints, evolution advantages those life forms which manage to divert most available energy to support life functions. When observing ecosystems with different energy scales that consist of organisms that make use of different* *energy kinds, the principle is more correctly stated by replacing energy with emergy, expressing a tendency towards* ***maximum empower****.*

As mentioned earlier, subsequently it has been evidenced that evolutionary processes take place on the group-scale and on a cultural and economical level. On account of that, the principle asserts that those ecosystems prevail that process the available energy and resources in such way that achieves the highest possible throughput of emergy for life purposes (Odum, 2007, p. 37). The difference is the finding that nature equally acknowledges high level transformation processes, although these metabolise the same amount of emergy transforming much less absolute energy. Therefore, it is important to clarify Lotka's principle by stating it as the principle of "self organization for maximum empower" (emjoule per second), not just power (Jorgensen et al., 2004, p. 18).

All in all, natural selection tends to make emergy flux through a system a maximum under the assumption that there is an unused residual of available energy (Lotka, 1922, p. 148). Lotka (1922, p. 150) states also that this principle may be modified by other forces when a system encounters input constraints. In that case, the efficiency of energy transformation plays an increasingly important role. A demonstrative example of this phenomenon is given by the observation of ecological successions (Mollison, 1988, p. 64). Ecological communities begin with relatively few dominant, competing pioneering plants and animals who manage to capture a large amount of energy (Odum, 2007, p. 150). Successively complexity increases and further organisms find niches. Networks and cooperation become additional means to convert available energy more efficiently into life-supporting actions and to establish recycling that eliminates limiting factors. Many layers of additional high level transformation processes are added until the climax community is reached (Odum, 2007, p. 150). Generally, the latter has a higher biodiversity and a more energy-intensive metabolism. This is also a key concept in permaculture: a primary aim is to enrich life-supporting qualities of ecosystems, such as biodiversity, by finding new niches for plants and by the smart composition of organisms with complementary functions and beneficial interaction (Mollison, 1988, p. 59). In 2.5. we discuss more in detail what other concepts permaculture principles deploy in order to improve the conditions of ecosystems for "maximum empower". Thus, the main characteristics of economic ecosystems can be described with thermodynamic laws, an approximate emergy analysis and evolutionary dynamics.

2.4 Modelling the organization of ecosystems - the energy systems language

Before finding strategies for the enrichment of economic and social systems, we have to outline how the energetic dynamics mentioned above translate into the organisation of ecosystems and especially to economic systems. Specifically, it has to be recognised how organisms communicate with each other, how they collectively regulate consumption, production, exchange and storage of substances or commodities and comply with external constraints. It can be stated that every system that surpasses a certain level of complexity relies heavily on autoregulation. Internal adaptive mechanisms are necessary to adjust systemic responses to external influences.

As Georgescu-Roegen (1975, p. 353) remarks, some organisms, like green plants which store part of the solar radiation, "slow down entropic degradation". It is of high interest how nature manages to maintain live while reducing energetic cost and thermal entropy production at the same time. Energetically important organisms like green plants are embedded within complex ecological networks and depend on the interaction with other consuming organisms. According to Odum (2007, p. 63), ecological principles govern a large portion of the transformations with different energetic quality. He states that spatial organization, the intensity of actions and signals, stored quantities and material concentrations derive from the energetic organization of organisms. Odum called this the "energy hierarchy" analogue to the concept of the "ecological pyramid", where some organisms at the top execute control over lower organisms and eat them. The idea is that these interactions are very much governed by energetic dynamics. However, one has to admit that the term "energy hierarchy" may be originating from a mental scheme, as we are used to analyse hierarchical structures into successive sets of subsystems (Mayumi, 2001, p. 114). Reconsidering the "soft systems" aspect of SSM that takes account of the observer's world view, it may be more correct to assert that our conceptual model of nature is structured hierarchically rather than stating that nature in itself is hierarchic. We may think of natural functioning as the organization of dominance, control and duties although we are at the same time watching the reconciliation of self-regulation and interdependence within organisms in ecosystems. As Mollison points out, the model of a "one-way pyramid" with different "trophic levels" leaves out much of the complexity and underestimates the importance of feedback flows (Mollison, 1988, pp. 28-29). In order to avoid misleading "humanised" interpretations of natural ecosystems, we may alternatively refer to the "energy hierarchy" as *energy succession*. The energy succession would be a more flexible concept of a sequence of energy conversions and transactions between previous scales of organisms and consecutive scales. Latter organisms typically process a smaller quantity of one energy kind that however belongs to a higher quality level and has a greater solar transformity. We define different energy-related quality levels according to their emergy density. While the energy succession begins with high quantities of materials and high energy flows, consecutive scales transform less quantity of more elaborated material that has a greater emergy density (Tilley, 2004, p. 122).

Thus the emergy flux increases along the energy succession and organisms inhabit increasing areas that are their interaction and nourishment territories. E.g. humans subsist on very large areas which they manage in a unique manner using technology and tools which reside outside their bodies.

Definition 10. *The* ***energy succession*** *is a conceptual device to examine the organisation of living systems by attributing the quantity of emergy involved in processes.*

Patterns of self-regulation and interaction can be identified by following the various energy transformations from the origin of the necessary inputs to the final usage.

Now we may view this concept by modelling the previously mentioned example of a green plant and its surrounding ecological network in a forest, displayed in figure 3. The figure also demonstrates the use of the "energy systems language" and its symbols as introduced by Odum (2007, p. 25 et seq.). The energy systems language is used to show main parts as well as existing pathways and relationships of systems in terms of energy, a measure "that is found in everything" (Odum, 2007, p. 25). As we turn further to the right of the energy diagram, energy quality increases. This visualization allows for a faster assessment of limiting factors, risks, additional unknown influences and the overall resilience of a system. Organisms are alimented by non-linear autocatalytic processes. Typically this means exponential, but not necessarily fast, reproduction of species within their environmental constrains (Odum, 2007, p. 46) .

Definition 11. *In ecology,* ***autocatalytic*** *processes take place when the creation of something is amplified by its output. For example, a population with a high rate of reproduction encounters exponential growth until other necessary resources become limiting factors.*

In our example, the trees of a forest expand their leaf coverage and increase photosynthetic production until all the area is covered. This process is accompanied by a minimum of necessary energy dispersal, i.e. the production of entropy, displayed by an outgoing flow towards the heat sink (three horizontal lines). Leafs are not able to capture all the energy present in sunlight as some of it gets passed or reflected. In line with this, as muscles use up organic energy for movement they must expel heat as well. As shown in the diagram, producers like these are depicted with the production symbol (rectangular form with one rounded side). The thickness of ingoing and outgoing flow arrows is based on the energy quantity transferred. Resource and energy supplies often fluctuate due to natural events, such

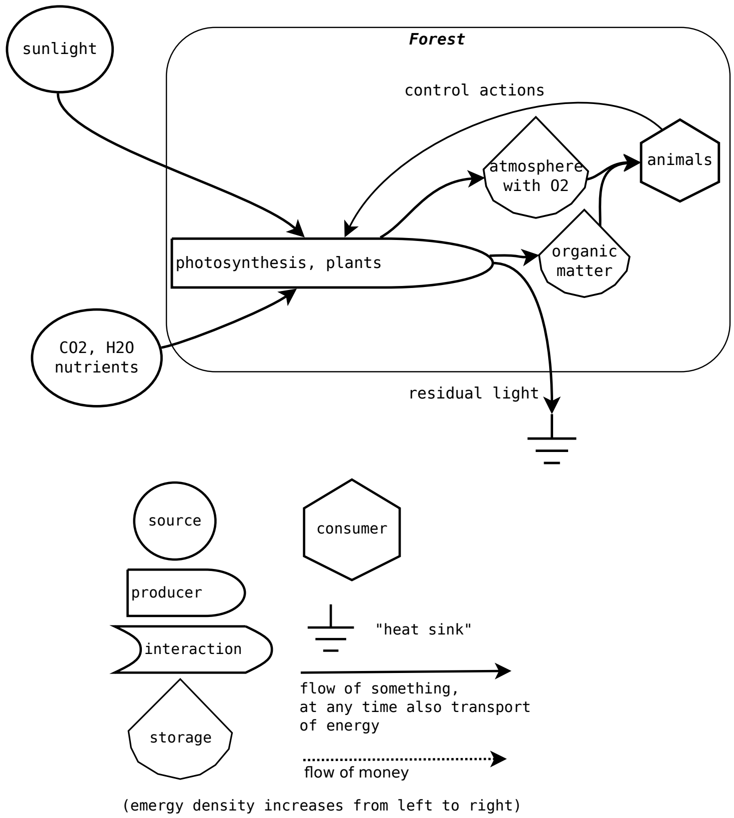

Figure 3: Energy diagram of a forest - an own representation of a forest using the energy systems language. Plants produce organic matter, bind sun energy and thereby slow down entropy production minimizing the dispersion through heat and reflection. Animals nourish themselves from photosynthetic production, i.e. residual processed material provided by plants. More valuable and energy-costly products reside further on the right side. Species transform their input into valuable coordination tasks during consumption. E.g. bees pollinate plants, herbivores feed back and distribute humus and seeds, others limit parasites. The energy diagrams in this paper are made with the software "Dia" and a custom shape set developed by the author. Below the diagram there is the disambiguation of the symbols of the energy systems language as utilised by system ecologists.

as changing climatic conditions during seasons, and also because of corresponding pulses in production among species, such as deciduous leafs of trees in winter. In order to even out the supply of nutrition and to be able to release work afterwards, organisms build up storages which we discussed earlier as means to reduce entropy production (Odum, 2007, p. 79). For instance, wood cells store reserves in the tree trunk. The organic matter and atmospheric oxygen stored in this way are represented by the storage tank symbol (triangle with the lower side curved).

Producers leave some of their output unused. Initially this would be wasted along with residual energy. But in line with the *maximum empower principle*, consecutive species in the energy succession find a way to process and value materials that have a higher energy quality (Odum, 2007, q. 163). In a forest, these are wildlife species, like bees that eat nectar or animals that eat fruits and herbs, as depicted in fig. 3. These are displayed as consumers (hexagon). In order to keep the system balanced, consumption cannot be a one-way relationship, e.g. unconditioned dominance. Consecutive units on the right side usually execute important coordination services, process information, give feedback and cause reinforcing pulses that regulate the reproduction of previous units (Odum, 2007, p. 165). For example, pollination done by bees is essential for the survival of many plant species. Interestingly, this work is done using a relatively small amount of energy that nevertheless represents a large amount of emergy. It has to be provided in such a elaborate, concentrated and targeted form so that it coincides with the instinct and ability of the bee to fly. Hence in the diagram, animals like bees reside on the right side of plants and determine a greater emergy flux. If we split up the diagram and zoomed in to view more details, we could see how such relations take place also between different animal species and subsystems. The famous predator-prey relationship describes how interdependence and regulation through two pulses, the reproduction of the prey and the predator which hunts, keeps the system stabilised and inside its external resource limits (Odum, 2007, p. 156). In permaculture, there is an enormous emphasis on maintaining and establishing this kind of self-stabilizing mechanisms which are composed of positive nurturing feedbacks, negative feedbacks that "constrain or control" the parts of a system (Holmgren, 2011, p. 72). The capacity of autoregulation is often missing in artificial monocultural environments which is why they depend heavily on human intervention.

Definition 12. *We can circumscribe **autoregulation** as a composition of feedback loops that, in their simplest form, provide either positive feedbacks that amplify the original action, or negative feedback that constrains the original action while reacting to external conditions.*

In like manner we can zoom out and view the ecosystem "forest", depicted with a curved frame in fig. 3, as a subsystem in relation to other units. Then we obtain a clear view on what has been described earlier as "economic ecosystem". Humans depend on wildlife and organic production in many ways. In the forest example, the most obvious are food and wood. Different emergy levels exist within human organisation as well. We may asses them depending on the necessary input of capital, time and natural resources. As with units of an ecosystem, we can position artefacts such as buildings, machines and institutions as well as intellectual constructs like knowledge, technology and networks of social relations along the energy succession (Odum, 2007, figure 9.7). Accordingly, we connect units with energy carrying flows of matter as well as with flows of information and social interaction which are equally characterisable with the emergy they use up. One exception is money as a unique social commodity especially designed for the exchange and coordination of flows which is depicted with dashed lines (Odum, 2007, pp. 252-253).

Now, that we are able to model society as an ecosystem, the striking question of the integrative analysis becomes whether an economy can also adopt nature's beauty and elegance in self-organization. With respect to this method, there is an important additional aspect that distinguishes the "soft" integrative approach presented in this thesis from other applications of the energy systems language. As already pointed out earlier, the integrative analysis aims at creating new insights and action proposals. The aim is not to assert new universally valid representations of economic ecosystems. We have already seen that emergy values from the embodied energy analysis depend on the observer's judgements. For example, today, a landfill may be regarded as a composition of vanished available energy that has been consumed and turned into waste. Thus, in an energy systems diagram, it contains almost no emergy and may be placed on the far left. But the viewpoint changes in a situation without other disposable mineral resources. Then, a landfill can be considered as a relatively high concentration of metals and substances that takes part in the economic production process. The landfill, now an emergy stock, may be placed further on the right. The latter model represents the energetically more sustainable organisation of a recycling society. In conclusion, we note that various models are possible based on different interpretations of the functioning of the observed reality. The "energy systems language" can display these conceptual models of economic ecosystems based on the flows, storages, producers, consumers and interactions along the energy succession either from distance or more in detail. After the problem analysis and the energy-conscious modelling of the economic ecosystem, the subsequent inquiry focusses on distinguishing and selecting desirable outcomes and model changes with the help of ecological principles.

2.5 The inquiry principles for ecological optimization

Beginning with the early, more practical "Mollisonian Permaculture Principles" described by Mollison (1988, p. 35) we now have 12 more generic permaculture principles that were devised by Holmgren (2011). They give an overview of the most important strategies nature applies in order to be more energy efficient and to balance its functioning. Our purpose now is to find criteria for the evaluation of economic ecosystems that incorporate the underlying knowledge that comes from those principles. With a concise set of questions we might manage to improve the conceptual modelling of economic problems and find new solutions that surpass exhausted viewpoints and approaches. Now, Holmgren's 12 permaculture principles are adapted for economic ecosystems. The result is the following sequence of questions and evaluation criteria:

1. **Are there excessive supplies that produce waste and reduce efficiency?** In nature, organisms often encounter the phenomenon of saturation when the supply of particular resources is excessive. This means that much energy is wasted or could have been used otherwise if the system was more stable and balanced. As I pointed out above, in the long run natural ecosystems tend to reduce excess as new species find niches and adapt by utilizing superfluous resources (Odum, 2007, p. 57). Excess can be a sign that this process is hindered by something. Permaculture responds to that fact by wanting to eliminate any form of waste (Holmgren, 2011, p. 111).

2. **Do interventions manipulate transformation processes near to the origin of problems?** In permaculture, many interventions concentrate on "catching and storing energy" right before it degrades (Holmgren, 2011, p. 27). Detecting the dissipation of resources and energy provides new possibilities for sourcing energy. For example, storing run-off water for irrigation on the rooftop or mountain rather than on the bottom avoids unnecessary pumping afterwards (cf. Holmgren, 2011, p. 30). Although society is far more complex, problem sources without a defined location can also be interpreted as places where dissipation is happening. For the cost efficient resolution of problems it is crucial that interventions concentrate on these sources instead of coping with a number of downstream consequences. Problems are not the only hints for possible "storages", i.e. the possibilities of obtaining currently dissipated resources. Near and careful observation may discover remaining potentials to produce a qualitatively more valuable commodity out of the same inputs.

3. **Does the system neglect yields or losses that are recognisable from additional perspectives?** The principle "provide a yield" reminds constantly of the fact that every effort emitted by an actor requires a benefit in order to be sustainable on the long run (cf. Holmgren, 2011, p. 55). The maximum power principle states that ecosystems essentially maximise their useful output by absorbing and transforming as much energy as possible. Whereas in ecology utility can easily be translated as the capacity to support life functions, this doesn't suffice to define usefulness within complex multilevel systems. In the end, new types and collective expressions of life can be found on the scale of croups, communities, institutions and organisations and their pursued objectives. Utility is perceived differently from various viewpoints and conditioned by the social characteristics of human behaviour. Thus, to optimise a system for a chosen indicator implies always a trade-off that neglects other perspectives. Any attempt to quantify the general "yield" of a system, therefore, cannot be limited to one single measure.

4. **What are the most lasting developments and what would be the long-term outcome?** In order to obtain processes that are less wasteful, more effective and stable, it is beneficial to consider larger time-scales. Within complex systems it becomes increasingly difficult to distinguish between impulsive changes and more durable effects. A short-term focus easily hides slow processes that have greater consequences within a longer time scale. The permaculture principle "use small and slow solutions" acknowledges the fact that it needs small, widely ingrained and incremental alterations to improve a system as a whole (Holmgren, 2011, p. 181). Small changes are also more resistant against brief and sharp disturbances. Usually, but not exclusively, small and slow solutions take effect in a more decentralised manner and depend less on external enticements.

5. **Are actions intrinsically motivated and do they respond to feedback signals?** We already emphasised the role of autoregulation within complex social systems that function on different scales. Permaculture practitioners endow the principles of self-regulation by "applying self regulation and accepting feedback" (Holmgren, 2011, p. 71).

   In psychology, there has been the distinction between those actions that are performed because of external motives and actions performed because of intrinsic motivation. In economics however, this concept is quite novel (cf. Frey and Jegen, 2001, p. 4). According to Deci (1971, p. 105) , "one is said to be intrinsically motivated to perform an activity when one receives no apparent reward except the activity itself".

   Definition 13. ***Intrinsic motivation*** *comes from within the person. Intrinsically motivated behaviour does not require rewards apart from those that emerge from the activity itself.*

   Intrinsic motivation results in a more effective behaviour as it has a competitive advantage over external incentives. Ecosystems consist of interdependent organisms that organise themselves through reinforcing feedback loops. Individual organisms may perceive such dynamics as intrinsic as long as they benefit from them. This way they do not need additional rewards coming from outside the system. Reconsidering the forest example of figure 3, animals may eat parasites without the need of benefiting plants to "pay" a reward. Equally, the action of collecting nectar is intrinsically connected to pollination, without the plant having to "negotiate" with the bee.

   The existence of intrinsically motivated behaviour makes it possible for a policy maker to value both autonomous regulation processes and already achieved synergies by identifying and acknowledging intrinsic motivation. This is also of great importance when economic policies are introduced to encourage a certain behaviour. Often those regulations don't achieve the desired outcome because they are based on an economic theory that undervalues intrinsic motivation and rationalises human behaviour. This leads to the anomaly of "monetary incentives crowding out the motivation to undertake an activity" (Frey and Jegen, 2001, p. 4).

This is especially the case with respect to the "informal" economic sphere. According to Guha-Khasnobis et al. (2014, p. 6) the notion of informal can be summarised as being outside the reach of different levels and mechanisms of official governance. However, there is various evidence for the unsound usage of the informality concept in the policy discourse. Specifically, the incorrect association of the informal with unstructured has been a "powerful impetus for interventions that have often led to disaster" in various occasions (Guha-Khasnobis et al., 2014, p. 7). The idea is that the informal sector may already have structures in place that are potentially governed by autoregulation and intrinsic motivation.

Definition 14. *The **informal economy** can be described as the total economic activity that is outside the reach of different levels and mechanisms of official governance. Following this definition, the attribution of being informal depends on the kind of governance. This way there is no clear split between formal and informal; rather, there is a continuum (Guha-Khasnobis et al., 2014, p. 5).*

6. **What are the scarcest inputs and are they potentially renewable?** With respect to Odum we have found that along the energy succession there is a corresponding distribution and concentration of material. Scarce and limiting resources have negative effects on all scales. In a society information, knowledge and relations can also become limiting inputs. Ecosystems cope with limiting inputs by providing a metabolism that produces renewable resources and services. That is why the effort to "use and value renewable resources and services" is an important permaculture principle (Holmgren,

2011, p. 93). Moreover, it has been noted that there is no free recycling and that "available matter" degrades "into unavailable states" just like available energy (Georgescu-Roegen, 1986, p. 7). Hence it becomes increasingly important how and under what expense of time and energy recycling occurs.

7. **How much is the cost of interaction and sharing?** Collaboration between organisms evolves if there are less obstacles and reduced efforts of adaptation (Odum, 2007, p. 150). Permaculture pursues this with the aim to "integrate rather than segregate" (Holmgren, 2011, p. 155). The right positioning of units accounts for an easier development of stable relationships. Whenever there is a potential for collaboration between two organisms, the cost of interaction and sharing resources has to be reduced by bringing them closer to each other. With respect to economic ecosystems there are many additional possibilities to reduce interaction costs. These include removing obstacles, reducing communication barriers and providing for regular and stable occasions of interaction and learning. With these measures one can manage to "use and value diversity" which is another permaculture principle (Holmgren, 2011, p. 203).

8. **What unavailable or speculative information does exist?** As an ancient Socratic teaching tells us, one person difficultly knows what one doesn't know about. This stands figuratively for the huge undetected sphere of uncertainty compared with collected or uncollected available information. The permaculture principle "observe and interact" puts an emphasis on monitoring without prejudices and reflection prior to taking action (Holmgren, 2011, p. 13). A "soft" approach to the manipulation of systems has to be conscious about its own limitations, unavailable information and assumptions that are taken based on speculation. Otherwise interventions and actions can have consequences that are contrary to their presumed outcome. Moreover, what is even more disastrous, their negative effects may not be detected as such. A

strategy of "design from patterns to detail" (Holmgren, 2011, p. 127) concentrates on the observation of the system as a whole and entails macroscopic research with less reductionist tendencies.

9. **What margins or centres are significantly dynamic?** If we wanted to search for the places with the highest emergy flux, we would have to look at the spatial organisation of economic ecosystems. In natural ecosystems, boundaries between differently structured zones or events may offer opportunities "for creating spatial and temporal niches" and higher biodiversity (Mollison, 1988, p. 76). Margins are enriched by inputs that originate from the different adjoining zones, e.g a forest and a lake. This causes permaculture to "use edges and value the marginal" as another main principle (Holmgren, 2011, p. 223). In society margins exist not only between spatial zones, but also between particular time segments, within groups, disciples and cultures. In some cases centres also offer these kinds of interfaces and, therefore, attract high emergy inputs, e.g. the centre of a city (cf. Odum, 2007, p. 203).

10. **Are proposals continuously adapted to changing conditions?** It is almost impossible to control complex systems completely as they evolve. The envisaged integrative approach takes account of that and concentrates on interventions to be beneficial and balanced. Because those manipulate the reality from which our conceptual system models are deduced, they have to be updated constantly. The resolution of problems within living systems is never finished entirely. Economic problem solving may only alter system conditions and the behaviour of the different actors. In order to achieve stable results, it is necessary to "creatively use and respond to change" (Holmgren, 2011, p. 239). In other words, designers or policy makers should not forget to insert themselves in the systems they conceptualise and close the feedback

loop between themselves and the rest by continuously adapting proposals to reality.

3 Integrative analysis of labour market challenges

A possible labour market reform would have to face many challenges. According to the European Commission (2010, p. 2), among the most urgent of them are decreasing employment rates, the shrinking working age population, the cost of welfare systems and global competitive pressures. With regard to those challenges there are various strategies and policy proposals that summarise the general approach to which many institutions and EU countries conform (BMAS, 2013, p. 141). Instead of repeating and commenting on them in an isolated manner, I integrate EU policy proposals into an exemplary integrative analysis. Recalling fig. 1 we outlined the integrative analysis method as an iterative procedure of different steps. These steps are the problem situation analysis, economic ecosystem modelling, the inquiry for the principles of ecological functioning and the recapitulation of action proposals and open questions that emerged during the inquiry. In consideration of the last step this sequence can then be repeated by redefining the problem situation and viewing it in relation to a widened context of additional actors and relations. Now, we may analyse the problem of unemployment in the context of the labour market doing three such iterations.

3.1 Iteration 1 - a systemic view on labour supply

Figure 4 shows how a conventional policy maker could view the system of labour supply while trying to solve the problem situation introduced above. Main actors are *unemployed* persons, the employed *workforce* and *employers* who manage the production process. The workforce can be seen as a stock of employed persons who embody a high energetic cost as they have already undergone a complex qualification and selection process. A high structural value can be also attributed to businesses that are hiring, because many premises have to fall together prior to offering jobs, beginning with the most simple premise that the business would have to sell its products and cover its costs. *Households* and *human capital* are also positioned on the right because they supply high emergy resources. Available time dedicated for work and acquired skills depend respectively on a functioning private and social life and many years of education. On the other hand, persons who are considered to take part in the "high-risk" population, including fixed-term workers, young people in their first jobs, the self-employed and many immigrants, have a higher probability of being unemployed (European Commission, 2010, p. 6). Another unit in this conceptual system of labour supply is the *labour market* where unemployed person and employers interact in order to form an active workforce. *Public Employment Services* such as job centres provide means to facilitate this process. The general equilibrium or tendency of the system is determined by the rate of "deprecation" of the workforce, i.e. dismissals, and the employment efficiency of the labour market. Still, the described system is a conceptual representation. In order to make judgements about policy proposals and possible improvements to the model, we check the system against the criteria elaborated in 2.5.

1. **Possible excess.** Surely, the most problematic excessive supply in the model of fig. 4 are unemployed persons. Job searching may produce correlating forms of waste which are depicted with the outflow to the "heat sink". Among those negative effects are allocation costs related to time spend on job searching and interviewing, the non-utilization of previously acquired skills (skill-mismatch) and training. Another aspect is that the income distribution is determined by the outcome of the labour market and may also cause public costs related to inequality.

2. **Dissipation and distance to interventions.** According to the European Commission (2010, p. 4), Public Employment Services recently delivered more targeted assistance and augmented active labour market measures, such as start-up incentives, training and work experience programmes. A program that detects potential dismissals in advance, perhaps by monitoring struggling

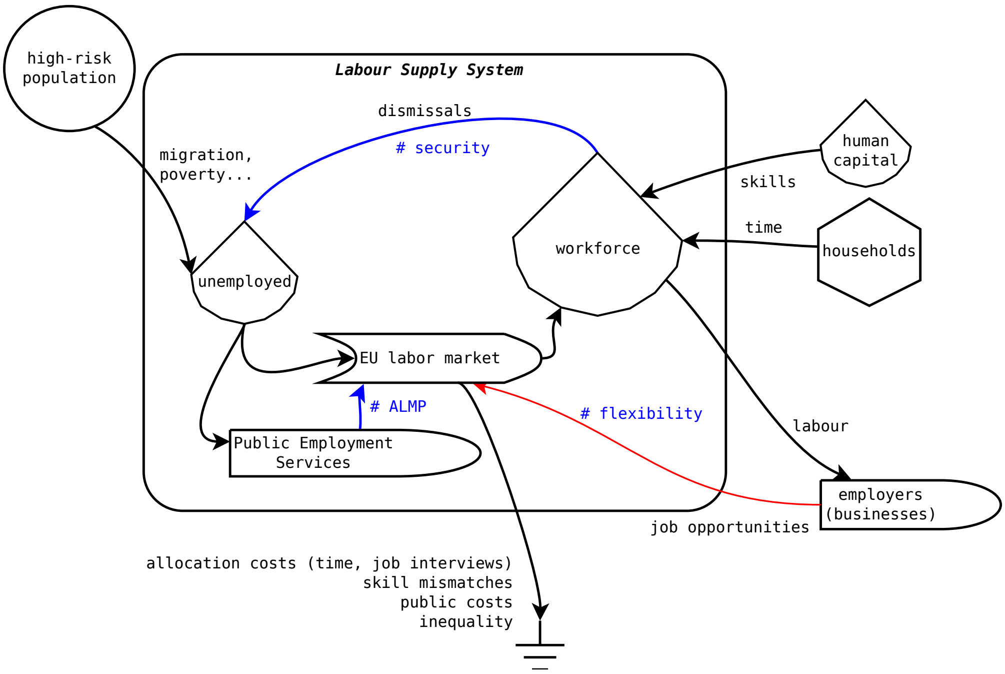

Figure 4: The system of labour supply - the supply of labour viewed as an energy diagram. It shows actors and flows that directly condition the labour market. Flows coloured in red are limiting factors. Furthermore, some key proposals of the EU Commission are positioned in the diagram (blue).

businesses, would manage to perform interventions prior to unemployment. This is just one possibility of decreasing the "distance" to the problem source.

3. **Neglected yields and losses.** Additionally to the public cost of unemployment benefits there are other costs that may or may not be considered by the policy maker. It is widely acknowledged that modern labour requirements invoke an increased risk of psychological and stress-related physical illness (BMAS, 2013, p. 28). There are negative effects of social exclusion which often emerges from being unemployed.

   But also society in general may suffer from social conflicts and from income inequality. In detail, the European Commission (2010, p. 5) doesn't make clear how the promotion of "flexible and reliable contractual arrangements" can avoid those negative effects. This applies especially for those originating from a reduced bargaining power (reduced wages) and increasing job turnover (costs for training periods, selection process etc.), while the attractiveness for the employer has to be maintained at the same time. While discussing the social security system, the European Commission (2010, p. 6) is concerned with "negative effects on re-employment incentives". This is the fear that too much benefits may reduce the readiness of unemployed persons to search and accept a job offer. However, there are no counterbalancing efforts to increase the employer's readiness to hire without weakening the job seeker's position. These are additional aspects to consider in a widened problem analysis during the next iterations.

4. **Long term dynamics.** The European Commission (2010, p. 2) suggests that the current workforce structure suffers from global competition and thus has to be oriented towards a "green, smart and innovative economy". This means that dismissals outweigh the creation of jobs unless radical and innovative changes are applied to the production system. The next analysis iteration may consider this additional aspect and respective EU proposals. On a more

trivial side, the system as depicted above states that all time and skills are used up on the long run as households and human capital have no inflows. This simply demonstrates the limited scope of the model and a the need to examine those factors more deeply.

5. **Intrinsic motivation.** It is very difficult to think of intrinsic motivation in a labour market environment. The labour market is generally thought of as a place that is governed by external monetary incentives and the evaluation of certified qualifications. Nevertheless, there are many psychological influences that may alter its outcome. Phenomena such as voluntary work, more present in an "informal" economic sphere, may raise interesting questions about other forms of labour and their motivations.

6. **Scarcest inputs and renewability.** In the system depicted in fig. 4 it is not given what determines the employers readiness to hire. In fact, the creation of job opportunities is one of the most uncertain aspects for policy makers. The lack of job opportunities is responsible for long-term unemployment. This means that the employer or business unit and its interactions could be examined more in depth, in order to get more insights about the creation of jobs.

7. **Costs of interaction and sharing.** The European Commission (2010, p. 6) tries to facilitate interaction on the labour market with active labour market measures (ALMP) that range from individual job counselling, job search assistance to employability improvements. These can reduce the allocation costs mentioned in fig. 4.

8. **Unavailable, speculative information.** Apart from the process of creating job opportunities, it is uncertain what contributes to the risk of young persons and immigrants to be unemployed. Moreover, it is not clear how skills and "human capital" are formed and, as the European Commission (2010, p. 2)

states, there a is lack of available information about required and unused skills (skill-mismatch) in our current economy.

9. **High emergy margins or centres.** One can make general statements about the location where employment opportunities are more concentrated. Usually they reside in the centres of cities because many people commute for work reasons.

10. **Continuous adaptation and analysis.** There are many efforts to monitor the progress and implementation of the EU proposals (cf. European Commission, 2010, p. 7). However, unexpected developments may challenge the existing strategy.

Recapitulating, the inquiry of the presented model of the labour supply system opens up questions and possibilities for further examination. To consider unemployment as a phenomenon that depends on the mere interplay between unemployed, employed and employers on the labour market delivers limited results. A clearer view on labour has to be aware of the origin of skills, of the conditions for the creation of job opportunities and of possibilities to reduce the negative side effects and the social costs of the labour market.

Thus, in the following iterative step we may concentrate on the connections between labour supply and the overall economy understood as production system. The next model is still deduced from conventional viewpoints and from proposals of the European Commission, this time with respect to the overall economy.

3.2 Iteration 2 - the role of labour in the economy

In fig. 5, the previous labour supply system is depicted as a compressed unit in conjunction with the economic production system. The production sphere of the economy is composed of *businesses*, *capital*, the *financial market* and *markets of goods and services*. As in conventional economic textbooks, the main inflows into the production system are capital and labour, both indirectly and directly provided by *households*. In the past, capital has been widely known as a scarce and limiting resource to the economic process and an important growth factor. The fact that capital cannot be formed without the contribution of labour and the economic production process itself makes it a high emergy resource positioned further on the right. Equally important is the slightly more complex formation process of what is called *human capital*. The latter includes skills and qualifications that are taught by *education providers*. Markets of goods and services are where businesses and households interact on the consumption side, exchanging goods and earned income. Financial markets are in charge of the allocation of capital. Their power is made visible regularly by the potent control pulses they emit, such as bursts of financial bubbles that cause the immense deprecation of capital in businesses. Economic costs of both dissipative events as well as malfunctioning of economic production and distribution are depicted as outflows to the "heat sink". As these markets are positioned on the right of the labour supply system it can be argued that they form a feedback loop with the labour market and have an enormous indirect influence on the unemployment rate.

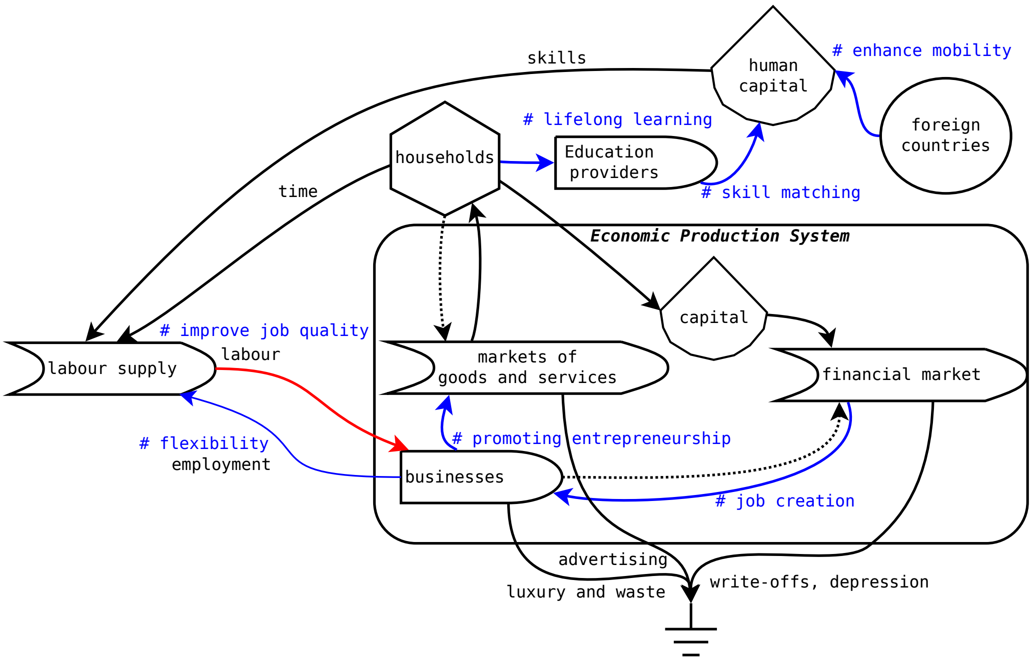

Figure 5: The system of economic production - the classic economic production process that includes capital, labour, households and businesses as represented by conventional economic understanding. It shows indirect connections to the labour market that are worth analysing.

1. **Possible excess.** Excess of supply can be observed when one of the three market units, labour markets, financial markets and market for goods and services, fails to distribute resources correctly. This can happen with capital during the build-up of speculative bubbles. But also imperfect market conditions, i.e. the absence of perfect information and perfect competition, may distort the distribution of goods and services. However, seen from an integrative viewpoint, there is no guarantee that those inefficiencies vanish in the case of perfect market conditions. In order to impede the overconsumption of natural resources for example, there is a need for additional control signals that originate from external sources. The restricted focus on individual preferences is only capable of adjusting human decisions to human valuations through markets. An interesting extension of the model would concentrate on excess that persists even with the hypothesis of perfect markets.

2. **Dissipation and distance to interventions.** The proposal "matching people's skill and job opportunities", here circumscribed as "skill matching", seeks to add impulses to the education process that prevent the mismatch between qualifications and job requirements (European Commission, 2010, pp. 10-11). We already noted in the first iteration that the "dissipation" of unneeded skills happens during the selection and hiring process. Hence it is very advisable to collaborate with employers as suggested by the EU Commission. The EU program "lifelong learning" goes in a similar direction. A further problem analysis however could raise the question whether it produces other kinds of costs or "dissipation" to adjust education providers exclusively to the requirements of the job market.

   The will to "enhance mobility" on the other hand corresponds to deeper problems. While it is beneficial to remove obstacles and barriers to transnational mobility from an intercultural viewpoint, the increasing need for mobility may also be a symptom for other problems, such as structural disparities between EU countries. These may even be aggravated by enhanced mobility in the absence of a more direct solution, causing brain drain as a result (cf. Horvat, 2004).

3. **Neglected yields and losses.** The most important neglected viewpoint in the given system is the evaluation of ecosystem services. It is not clear how natural reproduction is influenced by the human production system and how the reduced supply of energy (fossil fuels) and a diminished biodiversity influence the system of economic production negatively.

4. **Long term dynamics.** As the system in fig. 5 contains no external and potentially limited inflows, a logical conclusion is to expect the system to grow exponentially due to the autocatalytic dynamic of increasing consumption and accumulation of capital. In consequence, there would be no limit for employment either. The fact that the European Commission (2010, p. 2) targets full employment, aiming at an employment rate of "75 % by 2020", shows that this supposition is very common among institutions. However, it is important to note that these expectations may be unrealistic once we have detected further system boundaries.

5. **Intrinsic motivation.** It can be stated that human interests, talents and skills and therefore educational choices are very much determined by intrinsic motivation. This represents an additional difficulty for the initiatives "lifelong learning" and "skill matching". Should the interests of the population not coincide with the qualifications requested on the labour market, this may represent a tricky dilemma for the EU as it is not easily resolvable with monetary rewards.

6. **Scarcest inputs and renewability.** In the given system, the limiting input seems to be labour supply. This is because its preconditions, available time

and skills, are no direct consequences of a growing economy. Instead, a developed economy encounters an increasing conflict between the expenditure of time that has to be dedicated for consumption, in order to ensure the demand necessary for a stable economy, and the time dedicated to work (Paech, 2011, p. 67). There is simply no time left. This may seem paradox, but it is important to note that viewing systems from different scales can produce different insights. Each of them are part of the bigger picture.

7. **Costs of interaction and sharing.** The potential costs of market interaction are depicted as flows to the heat sink. Advertising and transportation don't improve the product experience but seem necessary for transactions to happen. It can be hypothesised that in increasingly saturated western consumer markets the share of those costs rises. In consequence, waste increases and goods suffer from earlier obsolescence. Instability and harder competition amplify these effects in times of depression, resulting in the destruction of capital and jobs.

8. **Unavailable, speculative information.** Apart from lacking information about the processes involved in all kinds of markets, which is usually covered by many economic research areas, there is lacking information about the resource "time" and how decisions about time expenditure are made. Main aspects about private and social life may remain unavailable.

9. **High emergy margins or centres.** Previously, we identified city centres as the usual location of working places where interaction concentrates. But on a smaller scale, households, businesses, schools and universities represent dynamic margins as well. The internet is no location in the strict sense. But as a collective extension of those places where computers reside, it hosts the high emergy resource information.

10. **Continuous adaptation and analysis.** The European Commission (2010, p. 9) promotes entrepreneurship, job creation, job quality and skill matching based on continuous monitoring and the assumption that the economy is trending towards a so called "Innovation Union" with a large technology and information sector .

    However, there may be a need to explore the fundamental causes behind a trend towards a greater service and knowledge orientation in relation to the basic human needs of social cohesion, co-operation and mutual respect.

Recapitulating, the inquiry of the second extended system model has shown that many EU proposals can be enhanced with the reduction of inefficiencies that cause flows to the "heat sink". New problem fields have emerged that require a deeper understanding about the social and informal aspects of the economy and the role of the environment. One conclusion is that unemployment is not a solitary problem. It is connected to social and ecological boundaries of a growing economy, beginning with the fact that available time dedicated to consumption reaches a maximum. The next iteration would model a system that includes the additional challenges for the overall market economy in order to elaborate clues for the resolution of interconnected problems.

3.3 Iteration 3 - introducing ecological principles on the macroscopic scale

The following iteration of the integrative analysis introduced in this paper aims for new practical solutions to an extended problem field. Up to now, the analysis has evaluated existing strategies and prepared the discourse for the consideration of additional dynamics. Fig. 6 shows both the labour supply system and the production system of the previous iterations as bundled units in relation to *natural production*, the *informal economy*, *social capital* and *cultural life*. Natural production and ecosystem services provide essential inputs for the human society. *Fossil fuels* have the particularity of being a finite stock without significant inflows. With

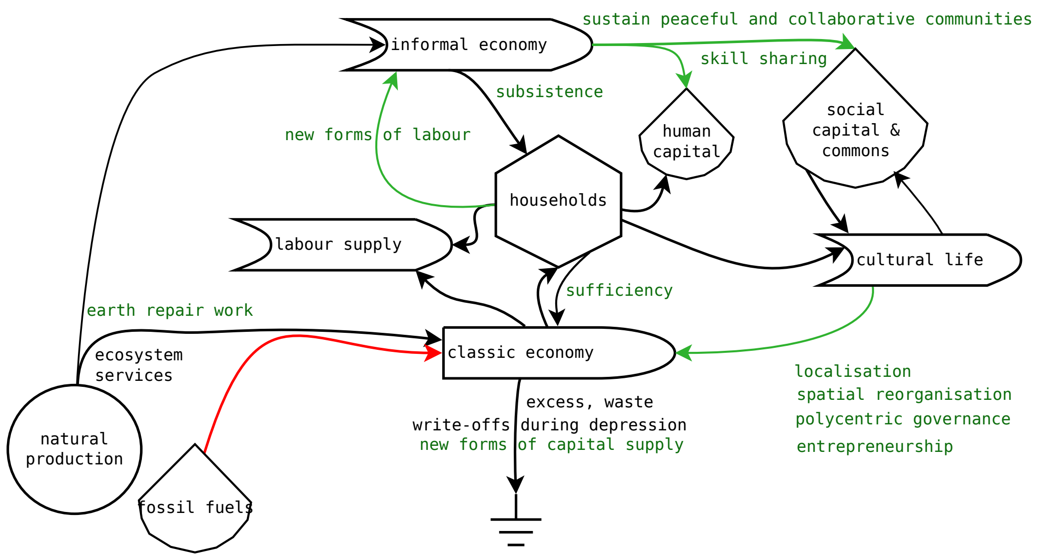

Figure 6: A macroscopic view on an "economic ecosystem" - the previous displayed systems viewed within their larger context. The graphic puts the economy in relation to its environmental and social interconnections. This time, the diagram also contains additional action proposals deriving from the integrative analysis.

respect to the models of the previous iterations there are new additional units. The informal economy may execute many of the functions of the formal production sphere, but is governed more by social motivations than by monetary incentives. Cultural life summarises every complex social interaction that goes beyond the economy. That is exchange and creation of collective knowledge as well as the maintenance of social relations and values. In consequence, social capital can be described as the total of socially formed structures, commodities and knowledge that produce collective benefits. Empirical research supports the idea that those units are interconnected. E.g. data has shown that income inequality "leads to increased mortality" because of the corresponding impairment of social capital (cf. Kawachi et al., 1997).

1. **Possible excess.** Additionally to the previously mentioned possibilities of excess, the economy may be supplied with an excess of fossil fuels with respect to a longer time frame. The concept of modern "sufficiency" promoted by Paech (2011, p. 89) seeks to eliminate excess with regard to consumption and the related waste problems highlighted earlier. This way persons can be arguably happy despite of decreasing their environmental impact.

2. **Dissipation and distance to interventions.** Other forms of externalised costs and inefficiencies can be avoided through localisation, eliminating transport distances and facilitating small-scale governance. The book "Small is Beautiful" by Schumacher (1973, p. 190 et seq.) makes a case for small-scale development as it often fits the education, organising skill and financial capacity of local populations. This applies also to the distances between work and households as a more balanced distribution of work opportunities near the actual location of consumption (households) can be beneficial for both the labour market and for the cultural life of local communities.

3. **Neglected yields and losses.** Negative yields from ecological destruction, extinctions and the long term impoverishment of the natural carrying capacity are almost as incalculable as far-reaching.

   Positive yields may derive from informal work, although the economic production value of the informal sector is impossible to quantify. The importance of socially motivated labour may be easily neglected. The European Commission (2010, p. 18) regards informal work as something that has to be shifted "into the regular economy". But on the contrary side, this raises the question whether these attempts actually crowd out existing social structures and make society more vulnerable to financial discrepancies. Important yields from the cultural sphere, including the formation of social capital, cannot be replaced by monetary regulation either.

4. **Long term dynamics.** A sociological examination of the existing small, steady and beneficial trends in our society would exceed the scope of this paper. However, it can be said that the construction of stable and pleasant communities, the creation and cure of social relations as well as the pursuit of individual and collective knowledge require long time frames. Nevertheless they are equally beneficial for the well being of the population.

5. **Intrinsic motivation.**

   The latest innovations to marketing provide strategies on how to enter the cultural sphere, perpetuating strong emotions and social identification along with a product. This is also the reason why online social networking has attained great economic importance. This shows the important role of intrinsic motivation in an economic ecosystem. However, those subtle economic influences may inadvertently cover intrinsic motivation. Viewed from an ample perspective, intrinsic social behaviour may have the function to adapt cultural structures to ecological constraints. "Earth care" was an important aspect of traditional populations and deeply integrated into cultural and religious values. E.g. Mollison (1988, p. 2) notes how aboriginal life philosophy resembles natural energy laws. The discipline of cultural ecology researches the interconnections between human culture and natural ecosystems, no we may think of a similarly transfigured concept of "cultural" ecosystems (cf. Finke, 2005). This kind of knowledge can open new concrete labour proposals that are are dedicated to surrounding ecosystems or healthy work environments. As an example, nature based therapy can incorporate permaculture ideas in order to cure work-related illnesses and stress (cf. Corazon, 2012, p. 14).

6. **Scarcest inputs and renewability.** In the long run, fossil fuels have no inflows and will be terminated. Provided that the discussed autocatalytic tendencies of a growth oriented economy outweigh, there will be a conse-

quential displacement of the biosphere, an increasing urbanisation and a more intense exploitation of nature. As stated in 2.3, if all the energetic demand of civilisation was provided exclusively by photosynthetic production or solar panels, there continues to be a serious reduction of nature's space and ability to produce ecosystem services for itself and for human society. The diagram suggests that economic effects deriving from a decreased energy supply unleash serious consequences for those units which have higher energetic costs. These include especially all the resources, knowledge and relations necessary to build peaceful and collaborative communities. A special attention and effort in order to sustain that peaceful and collaborative behaviour within communities thus becomes a necessity. At the same time it represents another occupation opportunity that creates useful yield.

7. **Costs of interaction and sharing.** The decreasing household sizes make it more difficult to share goods and activities among persons and within neighbourhoods. Moreover, one of the biggest limits for social and cultural activities in modern society is a general lack of time. From a holistic point of view, the functions of work are "at least threefold": self-realization, collaboration with others by sharing a common task and production for the satisfaction of needs (Schumacher, 1973, p. 57).

   The modern understanding of work focuses mainly on the latter purpose, the fulfilment of economic functions. Work has become increasingly separated from its social functions during the era of industrial labour. In response to that, there are attempts for a fundamental rethinking of the understanding of labour. New models and forms of labour and retribution could incorporate intrinsically motivated activities (cf. Blaschke, 2012), are more aware of the social aspects of work, and lead to a more balanced availability of time disposable for community development (cf. Baier and Biesecker, 2012). The promotion of skill sharing or a particular emphasis on work and organization dedicated to subsistence (cf. Paech, 2011, p. 99) are some possible measures that reduce the cost of interaction and sharing.

8. **Unavailable, speculative information.** There is a large variety of cost estimates for one ton of carbon emissions. The future damage deriving from ecosystem disturbances is almost impossible to assess. Therefore, any economic "price" of carbon emissions or any other kind of natural destruction is highly speculative. Too optimistic estimates as base for policy proposals are a sign of incomplete, reductionist analysis and may not achieve the expected outcome.

   In the second inquiry we have already mentioned that the market economy might influence education and human capital formation while these processes are adjusted to labour market requirements. We also mentioned possible spillover effects on cultural life. The unsubtle incorporation of social capital, commons and informal activity into the economic sphere can be viewed as a risk for the integrity of those units.

9. **High emergy margins or centres.** Additionally to the previously mentioned, community spaces where social activities, art and culture happens are dynamic margins or centres. Other potentially interesting places are the interfaces between households and the surrounding ecosystems. For example, local community gardens are both places of social aggregation and urban gardening. That is why the spatial organisation and design of cities and buildings is a field of great potential for reducing the obstacles of interaction and sharing.

10. **Continuous adaptation and analysis.** Policy changes and new adaptations in businesses take place within longer or shorter time intervals. We might have identified tendencies of self-regulation and feedback loops that were able to absorb market disruptions in the past and provide for the overall stability of the system. These belong more to the local, decentralised social

environment of persons. It has become clear that the single policy maker is not able to fulfil the continuous adaptation required for a balanced interplay of all actors. Local governance aspects are essential to improve the underlying conditions for stability and adaptation.

Recapitulating, the depicted system seems to be a very dense, and complex system although it is a simplified visualization of the author's conceptual representation of the society as economic ecosystem. Despite its simplicity, it already provides many clues either on how to soften the negative effects of unemployment or to create new occasions of employment that are beneficial in new ways. Among the former possibilities are schemes of subsistence and sufficiency as well as new forms of labour that are less intensive and more suitable for the diverse needs of persons. With regard to the latter kind of measures there is an increasing need for "earth repair", the maintenance of ecosystem health, and community development in order to promote peaceful and collaborative communities where people, among many other things, share their skills with each other. Nonetheless, a crucial challenge for establishing these work opportunities is that the rewards usually fall short off the produced yield until their benefits have not been recognised by economic decision makers. Other proposals that enhance the efficiency of markets, especially with regard to unwanted external effects (environmental and social costs), are related to localisation, small-scale governance as well as the holistic planning of cities and buildings.

4 Conclusions

In closing, it has been demonstrated how an integrative analysis can be used to analyse a problem in consideration of many different scales, layers and aspects and evaluate various policy proposals. The integrative analysis method integrates four main considerations about ecological organisation.

First, human civilisation is a subset of the earth ecosystem. The general characteristics of ecosystems apply also for economies as they can both be described in terms of energy, transformations and interactions. This leads to the concept of economic ecosystems.

Second, different energy forms have different energetic qualities depending on the amount of energy expended in the process of their creation (emergy). This means also that resources and organisms with a high emergy concentration contribute differently to the functioning of ecosystems.

Third, living systems follow patterns that we can perceive while tracing their organisation along the "energy succession". These patterns relate to the interplay between producing units, units that control high emergy resources and the resulting capacity of autoregulation. A useful visualisation tool is the energy diagram which uses the "energy systems language".

Fourth, evolution appears to have a propensity towards "maximum empower", that is the greatest possible absorption of available energy in order to sustain as much life as possible. As done in permaculture, sustainable ecosystems can be used as an inspiration in order to deduce design principles that help all actors achieve the best use of resources and energy. The integrative analysis adopts those principles as criteria for the inquiry of conceptual models of economic ecosystems.

On the theoretical side, it has been found out that there is a risk to confuse the concepts of thermal entropy and purposely designed order. Moreover, economists may have difficulties to resist the temptations of treating emergy evaluations as economic values or avoid claiming to make objective judgements while not undertaking further research. Thus, in order to anticipate the flaws of reductionism, the integrative analysis adopts the methodical sequence of the SSM. The latter is especially fitted for the evaluation of complex perceptions of systems by different actors and viewpoints.

In this paper I have applied the sequence of the integrative analysis to the problem of unemployment and corresponding labour market challenges in three iterations. During the analysis, the scope of the problem broadened. New questions about the EU Commission's strategy to deal with the upcoming challenges for the labour market have been raised. The given modelling method has been particularly able to view the EU strategies for innovation and job creation, labour market flexibility and security, mobility and education from different perspectives. The integrative analysis has provided a way to establish interconnections and compatibilities between proposals that are based on a more conventional economical approach on the one side and alternative suggestions on the other side. This makes it possible to combine many separate economical ideas to form a coherent whole. Such a synthesis may give important insights not only to face the challenges of the labour market or any other economic problem. It enables us to choose policies and actions that are consistent with diminishing energy supply as well as social and ecological disturbances. This way policy proposals address also the global challenges that our society is beginning to face during an era of post-growth and energy decline.

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