"BRINGING FORTH" THE ECOLOGICAL ECONOMY

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ABSTRACT

This paper looks at aspects of the development of Ecological Economic theory through the lens of second-order cybernetics. Ecological Economics aims to integrate Ecological and Economic disciplines while maintaining their distinction. This is required for the concept of "scale" which relates the size of the ecosystem with the size of the economy. Beyond the dynamic and complicated nature of these systems; this task is also conceptually difficult. How can the ecosystem be part of the economy but also distinct from it? How can the economic system be part of the ecosystem and also distinct? Which is the correct framing? While Ecological Economics was conceived in the era of "open systems" and "sub-systems", second order systems theory may shed light on the paradoxes which naturally arise from this perspective. As second-order systems theory would suggest, this fundamental paradox of observation results in a circularity. This circularity can be illustrated by attempts within Ecological Economics to generate definitions of sustainability; most notoriously through valuation of ecosystem services but also within alternative social and ecologically based models. It may be possible to embrace this circularity and seek an "operational closure". In the process of considering this, I reflect on my experience in studying Ecological Economics and Second-Order Cybernetics.

Keywords: Cybernetics, Circularity, Ecological Economics, Participatory Action Research, Agroecology

INTRO

The evolution leading to modern capitalism has taken place in the context of various social and political structures (Boix 1999; Torcal and Mainwaring 2003) technical capabilities, (Heilbroner 1997) ecological constraints and affordances (Daly and Farley 2011) and also beliefs about reality, knowledge, and experience (eg. Bates, de Figuieredo, and Weingast 1998; Farmer 1982; McLure 2002; Shapiro and Wendt 1992). Ecological economics has emerged across disciplines, and has begun to disentangle, not only the relationship between biophysical earth systems and economic activity, but also, fundamental relationships between objectivity, power, value, ethics, perspective, and purpose (eg. Nelson 2008; Moro et al. 2008; Tadaki, Allen, and Sinner 2015; O'Donnell and Oswald 2015; O'Hara 2009).

This can be an overwhelming task. Ultimately, the set of relations which become the focus of Ecological Economics will define the discipline. Increasingly, there is a reflexive awareness of this recursive process (eg. Spash 2013). This is manifest in the call by Spash (2012) among others to develop clarity regarding ontological and epistemological presuppositions in Ecological Economics.

Ecological Economics has natural roots in systems theory and systems ecology. Further, systems theory can offer valuable insights with regards to fundamental questions regarding ontology, epistemology, aims and boundaries even if it does so on its own terms.

This paper reflects on my experience as a student and researcher learning about Second-Order Cybernetics, and Ecological Economics. Neither are highly accessible as a new learner, nor are they as mainstream as they should be. In the case of cybernetics, I essentially began to find wonderful correlations between cybernetic thinking and my course content, but I generally had to learn the cybernetic material on my own. Part one introduces cybernetics giving examples of cybernetic inquiry which I found to be the most engaging. Part two demonstrates the extent to which second order circularity already underlies inquiry in Ecological Economics. Part three offers a path forward for Ecological Economics which embraces organizational closure, and part four offers a brief reflection with regard to a case study.

A Short History of Cybernetics

The cybernetics movement which I will crudely equate with systems theory[1], formally began with a series of interdisciplinary meetings held from 1944 to 1953 that brought together intellectuals such as Norbert Wiener, Warren McCulloch, John von Neumann, Claude Shannon, Heinz von Foerster, W. Ross Ashby, Gregory Bateson, Margaret Mead, Lawrence Frank, Heinrich Kluver, and Lawrence Kubie.

The term cybernetics evolved from the Greek term "kybernetes" found in the work of Plato, and later revived with the 19th century French mathematician Andre-Marie Ampere, who like Plato, used it to mean the science of effective governance (Heylighen and Joslyn 2001). Cybernetics was a theoretical transdiscipline which produced many applied developments in computer science, artificial intelligence, and engineering. With military inspiration, in particular, these developments dominated funding streams. Another camp focused on managerial and social systems, psychotherapy and epistemology.

Concepts such as complexity, self-organization, self-production, autonomy, networks, connectionism, and adaptation, were first explored in cybernetics between the 1940's and 50's derived from concepts such as order, recursion, hierarchy, structure, information and control (Heylighen and Joslyn 2001). In many cases these concepts were rediscovered and popularized at different points in time. The core of this thinking, expressed in dynamical systems theory is not theory about the building blocks of reality, but are mathematical theories which can be applied to many phenomena. This has to do with relationships and patterns and not "objects". It is a qualitative approach.

[1] Cybernetics emphasizes goal oriented systems, but because any distinction between system and environment eventually implies a break in time, which can only be made by an observer with an intrinsic aim, every system, as it comes to be defined is enclosed by a cybernetic system. This becomes more apparent with the second-order turn, discussed later.

After the initial separation between the "soft" camps (social science, epistemology), and the hard sciences (engineering, artificial intelligence), second-order cybernetics moved to bring the two together, focusing on observation itself. A system can be cybernetic, the observer is also a cybernetic system, and the two together constitute another cybernetic system, and so this second-order turn could be considered the cybernetics of cybernetics. Concepts of emergence and self-organization in particular, forced further investigation of questions regarding the nature of "bringing forth" (Proulx, 2008) objects of inquiry. In these cases of self-organization, it is not only an object, which has organized itself, but also an observer (or community of observers) which has organized their description. (Foerster, 2013) We see this a lot when disciplinary boundaries break down, and when this happens, "there" emerges "self-organization" (eg. physico-chemical soil processes: (Young and Crawford, 2004)). Heinz Von Foerster took this a step further arguing that descriptions are not descriptions of an independent reality, they are descriptions of descriptions, describing descriptions (Von Foerster, 1973). The distinction between first and second order cybernetics, really comes with the recognition of the circularity embedded in any description.

Second Order Cybernetics: Examples and Potential

Second-order cybernetics took its first steps on the premise of circularity and began to investigate how and why it comes into being. Researchers began to see that this circularity, far from being the end of a perspective, is the beginning; it creates space for inquiry. As opposed to a mechanical perspective, second-order cybernetics finds that an observer can create circularity with use of time, and the imagination. In my relatively short time period with second-order cybernetics a few inquiries stand out to me. First, Francisco Varela gives a great explanation of circularity in "The creative Circle: Sketches on the Natural History of Circularity" (Varela, 1984)[2].

Logic, Biology, Cognition, Perception and More

"This sentence is not true", is a popular example of the conundrum found in circularity. Logicians and mathematicians such as Russell Bertrand, Alfred North Whitehead and Kurt Gödel, have been confused and amused by circularity (Whitehead and Russell, 1910, Uspensky, 1994).

In "Laws of Form", George Spencer Brown breaks this down to its most primary form focusing on the simplest "distinction". Paradoxically, a form must arise within a cognitive domain, yet also be distinct from this cognitive domain in order to make any difference. Eventually George Spencer Brown unravels the paradox, through the discovery of "re-entry". In essence, the first form comes into being when a thing is the process which creates itself. This concept can be illustrated visually with fractal geometry. Fractal geometry can be generated mathematically with equations which are

[2] http://www.lifesnaturalsolutions.com.au/documents/varela---the-creative-circle.pdf

functions of themselves. Check out "Self-reference and Recursive Forms" by Louis H. Kauffman (1987) [3] which re-presents George Spencer Brown's laws of form. In some cases these equations yield stabilities, and in others they dissipate until infinite. These special forms, contain that which they exclude, and exclude that which they contain. There is an "interpenetration." According to George Spencer-Brown, if distinction generates space, oscillation generates time, and this introduces a fundamental indeterminacy within logic (Spencer-Brown, 2008).

This line of thinking does not stop at logic. Humberto Maturana, Francisco Varela and Heinz Von Foerster would take great interest in cognition, which they would come to correlate with life itself. To describe cognition, some have used the metaphor of a map (a representation) and reality (what the map is supposed to be about). Enactive cognition, greatly challenges the traditional view of cognition as representation and information processing. A more radical perspective is that any representation is more like a set of instructions. When we talk about space and time we are discussing the manual, not reality. The manual is the medium of interaction, a recording of past relationships between the observer and the observed. This resembles Donald Hoffman's "Interface theory of perception" Hoffman and Prakash (2014). The conscious-agent thesis is that *"Every property of consciousness can be represented by some property of a dynamical system of conscious agents."* (Hoffman and Prakash, 2014) The goal of this project is to derive physics from formalization of conscious agents. Thus far researchers have produced the equation for the non-relativist quantum particle. If the implications of this are accepted, science begins to be reimagined as describing the descriptions which have become hard-wired in our sensory-motor system. Further it is a step toward declaring that consciousness is no longer secondary to matter.

In "On Constructing a Reality" Heinz Von Foerster (1973) discusses the sensorimotor feedback at two levels, one which regulates connections, and one activates responses. In this case, a stable network of interactions must be present to generate meaning for some occurrence, and yet this meaning, also changes the network of processes. We make sense of a sensation according to our past experience and yet the present is re-writing the past.

Such closure is what defines "autopoiesis". Autopoiesis occurs with a stable network of processes which give mutual rise. Maturana and Varela uncovered a circularity in the biological domain regrading identity, interaction, meaning, and closure. They began to illustrate the manner in which everything from cells to larger organisms reproduce themselves and their boundaries, (Varela, 2009).

However, as Thompson (2009) writes, in reflection on Francisco Varela's thinking "It's one thing to have a scientific representation of the mind as participating in the "constitution" of its intentional objects; it's another thing to see such constitution at work in one's own lived experience." This presents some tension in second order science. On the one hand it is possible to point toward circularity. On the other hand it may be

[3] http://homepages.math.uic.edu/~kauffman/SelfRefRecurForm.pdf

possible to embrace this circularity in methodology. For Francisco Varela, Buddhist meditation presented the possibility of this embrace on a personal level.

Extension of Second-Order Cybernetic Thinking

The extension of these concepts outside of their original domain has been somewhat controversial. In particular, Francisco Varela was quite wary of applying the concept of autopoiesis outside of the biological domain. (Varela 2009; Protevi, 2008) Stuart Umpleby (2016), among others has interpreted Heinz Von Foerster as emphasizing a biological view of epistemology, as opposed to a social or transdisciplinary one. Many researchers have been skeptical of the use of laws of form, in the socio-sphere (Schiltz, 2009). This is one challenge of working both across and within disciplinary boundaries. Cybernetics cannot say anything without some content or distinction. One might say that cybernetics represents the "fixed point" point between the nature of being (ontology) and knowing (epistemology).

Formalizations developed in "Objects of Consciousness" by Hoffman and Prakash (2014) and concepts such as "reflexive domain" and "eigenform" (eg. Kauffman, 2016) are applicable in any domain. As Von Foerster (1973) writes "Objects are tokens for eigenbehaviors", or as Kauffman (2016) explains; "Ordinary objects are invariances of processes performed in the space of our experience."

A difficulty with extending cybernetic concepts to the socio-sphere comes with complexity. Given high numbers of variables, the bridge between imaginations grows long. Definitions can be vague or stiff and quantification can be impossible.

Ecological Economics offers a nice opportunity for considering the construction of a perspective. The field aims to integrate two cognitive domains, and broad sweeping, even crude formalization is both a legacy of classical economics and a necessity for coherence.

ECONOMICS, ECOLOGY AND EIGENFORMS

Here we can look at various approaches to engaging with Ecological Economics. The main journal of the discipline "is concerned with extending and integrating the study and management of "nature's household" (ecology) and "humankind's household" (economics). The meaning of these two terms has evolved over time and across users. For instance, in 'Nature: An Economic History', Vermeij (2004) argues that "economy" is actually an organizing theory for analysis of the evolution of the entire biosphere, and not just the part which humans manipulate. Similarly, 'ecological' analysis has been applied to the economy. For instance (Lopez-Ruiz and Fournier-Prunaret, 2006) treat corporations as species engaged in symbiotic, predator-prey and competitive relationships. Others contend that ecosystems and economies observe certain optimizations; eg. "Nature maximizes for gross production."(Chauhan 2008)

A diversity of thought has led to a certain lack of clarity regarding the boundaries within and around Ecological Economies; but most could agree on an ecosystem which distinct from the economy. There seems to be a tension as the context driven nature of socio-ecological inquiry competes with the needs to standardize, scale and communicate. Ecological Economics aims to shift the paradigm of Economics by considering the economy as an open system, and a subsystem of the ecosystem.

Like most, Robert Costanza (2010) defines Ecological Economics by the belief that "the economy as subsystem, cannot grow indefinitely into this larger containing system [a finite planet]." We might ask, what exactly is meant by larger? In what space are the two comparable? As Malghan (2010) writes, "even when the ecological economics literature has used scale as the proportional relationship between the economy and ecosystem, it has been in metaphorical and dialectic terms, rather than as an empirical and analytical tool for practical environmental policy".

Treating a Domain within a Domain

This is also a commentary on all science, as Kauffman (2016) writes "If an action is a scientific theory about the domain, then this theory becomes a (new) transformation of the domain…the fact that an entire domain can be seen as an eigenform suggests that one can be an observer of that domain in a wider view of the landscape. Thus physics can be seen as a reflexive domain…" Here I refer to the domains of Economics and Ecology. Both have fought to "contain" the other, yet neither up until this point is adequately outfitted. The economy and the ecosystem as objects are brought forth through a particular process of observation. The stability of meaning is what allows for drawing a distinction. It seems fair to say that no one distinguishes the ecosystem from the economy purely in material terms, and so this brings us at least toward what is called the behavioural perspective.

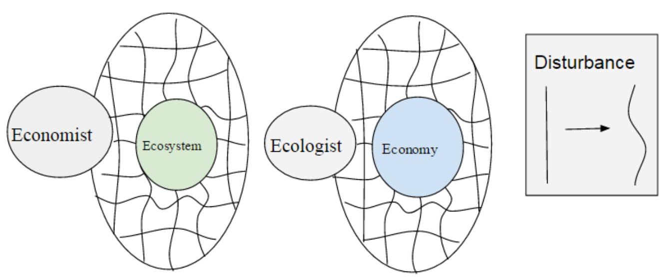

Figure 1. In this case, the Ecologist and Economist view their objects of inquiry. These objects 'make a difference'.

Through interacting with their respective objects of inquiry, the economist and ecologist come to gain information about the ecosystem and the economy. In the case of the economist, the "ecosystem" is defined by the difference it makes to the world which the economist takes to exist, and in the other case, the ecologist defines the economy by the difference it makes to the world which the ecologists takes to exist. An economist says, "Ah, we have an externality!" However, in order to do this, the Ecologist and Economist must determine what makes a difference. They must mark one state of the world as "natural" and the other state as disturbed. They must say, "The economy is not like this." An externality is an exception to the rule.

Market failures: We can begin to understand the intentions of economists when we start discussing market failures. This generates a window revealing what the economy is not. These conversations tend to revolve around non-rival and non-excludable goods, externalities, imperfect information and intertemporal discounting (Daly and Farley, 2011).

From the Ecological perspective the sentiment is gathered by Røpke (2004) *"The human economy is embedded in nature, and economic processes are also always natural processes in the sense that they can be seen as biological, physical, and chemical processes and transformations; therefore, the economy ought to be studied also, but not only, as a natural object, so economic processes should also be conceptualized in terms usually used to described processes in nature."* This makes it possible to assess the impact of the economy on the ecosystem. By doing this we find a sort of paradox, as each in their respective domain must create a space which does not belong to that domain. The drawing of a distinction helps both perspectives bring forth a cognitive domain, and it is also the beginning of a circularity.

As Kauffman (2016) writes "In the reflexive view presented here there is not fixed a priori. Pre and post conditions occur in a circularity wherein one may indeed describe a world that divides itself into a part that is seen and a part that sees in an endless round."

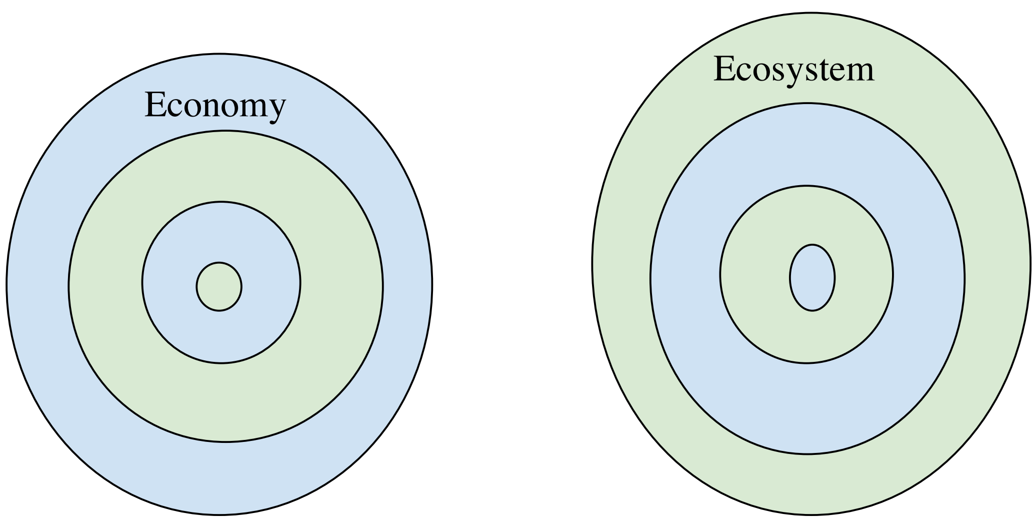

Figure 2. In order to bring forth a cognitive domain, a system must make a distinction between itself and its environment and then re-enter itself.

In Ecological Economics, 'sustainable scale' regards the relationship between the size of the ecosystem and the size of the economy. 'Just distribution' regards a distribution of resources which is ethical. 'Efficient allocation' regards optimization of resources toward desirable ends.

"Getting the price right" has become a notorious example of the economic self-reference. This would occur if a particular cap or distribution was set according to costs and benefits based on current prices. In this case, the value of the ecosystem is a function of the economy which is a function of the value of the ecosystem which is a function of the economy. In "Ecological Economics" Daly and Farley (2011) explain:

"The set of prices that corresponds to a Pareto optimal allocation will be different if we set the cap differently or if we distribute ownership differently. This means that we cannot set the cap or distribution according to computations of their social costs and benefits based on existing prices. To do so would be to engage in circular reasoning because the prices depend on the scale of distribution. The ideal scale or distribution, calculated on the basis of existing prices, would, if attained, result in a different set of prices that would invalidate the original calculation. Thus we can neither set the scale nor determine distribution according to the criterion of efficient allocation… What, then is the criterion for scale? Sustainability is the criterion for scale." (Daly and Farley, 2011)

If sustainability is the criterion, we find ourselves again in the same conundrum, because we have to ask, "The sustainability of what?" If our answer is the economy, then our definition of the economy, cannot be made at the same time that economic resources are defined. If we limit the economy then this changes the nature of the economy which we are attempting to define the limits of and therefore what is being sustained.

To illustrate the circularity embedded in this perspective, we can appropriate the case of scale as defined by Malghan (2006) as a deviation from "optimal scale". In fact, Malghan (2006) and Daly have arguably taken the greatest, (or only) steps to formalizing the "syntax" of scale. In this case the process defining optimal scale is a function of distribution and distribution is a function of scale.
As Malghan illustrates using symbols for normative rules, transformation functions, and optimal values:

$$S^{\bullet} = N^{S}\left(\tilde{S}, N^{D}(\tilde{D}, S^{\bullet})\right)$$

Figure 3 Circularity in Optimal Scale, (Malghan, 2010)

Cutting to the chase can see simply that S* (optimal scale) is on both sides of the equation. As Malghan explains, this is because the process which determines optimal scale, and by extension, scale, is impacted by the decision through distribution. For greater understanding on the relationship between scale and optimal scale see (Malghan, 2010)

In simple terms, the system which is drawing the distinction between the ecosystem and the economy, (through allocation of resources) is determined by the distinction between the ecosystem and the economy (through distribution of resources); just as the economic system is determined by the distinction between the ecosystem and the economy and also determines the value of the ecosystem. Absolute scale, deals with what is biophysically possible, but "possible" must still be enacted in order to bring scale forth.

"The "constraint" is thus a relation between observer and thing; the properties of any particular constraint will depend on both the real thing and on the observer. It follows that a substantial part of the theory of organization will be concerned with properties that are not intrinsic to the thing but are relational between the observer and thing." Ross Ashby (1968)

In the above cases each object of analysis, generates a value with regard to the system which encloses it, and yet, this enclosing system is changed by the drawing of this boundary. Noticing the circular process, one might ask, what claim do we have on reality at all? For instance, Malghan (2010) defines scale (necessarily intratemporal) differently at different points in time, and then seems to exclude this in applying logic through a model because this would result in indeterminacy. Developing the logic of drawing distinctions, George Spencer Brown arrives at this point, in Laws of Form (Spencer-Brown, 1969) "The value represented...being indeterminate in space, may be called imaginary in relation with the form. Nevertheless, as we see above, it is real in relation with time and can, in relation with itself, become determinate in space, and thus real in the form." So the question is, what it means to be "in relation with itself?" Mathematically, we are talking about functions which are functions of themselves. In theory these terms can stabilize. A phase space can display all of those values or operations which yield a recursive stability. The above cases were a very simple illustration of the circularity within inquiry, excluding the social system. In reality, each function is only partially a function of itself and so we will have interacting state spaces.

If this is accepted with regarding to scale, distribution, and allocation, this means a transition from a static optimization, to a dynamic field of potential. The efficiency identities, proposed by Daly and Farley (2011) redefine the boundaries of the economy, which redefines the relative value of the economy, which redefines the sustainability of this value, which redefines the boundaries of the economy. In this case, we might consider the difference between a regime and a trajectory. As Daly formalizes, consider sustainability, allocation and distribution, as vectors in vector space R3. A trajectory charts a particular path through this course. A regime is a next order distribution of trajectories, as movement through the space changes the structural parameters which guide the trajectory. In order to include the contingency, illustrated above we would need a fourth dimension of freedom in space and time. (insights from (Leydesdorff 1997) The irony is that this means these values only become real, the moment they have self-organized in a higher domain; in other words, when systems observing scale, distribution and allocation develop eigenbehaviors, recursive consensus, or attractors.

The Human Agent in the Ecological Economy

Another example of this recursion comes into being with regard to the model of individual agents within ecological economics. Initial efforts to engage with the model of the individual were approached from the behavioural perspective. That is; individuals were assumed to be independent of the cognitive domain in which they were studied. In particular, Ecological Economists were critical of “homo economicus”, which describes the human actor as selfish, rational and utility maximizing. Articles such as (Jager and Janssen 2000; Siebenhuner 2000) pointed to the empirical evidence against the homo-economicus model. Furthering this, Gowdy and Erickson (2005) contend that “it borders on scholarly malfeasance to persist in passing off known fictions on the grounds that it is the problem of those who criticize also to create.” This Spash (2013) calls “a distinct realist element to social ecological economics.”

Framing the issue, Gowdy and Erickson (2005) state that “Neoclassical welfare economics continues to offer bad advice in dealing with some of the most pressing environmental and social issues faced in the twenty first century.” It seems that the space Gowdy and Erickson (2005) have opened up for the human actor, regards environments and social issues and not necessarily decision making in markets.

Becker (2006) argues that the “crucial question is not whether homo-economicus can be proved or disproved in every empirical situation.” Becker (2006), organizes our definitions of the human being, “Its relation (i) with itself, (ii) the community and (iii) nature.” Becker (2006) proceeds to work toward defining a homo-ecologicus distinct from homo-economicus.

This reflexivity is not unprecedented within Economics. For instance, Pareto made a distinction between individual ophelimity, community ophelimity, individual utility, social utility, and utility of society, all of which were at the time and are still today generally defined as personal or social utility (McLure, 2002). In each case the individual is seen as residing in an alternative cognitive domain.

Pareto states: “From pure political economy comes applied political economy, which does not consider solely homo economicus, but also other models of humankind closer to reality.” (Found in (McLure 2002))

This reflexivity, once again, brings us into a recursive domain. For instance, we can discuss humans for the difference they make to the ecosystem, but of course humans are a part of the ecosystem, and thus, our definition becomes a function of itself. The distinction between humans and the ecosystem arises through a difference in value between alternative states of the world. Further, the distinction between domains, must ultimately be transcended if they are to be maintained. Anyways, this is another conversation within Ecological Economics which opens the possibility of semantic circularity and in this case adds the “social system”.

TOWARD ORGANIZATIONAL CLOSURE

Some of the earliest work within Ecological Economists spoke about entropy, and the desirability of continual growth. Resulting from the early cybernetic models of “open system”, Ecological Economics has wrestled with the concept of thermodynamic entropy and the relationship with information entropy. This represented a turning point in cybernetics. In order to compliment the "open system" perspective, an emerging camp within cybernetics would develop the control perspective. We can imagine that while the economy is an open system when it comes to material and energy throughput, it can also be seen (from the inside) as an 'informationally closed' system reducing the 'information' or 'variation' of its subsystem(s) (including the ecosystem) increasing control, and striving toward a dynamic balance at a higher level. It seems economists could not break from this informational closure. Ecological Economics breaks this closure, attending to the Ecosystem and alternative sets of values.

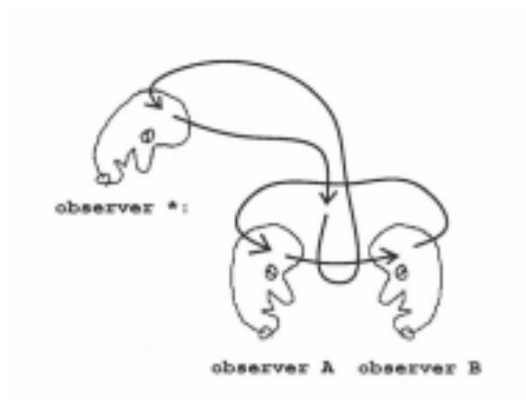

Figure 4. Inspired by Ranulph Glanville, an illustration from (Pangaro 2002). Used to illustrate the possibility of considering the economy and the environment in mutual observation.

From the mutual observation there emerges a new perspective, which attends to both economic and ecological perspectives. Arguably Ecological Economics is still early in the process of developing the Ecological perspective.

I will follow Kapp and Valentinov (2013) who, publishing in Ecological Economics give an extended quote regarding operational closure: "'operational closure' means that the system distinguishes itself from the environment by connecting its system-internal operations with other system-internal operations. Elements and structures of the system are thus produced solely within the system itself. The system cannot import elements or structures from its environment or operate in its environment by directly connecting to environmental events. With every new operation the system refers to its own previous operations and thus to itself; it works self-referentially. This does not mean however that the system is blind toward its environment. The opposite is the case. The operational closure enables openness toward the environment in a specific form. The system reacts to environmental events only through itself, through its internal operations. Put briefly, continuous self-reference (= reference of the system to itself) becomes a precondition for other-reference (= reference to whatever is perceived as outside the system) … The difference between self-reference and other-reference is inscribed in every operation" translated from Kapp and Valentinov (2013; by Schneider 2009)

The Embodiment of the System

In the case of defining sustainability, distribution and scale, Malghan (2010) alluded to the development of normative, process based rules "from behind the veil." Normative rules address questions such as "Who decides what the optimal scale should be? If biophysical sustainability is a goal, how does one aggregate different visions of sustainability among diverse stakeholders? What is to be sustained, and for how long, and in what form? In our network of actors, there is no "behind the veil"; there are only different ways of drawing distinctions within the system. This becomes clear as (Malghan 2010) differentiates normative rules and normative benchmarks, which provide an embodiment for the system. *"While normative rules for any one of scale, allocation, or distribution can be specified without reference to the other two variables, normative benchmarks form an interdependent system"*. That which is being observed affords particular manners of observing and regulating and this becomes part of the observed. A system which analyses scale, distribution and allocation, boundaries and distinctions, values and constraints, becomes embodied and produced by particular tools of analysis, regulations, technical capabilities, human relationships, ecological networks, communication systems and decision making processes. The observing community is a network of processes or actors that participate in observation and regulation of scale, distribution and allocation, much like the circular flow diagram of the economy; there is an informational closure. So the question, we have is, what might this closure look like, and how is it "brought forth". Here I will reflect on my personal experience with considering the "organization" of the Ecological Economy.

REFLECTION ON PARTICIPATORY ACTION RESEARCH

My advisor, Josh Farley, has been working with a collaborator named Abdon Schmitt for a number of years. Abdon Schmitt is an agroecologist and coordinator of the participatory action research project, Voisin Silvopastoral group in Santa Catarina, Brazil. Their ongoing efforts focus on the Atlantic Forest which spans much of Brazil's eastern seaboard. The forest contains both Rio de Janeiro and Sao Paulo within its boundaries and serves many essential functions for local and global ecosystems. Unfortunately, now it is considered the third most threatened biome on the planet, hanging on the edge of collapse (Morellato and Haddad, 2000) With a reduction in function we are seeing serious water scarcity in the large cities, landslides, species extinction, and reduced economic benefits. Various stakeholders have been involved with regulating the forest; in particular, local, state and national governments, as well as local and international NGOs. Involved with our project were stakeholders from these various organizations, as well as farmers, farming cooperatives and researchers.

Leading up to this trip I had done a lot of research on soil carbon and worked to understand ways to incentivize sequestration. There are a lot of difficulties in this endeavour. With the complexity and heterogeneity of farming systems, difficulties monitoring and measuring, incentivizing, considering whole systems, ensuring that carbon stays in the ground, and adapting to changing circumstances, it seems some hope has been lost in these efforts, despite the immense opportunity.(Henderson et al. 2015; De Gryze et al. 2011)

What struck me most, was that through the activities of researchers, the small farmers and cooperative economic structures, and engagement with governments at various scales, a world of possibility opened up. In a network of actors such as this, each must plan their activities according to expectations regarding their environments. This fundamental generation of expectation essentially boils down to trust.

The organic method of farming reduced the need to monitor input-output flux, or worry about shifting socio-technological power structures, and also lent agency to non-human actors. The participatory action research ensured adaptation to ecological and economic stressors, and farmers who were knowledgeable and could foster vision. Cooperatives offered an intermediary for communication, self-regulation, and vision. Further, this system was attractive to young farmers, which helps to ensure that a particular method of farming is maintained and that soil carbon is kept in the ground. The network of actors made possible financial schemes that never would have been possible in alternative circumstances. Josh Farley, Abdon Schmitt and others have recognized the emergent possibilities here, as they write about in "Integrating Agroecology with Payments for Ecosystem Services in Santa Catarina's Atlantic Forest" (Schmitt et al., 2013)

In an organizationally closed system, we can consider a state space of all possible activities and their connections. From this perspective, the challenge for Ecological Economics is not to choose between Payments for Ecosystem Services, and Regulatory approaches, it is to consider an organization of importance. Emergence is defined by Von Foerster (Clarke 2009; Foerster 2013b) as the transition from the chaotically complex to the manageably complex.

An organizationally closed system is "structurally determined". This means it can only respond to its environment, through its own operations which are embodied in a given structure of relationships. When considering the organization of the Ecological Economy, the requisite variety defines the possibility of system responses which maintain system integrity. Factors in structural coupling are beyond the scope of this paper.

The imaginary I hold regarding the boundary around the network of actors is "autological", embodied in my consciousness, intellect, emotions, and even neurophysiology. Here, I am watching my experience change before my eyes, as I sew any readers, systems thinkers, and Ecological Economists into this network of my imaginary, the cognitive domain through which I analyse my experience in Brazil. In this sense, the actor network in Santa Catarina becomes part of a global community with various institutional and philosophical proclivities. Ideally, researcher "take-aways" will eventually provide benefit to these actors in a new form. In a sense I will argue that I am harvesting and planting seeds in a collective sense-making. I hesitate to use the word autopoiesis.

When I discuss this, someone listening will inevitably have a different idea of this object; but it seems this is true whether we are talking about quantum particles the "self" or a socio-ecological system. These are reflections on contextual experience. What seems to matter is the coordination of action surrounding this imaginary, and the feedback we get when putting trust into our expectations. This can help to modify my expectations regarding the observing community and object of inquiry. Researching, reflecting and communicating, is one element in this process which allows for coordinated intentionality and action.

It seems a little strange to me to think of participatory research as inherently "second-order". The possibility of my participation is defined by the object of my participation. In this sense, it strikes me that all research is participatory and active. What is possible is to tighten the recursion. I have gone through a process of enacting the Ecological Economy and then reflecting on perturbations. Now, I am offering my experience toward analysis within your cognitive domains that we might develop some recursive consensus. I found the research process to be a great way to learn about cybernetics and the tools of cybernetics to be very influential in formalizing my thoughts, and last but far from least, I think the investigation of circularity contains a message which communicates at the subconscious level.

CONCLUSION

Ecological Economists are aiming to find a manner to define their inquiry. For instance, in "The Shallow or the deep ecological economics movement?" Spash (2013) divides the "big tent" of Ecological Economists into interdisciplinary, transdisciplinary, and multidisciplinary actors, including critical institutional economy, political economy, political ecology, and other orientations.

There seems to be evidence within past inquiry that Ecological Economics must embrace a certain circularity. A socio-ecological, "transdisciplinary" approach which fosters emergent possibilities could potentially operate in conjunction with an interdisciplinary approach which considers the relationship between the ecosystem, social system and economy. In this case, regulating scale, distribution and allocation, becomes a particular type of regulating boundaries. This gives rise to an interdependent system which once again regulates boundaries. The boundary drawing becomes a function of itself. Who makes this value judgement is who makes this value judgement.

To articulate my position at a very crude level, this would mean defining Ecological Economics as 'the mediation of people, communities, ecological actors, legal, economic and research institutions for analysis and procurement of sustainability, justice, and efficiency, according to this set of actors. The state-space would be defined and refined by activities which are consistent with the maintenance of a self-regulating network.

In this paper, I have stretched concepts in second-order cybernetics to the domain of Ecological Economics. Second order theory brings a particular humility to any investigation. We are inherently reducing the complexity of the world, according to our values. At the same time it seems that second order theory inspires toward the pursuit of variety, integrity and coherence.

"We have only the world that we can bring forth with others, and only love helps bring it forth."

- Humberto Maturana and Francisco Varela (1992)

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