

# Methodological limits in the construction of emergent knowledge of ecological economics

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## *Abstract :*

*The amplitude of the concept and definition of ecological economics urges to declare that within the framework of this study. Ecological economics is as complex knowledge that includes a wide range of theoretical foundations. Given the ecological economy's attempt to respond to the dynamic interrelationships between the economic system and the physical and social systems posed by applying methodologies over an overwhelmingly complex field, and requires intensely transdisciplinary work, its scientific development has been limited. Addressing the epistemological obstacles in the generation of complex solutions is important in the face of the urgency to respond effectively to the growing socio-environmental conflicts of not doing so. We propose that the ecological economics is defined under the theoretical structure of a disciplinary matrix in the sense intended by Kuhn's philosophy, under a structuralist vision, supported by Sneed and Stegmuller; determining essential theoretical elements, under its fundamental premise: the study of the sustainability of human activity and the ecological system. The proposal to delimit the ecological economics as an objective theory aims to assign specific tasks to each field of research, to facilitate the resolution of problems.*

*Keywords : ecological economics framework, disciplinary matrix, Kuhn's philosophy, structuralist*

## Introduction

The main problem to be found when objectively defining ecological economics is the establishment of a specific theoretical domain. As mentioned, there is no certainty in a disciplinary framework where to place the ecological economy or if it is necessary to understand it as a totally different knowledge to any discipline that seeks to achieve the same objective: to correct socio-environmental conflicts in an integral way.

Since literature tends to place ecological economics in three distinct disciplinary areas: branch of economics, a new scientific paradigm or a new field of transdisciplinary knowledge (Ropke, 2004). The first objective of this work is to include the ecological economy under each of these three fields; secondly, it is argued that it is feasible to be understood as an independent knowledge that is subject to the formal guidelines of what is conceived from the philosophy of structuralist science as a scientific paradigm; finally, the limitations and pertinences that such company would mean in practical terms of scientific work in a context that requires the resolution of problems specific to the theoretical domain are addressed

## Disciplinary demarcation

First, as a branch of economic science, ecological economics escapes the postulates of the dominant paradigm *-the neoclassical economy-*. Understanding the following universal components

that direct economic behavior from the study of neoclassical theory: human needs; existence of scarce resources<sup>1</sup>; possibility of alternative choice of the destination of resources, with respect to the satisfaction of human needs; and, finally, the efficient or frugal choice regarding said resource allocation. Certainly, any agent may have needs, but if there is no shortage, it does not have to economize, that is, make efficient use of resources (García de la Sierra, 1998).

From some perspectives of ecological economics, it is argued that neoclassical economists are those who empty the notion of production materially (which is closely linked to nature), completely separating economic reasoning from the physical world. Situation that continued without attracting attention, until the recent questions of the field of ecology (Naredo, 2006). It is precisely from this criticism, towards the search for the maximization of utility, under the logic of economic behavior with respect to the ecological system, from which the ecological economy arises: in which, the importance for the value of nature itself It takes relevance.

In conclusion, the questioning of economic science finds that at all stages of economic systems economic priorities have been imposed on the time and stability of the ecological system; what in favor of economic growth has generated an environmental deterioration (Fazio, 2012). Following the observations of the ecological economy: the neoclassical economy is itself unable to address the crisis it has created (Brown & Timmerman, 2015).

Not for that reason, the economy is absent as one of the disciplinary elements that are integrated into the ecological economy, on the contrary, it is considered that some tools of the neoclassical model can be extended to evaluate the relations between the economy and the natural world, in which is included. For example, the term efficiency is reinterpreted as a contribution that is considered of the neoclassical school; however, this should be limited by considerations of scale (the economy considered as a subset of the global biogeochemical processes) and the equity (Brown & Timmerman, 2015). Even, the concept of opportunity cost, defined as the best alternative to be sacrificed when making a choice for an end (Daly & Farley, 2009) is integrated as a tool.

Second, as a scientific paradigm, from a Popperian definition, ecological economics should gather the following elements: a body of prior knowledge, accompanied by a set of specific hypotheses; a problem; An objective; and a methodology (Bunge, 1999).

In this case, the body of prior knowledge is made up of the different disciplinary approaches that make up the ecological economy, which in turn is vague in terms of the minimum agreement on the basic theoretical elements of which a scientific theory is formed and allow its application. For the establishment of a scientific theory an organizational framework is necessary, which is given by the same scientific fields, seen as work, organizations that structure and direct the production of knowledge (Ropke, 2005).

The above situation leads to the following critical of the first definition of paradigm, hip or thesis. In scientific development the conjectures are reached from the interpretation of the data, in the form of theoretical hypotheses, this is what allows to increase the totality of knowledge. The positivist tendency of science has certain reservations regarding the value of hypotheses in

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<sup>1</sup> The concept of scarce resources is relative to certain ends, since there are no scarce resources in themselves, only for some purpose. The ends may also have conflicts with each other, in the sense that achieving some end can harm the attainment of another. When the resources available to an agent are sufficient to achieve all its purposes, there is no shortage problem, but there is also no economic behavior (García de la Sierra, 1998)

the social sciences, it has even been referred to as an inference or interpretation, this by the empirical tradition. On the other hand, a recurring error in the hermeneutic (scientific) school is to favor the analogy in social studies by overlapping the metaphor about the hypothesis (Bunge, 1999). This exercise is recurring within the analyzes of the ecological economy, leading to analogies, sometimes not well founded from a foreign discipline, and in general to an overwhelming divergence in terms of the following element, the methodology:

The methodology of a scientific approach consists of the relevant procedures for research, the procedures that result in objective and justified knowledge theoretically and empirically (Bunge, 1999). The absence of a dominant methodology can be interpreted as an empty discourse, while others, from the perspective of transdiscipline, see it as a field of opportunity where there is a gap in knowledge (Nicolescu, 1996). Although this discussion is present, the obvious thing is that the methodological accretion within the ecological economy does not allow us to reach a theoretical demarcation (of the Popperian type) that can differentiate it as scientific knowledge, from non-scientific knowledge.

Finally, as a new field of knowledge beyond any disciplinary demarcation, critical positions of the scientific method such as Feyerabend's methodological anarchism would have to be resorted to . This argues that the central problem of scientific change is a semantic change, noting that when the belief in a global theory is accepted within some field of research, a change in the metaphysical meanings of the observational terms of that field occurs (Pérez Ransanz, 1999) . As semantic meanings are changing, there can be no universality in theories, there is no rule however plausible that is within scientific epistemology, which is not infringed on one occasion or another, given that any rule, however fundamental or necessary that either for science, circumstances will always be found where it is pertinent to ignore said rule or even adopt its opposite (Feyerabend, 1986) .

The novelty in this type of proposals lies in the impossibility of a fixed theory of rationality (Feyerabend, 1986) ; in contrast, a well-organized theory explicitly shows its hypothetical-deductive structure, this type of organized theories work through the direction of laws and axioms (Bunge, 1999) .

In the case of ecological economics seen from the perspective of methodological anarchism, it lacks a theoretical structure that allows the formulation and application of laws. Currently, the theoretical and methodological postulates emanating from the ecological economy are more a road map for the future than a body of proven and consolidated knowledge (Martínez de la Torre, 2008). Without a structure, the union of theories does not necessarily result in a theory; reason why its amalgam is more than putting a theory on another one, for this it is resorted to additional statements that relate some of the concepts of the two theories. The statements that chain theories in basic sciences are formulas; in factual sciences, the statements of union relate properties that real things possess, so it is necessary to verify them empirically (Bunge, 1999).

Given this discussion, ecological economics does not deviate completely from any of the previous definitions, but in turn , no definition is able to completely cover the theoretical-practical needs required by the ecological economy problem; So it is proposed to resort to the second definition in a formal way, where it (ecological economy) should take the position of a new paradigm within economic science itself , this described beyond a Popperian demarcation, but rather in the manner described by metatheoretical structuralism.

Specifically, the problem is summarized as: the existence of methodological limits that obstruct the construction of the ecological economy as a new paradigm within economic science. Since, in its attempt to respond to the dynamic interrelationships between the economic system and the physical and social systems, it is proposed to apply methodologies on an overwhelmingly complex field, which requires intensely transdisciplinary work, which is precisely the greatest weakness of the ecological economy in its current state (Martínez de la Torre, 2008). Situation that limits its own scientific development.

In this sense, a green economy should define itself under the construction of a new paradigm in economic science from the theoretical structure of a matrix in the proposed discipline from philosophy of Kuhn sense.

## Disciplinary matrix, paradigms and scientific change

The first conception of paradigm proposed by Kuhn is an underlying structure to every discipline over a period of normal science. It was replicated for its irremediable vagueness; what Kuhn or to what and in the second edition he or n of "The structure of revolutions científicas", the same Kuhn attempt to clarify the notion of paradigm, even changing the nomenclature for the matrix disciplinary (Moulines, 1978); despite still being used in the philosophy of science today término paradigm.

The definition of ecological economics under the Kuhnian philosophy would imply from the structuralist analysis of Sneed, Stegmüller and Moulines -which reinforces the conceptual rigor of a disciplinary paradigm or matrix- the establishment of a theoretical structural core, which allows the determination of theoretical elements base, from which it is possible to act as axiomatic laws: Theoretical concepts in general have particular characteristics regarding their use within a given theory, to make indirect determinations of the values of non-theoretical quantities and to establish correlations between models of the same theory (Moulines, 1978).

The theoretical base element for a theory of ecological economics would necessarily be its fundamental premise: the study of the sustainability of human activity against the ecological system; from the study of economics as a subsystem of the physical system, which is why it is proposed that measurements and evaluations of human activity be measured from their flows of matter and energy, and not by their monetary flows (Martínez & Roca, 2013), so its exercise is based on the laws of thermodynamics. The economic process could then be defined, as the transformation of existing energy into usable forms, into unusable energy states (Leff, 2004).

From this postulate, and under the follow-up of the laws of thermodynamics -necessaries for the measurement of energy flows- laws could be established from which it is possible to construct a theory of ecological economics, thus cutting its conceptual vagueness and allowing its establishment as a new paradigm.

If the theory of ecological economics focused on the evaluation of economic activities through their physical dimensions, it would be possible to generate an objective theory, leaving out of its application the subjective elements that are currently included within its framework research.

It is not the objective to downplay the element of social justice within environmental conflicts, on the contrary, its urgency is recognized. The proposal to delimit ecological economics as an

objective theory, aims to assign specific tasks to each field of research, in order to facilitate problem solving. For this, the knowledge of political ecology, responsible for studying the purely sociological elements of socio-environmental conflicts, becomes important: political ecology, emerges from the blind spot of ecological economics to analyze the processes of significance, appropriation and valorization of the nature, which are not resolved by measurement or valuation (Leff, 2003); which would open the opportunity for interdisciplinary work between both knowledge.

## Theoretical domain of the disciplinary matrix

An empirical scientific theory can be represented as a network of theoretical elements dominated by a fundamental element, called the theoretical base element: all other theoretical elements in the network become special cases of the base element. Approximately (although in reality there is much more to a base element than a mere law), the theoretical base element is the fundamental law of theory (García de la Sienna, 1998).

For structuralist science philosophers, the empiricist vision of elaborating and testing the content of scientific theories only under the logic of the first order proved to be impractical, particularly when the theory under analysis presupposes more than just the logic of the first order (Balzer, Moulines, & Sneed, 2011).

In response, it is proposed that scientific theories are made up of a series of theoretical statements (not necessarily formulated from the first order logic), based on the characterization and definition of their contents from an extrinsic explanation of the same statements. All these statements are those that are structured in the form of subsets, arranged hierarchically within the topological space that makes up the whole of a fundamental theory (García de la Sienna, 2018).

The essence of a scientific theory is a set of different complex structures composed of simpler structures, such as: partial models and current models. In addition to other elements: the conditions that constrain the components of each model depending on the components of other models of the same and other theories, that is, restrictions; the determination of which concepts and methods are specific to the theory is a matter, as well as those that come from underlying or external theories, intertheoretical links; and finally a component of approximation inherent to any scientific model. All this constitutes the formal core of a theory. Likewise, it is necessary a historical- pragmatic domain, not formalizable, which is also part of the identity of empirical theory (Moulines, 2006).

The most convenient way to interpret the essence of scientific theories is not through a set of propositions, but through a set of different types of complex structures, themselves composed of simpler structures. The simplest units that constitute a theory are the models. From the way:

$[(D_1, \dots, D_m), (R_1, \dots, R_n)]$

Where  $D_1$  are the base domains and  $R_1$  are the relationships built on the base domains (from set theory). The domains fix the ontology, that is, the sets of objects admitted by the theory as

real entities. While the relationships fix the admitted links between the objects of the various sets -in more advanced theories the relationships are usually numerical functions- (Moulines, 2006).

The specific domains and relationships in a theory are characterized by a number of formal conditions that determine the conceptual framework of the theory. When all the formal conditions of the conceptual framework are satisfied, the structure is said to be a potential model of the theory; potential in the sense of setting a possible framework for conceiving reality, but without guaranteeing that it serves to represent some of its aspects substantially, such as giving explanations or predictions. For a structure to be a current model and not just a potential model, it is necessary to satisfy, in addition to the conditions of the conceptual framework, the laws of nature (Balzer, Moulines, & Sneed, 2011; Moulines, 2006).

The coherent conjunction of six types of sets of structures: set of potential models; current models; potential partial models; the one of restrictions; intertheoretical links; and the approximation structure determined by uniformity; it constitutes what can be called the (formal) core of a theory, symbolized by K.

In order for these formal structures to correspond to an empirical theory, it is necessarily estimated that this formal apparatus is supposed to be applicable to some situations external to it: phenomena that supposedly exist in reality independently of the formal apparatus. This exterior is described as the domain of intended applications, and is symbolized by I. The set I must be considered as belonging to the identity of the theory, since without it one would not know for what purpose the theory in question was constructed (Moulines, 2006).

A theory T, then is a pair T [K, I], where K is a formal core and I is a domain of intended applications. The pair is associated with an empirical claim, according to which I can be effectively (approximate) subsumed under K, that is, what the theory says about the world.

## Disciplinary matrix of the ecological economy

If the proposal of the ecological economy is to consider economic activities as part of a broader system, that is, the ecological system, it is first subject to the physical limits of the planet (Martínez, 2004; Leff, 2004). Then, if what is desired is to describe the formal structure that this premise should follow, it should be used to measure economic activity precisely from these physical laws, strictly from thermodynamic approach; where every action carried out by economic agents would have as consequence transformation of energy, which to be able to perform requires a certain amount of energy and which as a result expels another type of energy in the form of dissipated heat:

$E_i$ : is initial energy of a type 1 used to perform an action 1;

$E_f$ : is energy obtained from a type 2, as a consequence of performing action 1;

$E_d$ : it is energy dissipated in the form of heat.

Then a balanced thermodynamic model solves characterizations of the following type:

$$E_i - E_d = E_f$$

In the previous form only one action, one energy obtained and one type of final energy is considered. However, in the economic situation there are two differences to consider, first, that the result of an action does not always result in a single type of energy; second, the economic system viewed from the focus of the ecological economics is not a closed system, so that energy measurement from the system is not in balance (Ayres, 1998).

Therefore, an example of energy unbalanced model for a system economic is as follows:

$$E_i - E_d < E_f$$

The formal nucleus of the ecological economy must be able to contemplate this imbalance, this model should be able to function as a theoretical base element of the theory that the ecological economy intends to be, in order to be consistent with the possible applications. The establishment of the different theoretical elements would delimit the action of the ecological economy, in specific cases. While the variables that escape the theoretical models, would have to be addressed by other fields of research, allowing an interdisciplinary relationship.

The formal structuralist reconstruction of a scientific theory is also due to the hierarchy of laws, that is, for a system to be considered as a model of the theory, it is not necessary for the system to comply with all its laws, but it is sufficient that is consistent with the so-called fundamental law (Posada, 2009); In this case, for the ecological economy, the second law of thermodynamics would be understood as this fundamental law:

In an equilibrium state, the values of the parameters of a thermodynamic system, maximize the value of the magnitude that is a function of said parameters, said magnitude is defined as entropy  $S$ . Where a change in the entropy  $S$ , is always greater or equal to the heat transfer produced  $Q$ , divided by the equilibrium temperature of the system  $t$ :

$$dS = \frac{\partial Q}{\partial t}$$

Thus, it is necessary to model the other structures that would form the assemblies belonging to the formal nucleus  $K$  of the ecological economy, in order to comply with the form:  $T (M_p, M_{pp}, r, M, C)$

Where:

1.  $M_p$ : is the set of partial models of the theory;
2.  $M_{pp}$ : is the set of potential partial models of the theory;
3.  $r: M_p \rightarrow M_{pp} \mid r (X_1, \dots, X_k, Y_1, \dots, Y_l)$  are objects of the theory;
4.  $M \subseteq M_p$  are the current models;
5.  $C$ : is the set of restrictions for  $M_p$ .

The empirical content of a theory  $T$  is the family of all potential models  $M_p(T)$ , which can be extended through substitutable theoretical components by  $r$  function to models of  $T$  whose components theoretical satisfy the  $C$  constraints (Garcia de la Sienna, 2018).

The challenge for a positive conception of a theory of ecological economics is to define the structures that allow the application of the theory models to the observational content. Since the

informality with which it has been defined so far is insufficient for its full development as a discipline; since the absence of a methodology is indicated as an empty speech.

## Pragmatic content of the theory

An adequate logical reconstruction of a scientific theory must be accompanied by a narrative that makes explicit the empirical meaning of the terms. Each type of application must specify the type of entities ( $X_1, \dots, X_k, Y_1, \dots, Y_l$ ) to which it applies, the specific history behind the application of the theory, and in this way the content is completely explicit. It is not enough to present the mathematical structure of the theory; since the theory itself cannot be reduced to its logical or mathematical meaning (García de la Sienra, 2018).

As explained, the objectivity of a theory of ecological economics should define the models posed by structuralist metatheory. But at the same time, it requires a non-formal historical-pragmatic content, which would differentiate the theory of a Popperian or positivist view of science. In accordance with the above, this domain refers to the set called I of T [K, I].

Two epistemological assumptions are made regarding I to conceive it properly: first, it is not about pure reality, nor about pure experience (even if these expressions made sense); second, defining domain I as a subset of potential partial models, makes the univocal determination of I escape from principle to formal analysis, since this domain is an entity class strongly dependent on pragmatic and historical factors, not formally determinable. Therefore, there exists in the essential identity of any empirical theory an irreducibly pragmatic-historical component that cannot be formalized (Moulines, 2006).

The first condition is a fundamental point of structuralist meta-theory, and essentially it is what differentiates it from the positivist view of science. Not all statements of scientific theories have the same degree of generality. This represents a blow to the mathematical concept of a scientific theory as a mere set of sentences. The axiomatization of a scientific theory within the informal language consists in the definition of a set of theoretical predicates through a list of conditions formulated in that language, whose compliance with a structure is both necessary and sufficient to make the reference clause a reality between the structure and the set of predicates. Providing empirical meanings with the terms of a theory requires rather a complex narrative that presupposes a large amount of information about the entities that the theory deals with (García de la Sienra, 2018).

This information is precisely that which comes from the social dimensions of ecological imbalances, so there is a strong search for social welfare from the ecological economy, which makes use of the information obtained from studying socio-environmental conflicts at the local level, national and global caused by economic growth and social inequality (Delgado, Espina, & Sejenovich, 2013; Martínez J., 2004).

These social elements are of different characteristics for each particular case. The interest placed in social conflicts is possibly the way in which the ecological economy is most identified with economic science, both understood as social science (Brown & Timmerman, 2015).

The coherent union between both elements T [K, I] allows the establishment of complex fields of study that cross the boundaries between social and natural sciences (Ropke, 2004).

## Conclusions

There is no formal construction of a theory of ecological economics that allows it to have an integral functioning. Ecological economics from a scientific perspective lacks a formal core of theoretical structures that allow defining what are the elements to be considered in their application, their applicable forms being diffuse or contradictory.

Ecological economics contains a strong pragmatic element that makes it possible to apply different methodologies to different problems; In its current state and with greater reason in the future, it requires recognition of the functioning of ecosystems and social systems, of which the economic is part. That is why this discipline has put as central objects of study problems of equity, the distribution of wealth, ethics, as well as cultural processes (Martínez de la Torre, 2008) . These non-formal objects make up the historical-pragmatic element of ecological economics. However, this element needs a formal structure that reduces the inaccuracies and contradictions that currently exist between the currents of the ecological economy.

Ecological economics, following the terminology proposed by Kuhn has not reached sufficient maturity to be confirmed as a new scientific paradigm:

Periods of pre-paradigmatic science are identified when there is no paradigm; Normal science, when it is established and specializes in a dominant paradigm , in the process of developing a scientific discipline, normal research, with its increasing specialization and extension of the field of applications, leads sooner or later to the approach of problems (anomalies) they resist being solved with the conceptual and instrumental tools of the established paradigm ; and finally, the period of extraordinary science when new instrumental theories or practices arise to solve unresolved anomalies (Kuhn, 1971) .

In economic science the neoclassical paradigm corresponds to the establishment of the period of normal science; where the socio-environmental conflicts that this (neoclassical) theory has not resolved, can be understood as the anomalies facing the dominant paradigm; being the ecological economy one of the answers to these anomalies that originate from different theoretical and methodological postulates, which in turn seek to generate disciplinary changes, that is, a scientific revolution that seeks to strengthen itself , if the proper construction of its domains was achieved Theorists and their correct pragmatic resolutions.

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