3 ETHICAL MASTERY OF INNOVATIVE TECHNOLOGIES

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Abstract

In this paper we present an alternative bio-epistemological-based approach to economic ethics issues, which suggests that economists need not only an understanding of the ecosystem in terms of irreversibility, but even more an understanding of the way the process in ecosystem make actual the principle of ameliorative equilibration. This means that among many technological innovations that extend the field of the possibilities only those that prove to be integrative and able to ameliorate the adaptation process will be chosen and preserved. In our view, only this type of prospective approach could be considered ethical as it realizes the principle of ameliorative equilibration and harmonizes the technological innovation process with the process of the ecosystem.

Keywords: social cooperation, biophysical constraints, negentropic rocess, ameliorative equilibration, vection, cross-disciplinary research.

JEL classification: A11, B59, Q56, Q57

Overview

According to conventional wisdom, economic activity is part of society, and therefore, the economic actions of people are subject to ethical rules and can be evaluated from the moral point of view, just as any other human activity can be so evaluated. There is hardly an ethical problem, in fact, without its economic aspect; human daily ethical decisions are in the main economic decisions, and nearly all people's daily economic decisions have, in turn, an ethical aspect. Ethical conclusions cannot be arrived at independently of, or in isolation from, analysis of the economic consequences of institutions, principles, or rules of action. Ethics and Economics are intimately related, as both of them study human action, choices, and valuation, though from different points of view.

Under these circumstances, it is not surprising that, particularly during the last decades, research works situated at the interface between Economics and Ethics

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have proliferated and a new field, Economic (Business) Ethics, has emerged. It is now a firmly established field, defined by a set of interrelated problems with which it deals. In fact, Economic Ethics typically involves four main kinds of activities [De George, 1986, pp.18-19]. The first is the applying of general ethical principles to particular cases or practices in business. The second kind of activity is metaethical: investigation of whether moral terms that are generally used to describe individuals and the actions they perform can also be applied to organizations, corporations, businesses, and other collective entities. A third conventional activity of Economic Ethics is the analysis of the presuppositions - both moral presuppositions and presuppositions from a moral point of view - of economic activity. Fourthly, it deals with macro-moral issues, such as whether rich countries have any moral obligations to poor countries or transnational corporations to host countries. In brief, the traditional approach to Economic Ethics suggests that this field can help people address moral issues in business more systematically, and with better tools than they might otherwise use.

The Conventional Morality-Based Approach to Economic Ethics

For conventional researchers in Economic Ethics, ethical rules, judgments, and propositions are attempts to answer the question: what is the best thing to do? As all human action is undertaken in order to substitute a more satisfactory state of affairs for a less satisfactory state, the ethical conduct is the conduct considered likely to lead to the most satisfactory situation in the long run. But, to say that people seek to maximize their satisfaction in the long run is only another way of saying that they seek to maximize their happiness and well-being (In its broadest sense, happiness is synonymous with the greatest possible harmonization and satisfaction of human desires). Accordingly, for standard ethical economists, **the morality of human (economic) actions can be judged by their tendency to promote long-run happiness and well-being.**

It follows that the conventional approach to Economic Ethics can be fitted into several very broad classifications, namely [Hazlitt,1990, pp.166-167]:

- **it is eudaemonic**, because it regards the end of economic action as the promotion of the greatest happiness and well-being in the long run;
- **it is teleological,** because it judges economic actions or rules of action by the end they tend to bring about, and defines “right” actions as actions that tend to promote “good” ends;
- **it is utilitarian,** insofar it holds that economic actions or rules of action are to be judged by their consequences and their tendency to promote human happiness;
- **it is also cooperative**, as the broad purpose of ethical rules in economic activity is to harmonize human attitudes and actions so as to make the achievement of everyone’s aims as far as possible compatible. This purpose can be realized when these rules are not only such as to enable people to anticipate and to depend upon each other’s behavior, but when they promote and intensify people’s positive cooperation with each other. That is why, advocate conventional ethical economists, **social cooperation can be considered as the heart of morality in economic affairs,** and the means by which each individual can most effectively supply his own wants and maximize is own satisfactions.

Consequently, the conventional approach to Economic Ethics appears to be an essentially anthropocentric one, as the content and scope of ethical judgments applied to economic activity are exclusively limited to social requirements and norms. In fact, the ethical limitations on economic activity as perceived by standard economics are basically social limitations (from reverse discrimination or truth in advertising to workers' rights or trade secrets). By contrast, it seems to us that there is an increasing number of researchers who are now much more inclined to see economic activities and ethical judgments attached to them as being limited by physical factors, rather than by social ones. It is what we call **the first radical reconsideration** of the conventional Economic Ethics.

A Non-Conventional Biophysical-Based Approach to Economic Ethics

Over the last hundred years, economist remained attached to one particular idea, the mechanistic epistemology which dominated the orientation of the founders of the neoclassical school [Georgescu-Roegen/ 1975, p.347]. By their own admission, the greatest ambition of these pioneers was to build an economic science after the model of mechanics - in the words of Stanly Jevons - as "the mechanics of the utility and self-interest" [*apud* Georgescu-Roegen, op.cit., p.347].

The latter-day standard economists have apparently been happy to develop their discipline on the mechanistic tracks laid out by their forefathers, strongly fighting any suggestion that economics may be conceived otherwise than as a sister science of mechanics. The consequence of this indiscriminate attachment to the mechanistic dogma was the viewing of the economic process as a mechanical analogue consisting of a principle of conservation (transformation) and a maximization rule. The economic science itself was thus reduced to a timeless kinematics.

To equate the economic activity with a mechanical analogue implies, therefore, the idea that the economic process is a self-sustaining, circular flow between "production" and "consumption" which cannot possibly affect the environment of matter and energy in any way. The obvious conclusion is that there is no need for bringing the environment into the analytical picture of that process. However, the crucial point is that the economic process is not an isolated, self-sustaining one. This process cannot go on without a continuous exchange which alters the environment in a cumulative way and without being, In its turn, influenced by these alterations [Georgescu-Roegen, op.cit., p. 348]. For the critics of mechanistic epistemology which dominates standard economics, actual economic phenomena move in a definite direction and involve qualitative change. At least, this is the lesson of classical thermodynamics. Therefore, the economic activity, like any other life process, is irreversible and cannot be properly explained in classical mechanical terms alone. It is thermodynamics - as already we have said – through the entropy law, that recognizes the qualitative distinction which economists should have made from the outset between the inputs of valuable resources (low entropy) and the final outputs of valueless waste (high entropy).

The extraction of resources, their combination and transformation in production and their final disposal in the form of waste (or their recycling) results in a continuous change of the "orderliness" of the earth. The concept of entropy can be used to characterize the orderliness of a system: the higher the disorder the higher the entropy and vice versa. The extraction of a resource from a site with a high concentration and its final disposal into the environment, where a diffusion process takes place, increases the entropy of the system [Faber and Proops,1985, p.607].

One important implication is the fact that the entropy law is actually the taproot of economic scarcity; in the context of entropy, every action, of man or of on organism, in fact, any process in nature, must result in a deficit for the ecosystem [Paul Weiss,1970-1]. Another critical implication is that, given the entropic nature of the economic activities and processes, waste is an output just as unavoidable as the input of natural resources. "Bigger and better" economic products necessarily cause not only "bigger and better" depletion of natural resources but also "bigger and better" pollution [Georgescu-Roegen, 1972, p.18]. In this respect, it is worthwhile to mention that the last two decades witness the realization by many economists that economic activity has a biophysical underpinning that cannot be ignored [Faber and Proops, 1985, p.599]. Thoben [1982] has suggested that the use of mechanical analogy in standard economics should be supplanted by the use of "organistic" analogy, recognizing that a complex economic system is more akin to a self regulating and developing organism than to a mechanical system. A similar exploration of organistic analogy is due to Fehl [1983, *apud* Faber and Proops, op.cit., p.601], who draws an analogy between economics and "dissipative structures". In a similar way Hannon [1985] has argued for the analogy between economics and ecosystems to be recognized, with ecosystems offering the potential for an experimental systems basis for economics.

The fact is that the debate over the importance of environmental and resource problems generated by economic activity caused many economists to adjust their conventional stance and come to accept that **economic activity has a biophysical foundation**, rather than a merely socially - conditioned one. Moreover, they came to understand that the economic activity of any generation has some influence on that of the future generations - as terrestrial resources of energy and materials are irrevocably used up and the harmful effects of pollution of the environment accumulate. For the non-conventional economists, **one of the most important ethical economic problems for mankind, therefore, is nowadays the relationship of the quality of life of one generation with another** - more specifically, the distribution of mankind's dowry among all generations. Standard economics cannot even dream of handling this problem. The object of mainstream economics, as has often been explained, is the administration of scarce resources; but to be exact, one should add that this administration regards only one generation. For conventional economics it could not be otherwise: each generation can use as many terrestrial resources and produce as much pollution as it alone decides. Future generations do not exist, simply because they cannot be present on today's market. And it would certainly be poor economics – for standard economists - to sacrifice anything for a nonexistent beneficiary. Accordingly, there is no doubt that the market mechanism cannot protect mankind from ecological crises in the future and cannot optimally allocate resources among generations, even if we would try to set the prices "right".

The only way to protect the future generations, argue the supporters of the non-conventional, biophysical-based approach to ethical judgments in economics, is by **reeducating ourselves** so as to feel some sympathy for our future fellow humans in the some way in which we have come to be interested in the well-being of our contemporary "neighbors" [Georgescu-Roegen, 1975, p.376].

This non-conventional perspective suggests that economists need not only an understanding of environmental and resource problems from their biophysical foundations, but even more, an appreciation of the ethical implications attached to economic activity within a biophysical framework. Under such a new ethical orientation, the morality of the economic actions will no more be primarily judged by their tendency to promote long-run happiness and well-being, but rather by **their tendency to refrain from "unnecessary" harm to the ecosystem.**

The Intermediating Role of Technical Change

The biophysical view on ethical issues in economics represents, as already mentioned, a first major reconsideration of the standard economic ethics. This non-conventional perspective is due to the realization by many economists that economies have a biophysical underpinning that cannot be ignored. They are concerned, in fact, about the biophysical limits to social activity, as follows:

- on the one hand, the problem of the irreversibility of productive activity and the constraints this places on economic activity in the long run because of finite exhaustible resources;
- on the other hand, the problem of how pollution may act as a physical limitation on man's economic activity.

For non-conventional economists, in the long-run biophysical limitations might well be binding. However, they argue, these constraints are likely to generate a social response which moves the economy away from the constraint, through technical and social adjustment. In the view of these economists, social transformation, technical change and biophysical constraints come together to form a web of recursive interrelationships, with technical change springing from the combination of social demand and the constraints on physical supply [Faber, Niemes and Stehpan, 1983, chapter 8; Faber and Proops, 1985, pp.608-609]. Therefore technical progress, in addition to its usual interpretation, has the important role of intermediating between social demand and the physically and technically possible.

These leads the above mentioned economists to conclude that it is not sufficient to look at social and economic activity solely with the concepts of standard economics and conventional economic ethics since this would ignore a major source of social change, namely **technological innovation which springs from the biophysical nature of economic activity.** In other words, in order to be ethical, human (economic) actions should refrain from "unnecessary" harm to the ecosystem, and this can be effectively achieved if technological innovation intermediates between social demand and biophysical constraints. That is, **technological innovation means social demand adjustment to biophysical constraints by restraining from "unnecessary" harm to the ecosystem.**

The Bioepistemological-Based Approach to Economic Ethics

Conventional ethical economists remain attached to **anthropocentric approach;** insofar the content and scope of ethic judgments applied to economic activity are exclusively limited to social requirements. Their object study is the application of general moral principles to particular cases or practices in business, while **social cooperation** is considered as the heart of morality in economic activities. Consequently, the purpose of moral rules in economic affairs is to harmonize human attitude and action so as to make the achievement of everyone's aims as far as possible compatible. All these explain why, for conventional ethical economists, the morality of human economic actions can be judged by their tendency to promote **long-run happiness and well-being.**

By contrast, biophysical economists are much more inclined to see economic activities and the ethical judgments attached to them as being primarily defined in terms of physical constraints, rather than in social ones. For these economists, the **thermodynamic approach** is a way for economics to get in touch with its **biophysical foundations,** while using the concept of entropy makes an economist aware of **the irreversible nature** of the time structure of many environmental and resource processes. In the context of entropy, every human economic action results in a deficit for the entire ecosystem, so that resource depletion and environmental pollution are unavoidable outputs. Accordingly, **the principle of optimal resource allocation among generations** gets a crucial relevance, and the ethical content of any human economic action can be judged by its tendency **to refrain from "unnecessary" harm to the ecosystem.**

There is no doubt, in our opinion, that the approach proposed by biophysical economists represents a radical and beneficial reconsideration of the reductionist view promoted by conventional ethical economists. However, thermodynamics – with its concepts of irreversibility – is only a component process of the evolution and development of the Universe, in general and of the ecosystem, in particular. Recent authoritative research works in the field of physics and evolutionary biology suggest that in our Universe **the negentropic processes complement the entropic ones.** Accordingly, it is our conviction that a more integrative perspective is needed (we shall propose the self-organization approach) and a more elaborate **founding principle** has to be employed (we shall propose the ameliorative equilibration principle) [Piaget/1974 & Piaget/1976] in order to properly explain and understand the way ecosystem evolves and to better define the issues that Economic Ethics has to deal with. In other words, it seems to us that a second-generation revision of conventional Economic Ethics is needed.

The Principle of Ameliorative Equilibration

The phylogenetic, psychogenetic and sociogenetic systems operate according to a law of direction (called by biologists vection) which is the ameliorative equilibration. This vection is being realized by means of an evolutionary strategy which could be summarized as it follows: **introduction of a maximum of COMPATIBLE novelty with the conservation of the maximum of validated acquisitions** [Weiss, 1970-3 , Weiss, 1974 & Piaget, 1974].

We won't insist upon the functional reason of the vection as it is obvious that in all fields and at all levels the disequilibria play an important role since they require re-equilibrations.

From a structural point of view the main issue is to justify both functionally and inseparable dimensions: the compensation of disturbances, which trigger the disequilibrium motivating the search, and the construction of novelties, which characterizes the amelioration (i.e. re-equilibration).

Unlike the organic assimilations and accommodations, which lay upon substances and energies necessary to conservate structures that continuously became more specific, the assimilation and accommodation at the cognitive level, extending these biological process, can constantly enlarge its field (that comprises larger sectors of reality, including the progressive world of co-possibles). This indefinite extension cannot be reduced to empiling because the specificity of the assimilation consists, on the contrary, of a genuine **integration** - that is, a game of establishing relations which entails the formation of totalities cyclically self closed. These remarks lead us to the structural considerations.

1. The first reason that conditions the other ones is the **feature of interdependence** of the components of the entire assimilation cycle (beginning with the elementary schemes up to the formal schemes of sciences). When we talk about assimilation we necessarily refer to a previous system, irrespective of its rank, that is more or less solidly or durably integrated, this integration depending on such cycles. Otherwise the assimilation would be reduced to some accidental-empirical associations.
2. The second reason takes into account the fact that the fundamental factor of an epistemic equilibration is the **conservative action** that the totalities of the systems of any rank exercise over their parts to the extent that both are accomplished. It is also true that this accomplishment is variable, hence the degrees of invariance: a stronger or a weaker stability depending of the new accommodations. But the action exercise by the totality is essential to all stages because it arises from the previous functioning of the assimilation and the conservation of the entire cycle, that is the parts' subordination, is a sine qua non condition of the continuation of this functioning.

   Consequently, this power of conservation exercised by the totality is the supreme regulator that orientates every minute the local regulations of the parts. This is done as an imperative requirement: either the insertion of new assimilations and accommodations within the entire cycle became possible, or the cycle is broken and the system abandoned.
3. The third reason refers to the fact that the totalities elaborated as we described before never represent the final term. This is so because, on the one hand, the **possibilities opened by the establishment of its structure are virtual disturbances related to its current (present) state (which raise the**

problem of the critical thresholds) and , on the other hand, due to the fact that the regulation of their functioning generate sooner or later anticipations which at their turn produce "réfléchissements", hence new levels on which the actions or operations used as instruments in previous structures become thematized object of thinking.

The result of it is **an enlargement of a structure,** with to the extension of some variations in plus or minus and new morphisms between negations and positive features. The entire history of sciences reveals such a process of reflective abstraction which explain the formation of the new structures (totalities) starting from the previous ones.

4. The reflective abstraction (abstraction réfléchissante) [Piaget, 1977], responsible for the formation of new levels, is indissolubly connected to a **reorganizing reflexion** (abstraction reflexive) oriented towards more sophisticated compensations between negations and affirmations. Both the reflective and reflexive abstractions are jointly responsible for the sophistication of the process of regulation: if the first arises from what is called "prise de conscience" (J. Piaget), hence the thematization of previous operations, the second is in fact **a new regulation grafted onto the previous regulation, which provides them a better guidance**. The formation of **the regulations of regulations** can be explained by the joint action of reflective and reflexive abstractions and not as a new factor introduced from the outside [Piaget, 1977].
5. The fifth reason leads to this apparently paradoxical result: each structure (totality) is backed upon the next one which realizes the possibilities opened by the previous structure (totality): indeed, if the regulator of the previous structure is the power of its totality as cycle, then the construction of the next totality is submitted even from its starting point to the necessity to preserve the previous one in its form of cycle, but extending it.

In other words, the new assimilations and accommodations are simultaneously derived from the previous and the back-up of previous because they clarify them by completing them.

Distinct from the return to a previous equilibrium, the ameliorative equilibration which unites indissolubly the constructions and compensations is not explicable only by the need to feed the scheme of assimilations (theoretically unlimited, but alone it could lead only to an accumulation of juxtapositions). The ameliorative equilibration consists of the fact that the forms of the previous structure (totalities) become, due to the reflexive thematization, contents for the superior forms and can be then completed with new contents thanks to this type of **completive generalization** which generates its own contents by combining and synthesizing the proactive, retroactive and justificative implications.

The fact that these systems are based on the evolutionary strategy of knowledge acquisition means that the ameliorative products of the previous constructive cycle are integrated in the current (present) totality to form the initial object of the next cycle.

It results from this that, on the one hand, the system is self constructive and "on the other hand that the constructions of the previous cycle become available for the next cycle both as components for new constructions and as precursors (forerunners) submitted to an ameliorative reconstruction, the products acquired being also submitted to a continuous and selective re-evaluation which can at each cycle replace them.

To sum up, the evolutionary principle of ameliorative equilibration can be expressed as it follows: the goals and the forms of the parts are compatible with the goal and the form of the totality.

The Epistemological Precariousness of the Process of Technological Innovation

Non-conventional biophysical economists have convincingly argued that social transformation, technical change and biophysical constraints come together to form a web of recursive interrelationships, with technical change springing from the combination of social demand and the constraints of physical supply. Therefore, the process of technological innovation has the important role of intermediating between social demand and the physically and technically possible.

The point is that modern technological innovation process does not play such a role. On the contrary, there is strong evidence that most of the current technologies that dominate the productive processes in advanced countries conflict with the ecosystem. In our interpretation, the reason lies **in a basic epistemological precariousness** of the modern process of technical change. This precariousness consists of its **serious deviation from the principle of ameliorative equilibration**. This deviation means that the goals and forms of the parts (synchronic logics of the market, market fundamentalism[1]) try unwisely to impose its hegemony over the goal and form of the totality (the evolutionary self-equilibration of the ecosystem, which sustains the human subsystem).

The deviation from the principle of ameliorative equilibration takes the shapes of **monotelism, fragmentalism, and reductionism.**

First of all, in order to properly understand the epistemological precariousness of the technological innovation process, a comparative approach between the engineer's cognitive effort (who finds himself involved in economic process) and the biologist's cognitive effort (involved in the study of the ecosystem) is worthwhile to be undertaken.

The engineer is focused on a function which is supposed to become operational within certain artificial structure having a final economic utility, without paying attention, however, to the causal context[2] of both the selected function and the selected components needed for assembling the artifact. By contrast, the biologist starts his investigation from the study of some already synthesized superior (integrative) structures

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[1] We have in view the interpretation proposed by George Soros in The Crisis of Global Capitalism, Public Affairs, 1998.

[2] In our understanding, a causal context refers to the relationships between the function and its selected components, on the one hand, and the web of inherent, multiple and often imperceptible relations of the ecosystem.

and functions, in order to perform afterwards a functional decomposition, having all the time in view, across all decomposition phases, the totality (that is, the organism).

Being conceptualized in such a way, the technology is subordinated to the end of the market subsystem, while entailing a causal chain which goes beyond the logics of market.

It is what we call **the monotelic feature** of the technological innovation process. It consists of focusing exclusively on a single purpose (the mercantile logics of market) and ignoring both the ecosystem's context and the consequences upon it. Missing the functional synthesis, as a necessary complement to functional analysis, the engineer's performance is condemned to **the fragmentation of problems and process he wants to address**. In this manner, the avoidance of the multiple causality context – generated, in its turn, by the absence of functional synthesis – implies the unavoidable limitation to the market logics.

Now, if we approach a more profound level of analysis, required by the self-organization theory, we can better understand the epistemological precariousness of modern technical change process by means of a comparative analysis between technogenesis and phylogenesis. In this respect, the engineer places himself exclusively within a synchronic level, paying no attention to the fact that the synchronical stand he adopts is only a transitory moment of an indefinite diachronic process in time – in other words, of the evolution itself. A crucial difference between the functional construction performed by the engineer (that is, technogenesis) and that performed by the natural evolution (phylogenesis) comes to evidence, namely:

- on the one hand, within the engineer's cognitive system, the representation of the function to be performed comes first to the construction of the structure;
- on the other hand, within the phylogenesis system, the stage of the construction of structures comes first to the stage of their selection. This selection is determined by the fact that the variant performs a new subfunction which differentiates a superior function of the organism or improves on already existing one, contributing in this way to the differential reproduction of genes, that produces it.

The lesson to be learned from the comparative analysis between technogenesis and phylogenesis is the following: phylogenetic processes, to which the technogenetic ones belong, operate according to logics which say that goals and forms of the parts are compatible with the goal and the form of the totality [Leśniewsky, 1986]. In the living processes, there is a **transitivity mechanism induced by the goal of totality** (the organism, *i.e.*) **upon the goals of the parts** (the organs, *i.e.*). A different story is illustrated by the process of technogenesis, corrupted by **a certain reductionism** that is the conception that the effective understanding of a complex system (the totality) can be achieved by focusing on the properties of the isolated parts of that system. The implied presupposition of this reductionist view can be summarized as follows: the totality is the sum of its parts. However, life shows us that totality, irrespective of its rank, is more than the sum of its parts.

In this way, the reductionist methodology so typical to the present-days techno-corporative structures can be neither an efficient way of understanding the large natural systems to which these structures belong, nor an efficient way to harmonize them.

An Exemplification of the Epistemological Precariousness

Scientific revolution from the first half of the 20th century turned modern Physics and Chemistry into sciences capable to influence nature on a global scale and to create, for the first time on earth, absolutely new forms of substances.

For example, chemistry made remarkable strides (progress) during this period. Especially important for their effects on the ecosystem proved to be the knowledge acquired by the chemistry of organic compounds.

The chemists discovered practical methods to create most of the molecular structures theoretically possible. The knowledge of the fact that the organic compounds' variety is quite infinite and that the methods to realize most of possible combinations are at hand proved to be irresistible. As more knowledge has been accumulated about the chemical basis of some molecular properties types of molecular structures (that determine color, elasticity and resistance of a substance or its capacity to kill bacteria, insects and weeds), became possible to design new molecules with a unique purpose. These instruments, unprecedented as force and overwhelming as novelty, came into force as a result of market mercantilism (increase production under the pressure of demographic boom, hence increase consumption and profit).

Only later, the vice with potentially fatal consequences of the new technologies applied in industries on large scale was detected. The vice was the lack of reference to ecosystem and the lack of connection with one of the discipline which largely contributes to its understanding - the biochemistry (the chemistry of natural living systems).

The evolutionary biochemistry teaches us that the types of chemical substances existent in the living creatures and in ecosystem **are a class more restraint than the class of possible ones**.

The reason of this fact is that each living creature and the entire ecosystem have benefit of three (3) billions years of "research – development – evaluation"of evolution. By differential reproduction and differential conservation the living creatures have acquired a complex structure made up of COMPATIBLE PARTS: those possible combinations between parts which are incompatible with the totality are eliminated. Therefore, the structures of the present living creatures and present ecosystem organization are the best solutions selected by the ameliorative equilibration of the phylogenetic system. This is true to such extent that any other form of organization would be undoubtedly unfit from the point of view of adaptation.

A striking feature of the living – systems' chemistry is that for each organic substance produced by an organism there is in nature an enzyme capable to decompose it. In this way the recycling interactions are made effective.

But when men creates a new synthetic substance whose molecular structure cannot be founded in the eco-system or deviates very much from the types existing in nature, there will not exist any degradative enzyme and the substance will tend to accumulate and destroy the self-regulatory mechanisms of the ecosystem.

The technological mutations – initiated by a conceptual and methological reductionism – are typical for the numerous substitutions of the natural process with the artificial ones.

This reductionism injects a disjunction, a lack of coordination between the field of theoretically possible and the field of really necessary, ignoring the category of potentiality.

As a consequence, any technological innovation derived exclusively from one discovery in a single discipline is meant from the very beginning to error and failure because it ignores the fact that its application within the domain it defined trigger a chain of complex causal mechanisms at many levels of the reality.

Some final remarks

Our bioepistemological approach suggests that economists need not only an understanding of the ecosystem in terms of irreversibility, but even more, an understanding of the negentropic processes of the evolution. That is, an understanding of the way the processes in ecosystem make actual the principle of ameliorative equilibration [Laprieno, 1971].

The **cross-disciplinary approach** (which synthesizes the horizontal coordination [Weiss/1970-1] between sciences with the vertical coordination of their epistemologies) and the **multiparametric optimization method** are able to exercise a negative selection against the nonintegrable and nonintegrative technological innovations. This means that among many technological innovations that extend the field of the possibilities only those that prove to be integrative and able to ameliorate the adaptation process will be chosen and preserved.

Only this type of **prospective approach** could be considered ethical as it realizes the principle of ameliorative equilibration and harmonizes the technological innovation process with the processes of the ecosystem.

References

Apostol, L., Grize, J.B., Papert, S. and Piaget, J. (1980): “La filiation des structures”, vol. XV *Etudes d’epistemologie genetique*, PUF Paris.

Bertalanffly, Ludwing von (1973): *Theorie generale des systemes*, Dunod, Paris.

De Georges, Richard (1986): *Business Ethics*, Second Edition, New York, Macmillan Publishing Company.

Faber, M., Niemes, H. and Stephan, G (1983): “Entropie. Unweltschutz und Rohstoffverbrauch. Eine naturwissenschaftlich ökonomische Untersuchung”, Lecture Notes in *Economics and Mathematical Systems*, 214, Heildelberg, Springer-Verlag.

Faber, Malte and Proops, John (1985): “Interdisciplinary Research between Economists and Psysical Scientists: Retrospect and Prospect”, *Kyklos*, vol. 38, Fasc. 4, pp. 599-616.

Forester, J. (1990): “*From Noise to Order*”, Science 10-685.

Georgescu – Roegen, Nicholas (1975): “Energy and Economic Myths”, *Southern Economic Journal,* Volume 41, No.3, January, pp.347-381.

Georgescu – Roegen, Nicholas (1972): “The Entropy Law and the Economic Problem”, *The Ecologist,* July, pp.13-18.

Hannon, B. (1985): “Conditioning the Ecosystem” in W. van Gool, and J. Bruggink, (eds): *Energy and Time in the Economic and Physical Sciences*, Amsterdam, North Holland.

Hazlitt, Henry (1990): *Foundation of Morality*.

Klir, G. (1995): *Trends in General Systems Theory*, Ed. G. Klir Inc., New York.

Laprieno, N (1971): *Il pericolo del mutagenii chimici ambietali per l’uomo*, Consiglio Nazionale delle Ricerche, Pisa, Publ., 46.

Leśniewsky (1986): *Mereology*, Springer Verlag.

Piaget, Jean. (1972): *Traite de logique essai de logistique operatoire*, Deuxiemme edition, Dunod.

Piaget, Jean (1974): *Biologie et connaissance*, Gallimard.

Piaget, Jean (1976): *Le comportament, moteur de l’evolution*, Gallimard.

Piaget, Jean (1975): *Adaptation vitale et psychologie de l’intelligence. Sélection organiquè et phénocopiè*, Hermann.

Piaget, Jean (1977): *Etudes d’épistemologie génétique XXXIV – Recherches sur l’abstraction réfléchissante 1,2*, PUF, Paris.

Piaget, Jean (coord.) (1975): “Logique et connaissance scientifique”, *Encyclopédie de la Pléiade*.

Simpson, G.G. (1968): *Behavior and Evolution*, Ed. A Roe and G.G. Simpson, Yale University Press.

Thoben H. (1982): “Mechanistic and Organistic Analogies in Economics Reconsidered”, *Kyklos*, Vol. 35, pp. 292-306.

Weiss, Paul (1970-1): *Beyond reductionism*, Koesterland Smythies, Macmillan.

Weiss, Paul (1970-2): *L’Archipel Scientifique*, Gallimard.

Weiss, Paul (1970-3): *Principles of development*, pp. 567-571, Macmillan.

Weiss, Paul (1974): *Dynamics of development*, p. 447, Yale University Press.

Whyte, L. Lawance (1965): “Internal Factors in Evolution”, *Science*, 149, 3582:417, 1965.