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Oeco-Nomics in the Light of the Maximum Ordinality Principle The N-Good and Three Factor Problem

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Abstract

Fundamental Principles in Economics and, in particular, in Neo-Classical Economics (NCE), such as Walras General Equilibrium, Pareto Optimality, etc., are the result of a direct transposition to economic activities of the Principles of Classical Mechanics (CM) and, even more, of Classical Thermodynamics (CT).
Consequently NCE Principles suffer from the same defects as CT Principles, when the latter are analyzed in the light of the Maximum Ordinality Principle (MOP). In fact Utility-Expenditure Conservation Principle (corresponding to Energy Conservation) does not hold when reconsidered in terms of Incipient Differential Calculus (IDC), a mathematical language which is much more appropriate to describe Generative Systems.
This also means that neither does Walras General Equilibrium represent a "stable" equilibrium condition nor does Pareto Optimality represent a "maximum" condition, precisely because the latter presupposes the former.
In reality traditional Economics, in all its different Schools of Thought, does not recognize that Emerging Property, usually termed as Quality (with a capital Q), which vice versa is clearly pointed out by the Maximum Em-Power Principle or, in more adherent formal terms, by its generalized version represented by the Maximum Ordinality Principle. Quality in fact represents that fundamental aspect which is ever-present in any physical-biological-social Process, never ever reducible to mere phenomenological processes or to our traditional mental categories.
As a consequence of the same subjacent presuppositions, NCE is not even able to solve the "Three good, two factor Problem" which, on the other hand, is very similar to the more famous "Three body Problem" in Classical Mechanics.
So, by starting from the solution to the latter problem, this paper will focus on a different concept of "Economics" (thus here renamed as "Oeco-Nomics") which, being based on the Maximum Ordinality Principle, is consequently able to lead us to a general solution to the "N good, three factor Problem". A solution which evidently includes the solution to the "Three good, three factor Problem" and, as a particular case, the solution to the "Three good, two factor Problem" too.
These results then suggest that traditional economic maximization criteria (usually corresponding to Pareto Optimality) should preferably be replaced by the Maximum Ordinality Principle. The latter in fact enables the Decision Maker to recognize those optimal working conditions which realize the Maximum Ordinality level of the System and, at the same time, to evaluate the corresponding optimum economic conditions (Investments, Benefits, Incentives, etc.) as a consequential adherent reflex.
As a term of comparison, two well-known approaches will also be reconsidered: i) Kummel's KLE and KLEC Models; ii) and Odum's Emergy Synthesis.

The proposed approach allows us to conclude that: *Production becomes cleaner when Processes become Generative* and, at the same time, they are also characterized by a progressive Ascendant Ordinality. In other words, when Decision Making progressively tends to realize, in actual fact, the Maximum Ordinality conditions.

Keywords: *Economic Complex Systems, Walras General Equilibrium, Energetics and Classical Thermodynamics, Maximum Ordinality Principle, Incipient Differential Calculus (IDC).*

1 Introduction

Fundamental Principles in Economics and, in particular, in Neo-Classical Economics (NCE), such as Walras General Equilibrium, Pareto Optimality, etc., are the result of a direct transposition to economic activities of the Principles of Classical Mechanics (CM) and, even more, of Classical Thermodynamics (CT). Thus NCE Principles suffer from the same defects as CT Principles, when the latter are analyzed in the light of the Maximum Ordinality Principle (MOP). In fact, Utility-Expenditure Conservation Principle (corresponding to Energy Conservation) does not hold when reconsidered in terms of Incipient Differential Calculus (IDC). Such an assertion can easily be shown by adopting the same procedure already followed to show that “Energy is not constant” (Giannantoni, 2010a). In actual fact it is sufficient to replace “Energy = constant” with the assumption of NCE that “Utility + Expenditure = constant” (1).
However, that is not the point. What is really fundamental is that: i) in the same way as Energy Conservation represents “a limitation imposed on *freedom* of complex systems” (Poincaré 1952, p. 133), so does assumption (1) prevent us from recognizing the genesis of “Ordinal Benefits”, which originate from Ordinal Economic Interactions (Giannantoni 2009, 2010a); ii) in the same way as Energy Conservation prevents us from getting a closed form solution to the “Three body Problem” (in CM), so does Walras General Equilibrium assumption (as well as Pareto Optimality, which is based on the former) imply that the search for the solution to any problem concerning “maximum”, “minimum” or even “equilibrium” conditions, systematically leads to NP-Complete Problems. This is precisely because the research is based on pre-assumption (1). This depends on the fact that Economic Processes, as usually modeled by NCE, are not mere “mechanisms”. This is the basic reason why, when modeled as such, they lead to NP-Complete Problems (or, more simply, to NPC Problems).
The “N good, three factor Problem” is, for many respects, very similar to the “N body Problem” or, even better, to Protein Folding, which is an NPC Problem too. This is because the problem, even in such a case, is faced by neglecting that very Emerging Property, usually termed as Quality (with a capital Q), which vice versa is clearly pointed out by the Maximum Em-Power Principle or, in more adherent formal terms, by its generalized version represented by the Maximum Ordinality Principle. Quality in fact represents that fundamental aspect which is ever-present in any physical-biological-social Process, never ever reducible to mere phenomenological processes or to our traditional mental categories.
This aspect is particularly important because, on the basis of the *universality* property of the class of NPC Problems, we may think about the transposition of “Protein Folding” (understood as an “N body Problem”) to the case of the “N good Problem”.
Let us then recall the basic aspects that allowed us to pass from the solution to the “Three body Problem” to the Folding of Dystrophin, the largest Protein in a human body.

2 From the "Three body Problem" to the "N body Problem"

The solution to the "Three body Problem", already given in (Giannantoni 2007a, ch. 5) was directly transposed to the well-known Problem of Protein Folding, understood as an "N body Problem", because this is one of the most important "intractable" problems. In fact, although the problem is thought of as being theoretically solvable in principle, the time required in practice to be solved may range from hundreds to some thousands of years, even when run on the most updated computers.
The solution to the Problem was obtained by reformulating the Maximum Em-Power Principle (Odum 1994a,b,c) in a more general form, by introducing a new concept of derivative, the "incipient" derivative, whose mathematical definition has already been presented in (Giannantoni 2001a, 2002, 2004, 2008, 2009, 2010a). In this way both Emergy and Transformity are replaced by the concept of Ordinality. This is why the principle was renamed as the Maximum Ordinality Principle (Giannantoni 2010a,b). Its corresponding enunciation then becomes: "Every System tends to Maximize its own Ordinality, including that of the surrounding habitat". In formal terms:

$$(\tilde{d}/\tilde{d}\,t)^{(\tilde{m}/\tilde{n})}\{\tilde{r}\}_s = 0 \qquad\qquad (\tilde{m}/\tilde{n}) \to Max \qquad (2)$$

where: $(\tilde{d}/\tilde{d}\,t)$ is the symbol of the incipient derivative; $(\tilde{m}/\tilde{n})$ is the Ordinality of the System, which represents the Structural Organization of the same in terms of Co-Productions, Inter-Actions, Feed-Backs; while $\{\tilde{r}\}_s$ is the proper Space of the System.
At this stage, by modeling Protein Folding as a Self-organizing System which evolves in adherence to the Maximum Ordinality Principle, the problem becomes solvable in explicit terms. This enabled us to assert that the simulation of Protein Folding, even in the case of a macroscopic protein, such as Dystrophin (made up of about 100,000 atoms), can be obtained in a few minutes, when run on the next generation computers, characterized by a computing power of 1 Petaflop (Giannantoni 2010b).
In reality, during the development of an associated computer code, we discovered some additional properties of the mathematical model adopted, which enabled us to further improve the solution in terms of Informatics.

3 Ordinal Properties of The Mathematical Model Adopted

The intrinsic Ordinal properties of the Model, which facilitate the research for a solution, are strictly related to the Maximum Ordinality Principle. In fact, when a Self-organizing System, persistently propending toward the Maximum Ordinality conditions, effectively reaches such very special conditions, it presents itself as being self-structured in a radically different way with respect to its initial Ordinality. This is because the latter has evolved according to the following Trans-formation

$$(\tilde{m}/\tilde{n}) \to \{\{\tilde{2}/\tilde{2}\} \uparrow \{\tilde{2} \uparrow\}\} \uparrow \tilde{N} \qquad (3),$$

where: $\{\tilde{2}/\tilde{2}\}$ represents a "binary-duet" coupling; the Ordinal power $\{\tilde{2}\uparrow\}$ indicates the "perfect specularity" of the previous "binary-duet" structure; while $\uparrow \tilde{N}$ indicates the Ordinal Over-structure of the $\tilde{N}$ elements of the System considered as a Whole (this is the reason for the "tilde" notation) (see Giannantoni 2009, 2010a,b).
The Ordinal Structure represented by Eq. (3) is due to Eq. (2), which appropriately expresses the Maximum Ordinality Principle, and to another equation, which is always associated to the former, that expresses the internal Ordinal stability of the System,

for each level of Ordinality achieved. For the sake of simplicity and clarity the latter can be formulated for any *single couple* of elements, when structured in a "binary-duet" relationship:

$$(\tilde{d}/\tilde{d}\,t)^{(\tilde{2}/\tilde{2})}\{\{\tilde{r}\}\otimes(\tilde{d}/\tilde{d}\,t)^{(\tilde{2}/\tilde{2})}\{\tilde{r}\}\}=0 \qquad (4).$$

This equation asserts that the proper Space of the System (now considered as being made up of two sole elements) is coupled with its specific Generativity in such a way as to originate a comprehensive Generative Capacity which is always in equilibrium.[1]
Equation (4) is precisely that which leads to the afore-mentioned perfect specularity which, in the case of two sole elements, is represented by the Ordinal structure $\{\{\tilde{2}/\tilde{2}\}\uparrow\{\tilde{2}\uparrow\}\}$, while in the case of $\tilde{N}$ elements is represented by the right hand side of Eq. (3).
Under these conditions, the solution to Eq. (2) (and associated condition (4)) can be expressed in the form of an exponential Ordinal Matrix

$$\{\tilde{r}\}_s = e^{\left\{\begin{matrix}\tilde{\alpha}_{11}(t) & \tilde{\alpha}_{12}(t) & \dots & \tilde{\alpha}_{1N}(t)\\ \tilde{\alpha}_{21}(t) & \tilde{\alpha}_{22}(t) & \dots & \tilde{\alpha}_{2N}(t)\\ \dots & \dots & \dots & \dots\\ \tilde{\alpha}_{N1}(t) & \tilde{\alpha}_{N2}(t) & \dots & \tilde{\alpha}_{NN}(t)\end{matrix}\right\}} \qquad (5).$$

The search for such a solution is facilitated not only by the structure of Eqs. (2) and (4), but also (and especially) by the conception of the basic reference space $\{\tilde{r}\}$, which is understood as *one sole entity*. This is why it can more appropriately be represented as follows

$$\{\tilde{r}\}=\{\tilde{x}\circledR\vec{i}\oplus\tilde{y}\circledR\vec{j}\oplus\tilde{z}\circledR\vec{k}\} \qquad (6),$$

where the coordinates $(\tilde{x},\tilde{y},\tilde{z})$ are understood as being the exit of a Generative Process (this is the reason for the tilde notation) and the symbols $\oplus$ and ® express more intimate relationships between the same: both in terms of sum ($\oplus$) and in terms of (relational) product (®) with respect to the traditional versors $\vec{i}$, $\vec{j}$, $\vec{k}$. However, for practical purposes, it is more useful to adopt the representation obtainable from a generalized version of Moivre's formula

$$\{\tilde{r}\}=\{\tilde{\rho}\circledR\tilde{i}\circledR e^{\tilde{\varphi}\circledR\tilde{j}}\circledR e^{\tilde{\vartheta}\circledR\tilde{k}}\} \qquad (7),$$

where the coordinates $(\tilde{\rho},\tilde{\varphi},\tilde{\vartheta})$ are still considered as being the exit of a Generative Process, whereas the traditional $\vec{i}$, $\vec{j}$, $\vec{k}$ are now replaced by three unit spinors $\tilde{i},\tilde{j},\tilde{k}$. Representation (7) is very similar (albeit not strictly equivalent) to a system of three complex numbers, characterized by one real unit $(\tilde{i})$ and to imaginary units ($\tilde{j}$ and $\tilde{k}$). Any element $\tilde{\alpha}_{ij}$ of the Ordinal Matrix in Eq. (5) is characterized by the Ordinality $\{\tilde{2}/\tilde{2}\}\uparrow\{\tilde{2}\uparrow\}$. Such an Ordinal Matrix, in fact, as already shown in (Giannantoni 2010b),

[1] The symbol $\otimes$ represents a more general form of the "vector" product. However, in the case of the "N good Problem" it can be considered as being perfectly equivalent to the traditional vector product.

reflects the fact that the relationships between the different parts of the System cannot be reduced to mere "functional" relationships between the corresponding cardinal quantities. This is because such quantities always "vehicle" something else, which leads us to term those relationships as "Ordinal" relationships. The term "Ordinal" thus explicitly reminds us that each part of the System is related to the others essentially because, prior to any other aspect, it is related to the Whole or, even better, it is "ordered" to the Whole. This is also the reason why the most important terms, when understood in such an Ordinal sense, are usually *capitalized* to expressly point out such a fundamental concept.
Under these conditions, each element of the Ordinal Matrix can be interpreted as being Inter-Acting (in Ordinal terms) with all the other elements of the System. In addition, the adoption of an *internal reference system* reveals that the afore-mentioned *perfect specularity* is a property which also characterizes the Ordinal Matrix as a Whole. This suggests we give an equivalent representation of the System by choosing, as a preferential reference perspective, *any* of the N elements of the Ordinal System.
Such a preferential choice introduces a further simplification, due to the fact that any preferential description adopted is "perfectly specular" to any other perspective specifically associated to each one of the remaining $N-1$ elements of the System. This evidently means that $\tilde{\alpha}_{ii}=0$ (for i =1,2,..N) and reduces the description to $(N-1)(N-2)/2$ distinct elements, which are coupled together in the form of "binary-duet" structures. However, under particular conditions, all these distinct basic elements can also be so strictly related to each other (in Ordinal terms) that the description can equivalently be given by means of one sole element (assumed as a preferential reference perspective) and only $(N-1)$ correlating factors λ_{ij}. Clearly, all these properties are exclusively related to the concept of Ordinal Matrix. These intrinsic properties, in fact, express a much more profound concept of "symmetry" (with respect to the traditional one), which can more appropriately be termed as "specularity". That very aspect which offers such relevant advantages when developing a computer code based on an Ordinal Model. More specifically, in the case of Dystrophin Folding, the above-mentioned properties allow us to reduce the corresponding computing power of about 10^6 Flops. This means that the same Ordinal Model can also be run in less than 2 hours on an ordinary PC, usually characterized by a computing power of about 1 Gigaflop (Giannantoni 2010b, 2011).

4 Transposition of the "N body Problem" to the "N good Problem"

The first step consists in the passage from "two" to "three" factors. This is because one of the major criticisms addressed to NCE is that of neglecting Nature as the *third fundamental factor* and, consequently, the *intrinsic value* of Natural Resources.
Under such conditions the transposition between the two different Spaces of analysis becomes very easy. In fact, the new Space now becomes the Space of goods (or good Space), which can analogously be represented according to Eq. (6), in terms of its proper coordinates

$$\{\tilde{r}\}_G = \{\tilde{K} \circledR \vec{i} \oplus \tilde{L} \circledR \vec{j} \oplus \tilde{N} \circledR \vec{k}\} \quad (8).$$

Such an equation clearly shows that any Good (*i*), represented in the Space of goods as $\{\tilde{r}\}_{G,i} = \{\tilde{K}_i \circledR \vec{i} \oplus \tilde{L}_i \circledR \vec{j} \oplus \tilde{N}_i \circledR \vec{k}\}$ (9), constitutes *one sole entity* and, at the same time, it represents something "*extra*" with respect to the simple "sum" of its factors.

This evidently reflects the *Holistic* Approach subjacent to the Maximum Ordinality Principle, which is ever-present in all the developments presented in this paper .
On the basis of this transposition, the "N good Problem" can still be formulated in terms of the Maximum Ordinality Principle (see Eq. (2)), in order to obtain the explicit general solution in the corresponding Space of goods:

$$\{\tilde{r}\}_{G,N} = e^{\begin{Bmatrix} 0 & \tilde{\alpha}_{13}(t) & \dots & \tilde{\alpha}_{1N}(t) \\ \tilde{\alpha}_{21}(t) & 0 & \dots & \tilde{\alpha}_{2N}(t) \\ \dots & \dots & \dots & \dots \\ \tilde{\alpha}_{N1}(t) & \tilde{\alpha}_{N2}(t) & \dots & 0 \end{Bmatrix}} \quad (10).$$

Such a solution shows that, under dynamic conditions, the evolution of the N Goods in their proper Space is not driven by a "price vector field", as supposed by NCE, but is "guided" by the Tendency toward the Maximum Ordinality. Under these conditions the Space of goods is also characterized by a set of harmony conditions that will be now shown with specific reference to the case of the "Three good, three factor Problem".

5 The "Three good, three factor Problem"

In this case, as a consequence of the above-mentioned perfect specularity, we only have three distinct elements $\tilde{\alpha}_{12}(t)$, $\tilde{\alpha}_{13}(t)$, $\tilde{\alpha}_{23}(t)$. However, given three arbitrary elements, these will not be (in general) under harmony conditions. The latter in fact are expressed through the afore-mentioned correlating factors $\tilde{\lambda}_{ij}$, in such a way as to satisfy the following *assignation* conditions (this being the reason for the symbol $\overset{*}{=}$)

$$\tilde{\lambda}_{12} \oplus \tilde{\alpha}_{12}(t) \overset{*}{=} \tilde{\lambda}_{13} \oplus \tilde{\alpha}_{13}(t) \ , \ \tilde{\lambda}_{12} \circledR \tilde{\alpha}_{12}(t) \overset{*}{=} \tilde{\lambda}_{23} \circledR \tilde{\alpha}_{23}(t) \ , \ \tilde{\lambda}_{13} \circledR \tilde{\alpha}_{23}(t) \overset{*}{=} \tilde{\lambda}_{23} \circledR \tilde{\alpha}_{23}(t) \quad (11),$$

together with all their pertaining *incipient* derivatives, up to the order N-1.
Such harmony conditions are precisely those that configure all the different possible solutions to the "Three good, three factor Problem".

6 Solutions to the "Three good, three factor Problem"

Let us consider three different goods, characterized by the arbitrary values of $\{\tilde{K}_i, \tilde{L}_i, \tilde{N}_i\}$ (for $i = 1,2,3$). In such a case: i) there is no certainty that (at least in principle) their "coordinates" satisfy all the above-mentioned harmony conditions; ii) this means that the production of three goods, considered as the exit of Generative Processes, and analyzed in a holistic approach which considers the good Space as a unique Ordinal entity, requires that the three goods must be "harmoniously" coordinated among themselves.
Such a conclusion becomes even clearer if we consider three distinct goods that, at the time t=0, satisfy the corresponding harmony conditions (11) (for any order), with constant correlating coefficients $\tilde{\lambda}_{ij}(0)$. Even in such a case, in fact, the corresponding distribution of factors $\{\tilde{K}_i(0), \tilde{L}_i(0), \tilde{N}_i(0)\}$ (for $i = 1,2,3$) do not represent (in general) a *steady state* condition. This is because, the hypotheses usually assumed by NCE

$$(d/dt)K_{tot} = (d/dt)\{K_1 + K_2 + K_3\} = 0 \quad , \quad (d/dt)L_{tot} = (d/dt)\{L_1 + L_2 + L_3\} = 0 \quad (12),$$

when reformulated in terms of *incipient derivatives*, that is

$(\tilde{d}/\tilde{d}\,t)\tilde{K}_{tot} = (\tilde{d}/\tilde{d}\,t)\,\{\tilde{K}_1 \oplus \tilde{K}_2 \oplus \tilde{K}_3\} = 0$, $(\tilde{d}/\tilde{d}\,t)\tilde{L}_{tot} = (\tilde{d}/\tilde{d}\,t)\,\{\tilde{L}_1 \oplus \tilde{L}_2 \oplus \tilde{L}_3\} = 0$ (13),

do not imply $\tilde{K}_{tot} = const$, $\tilde{L}_{tot} = const$ (14),

as happens in the case of *traditional derivatives* (see Giannantoni 2010a). The same assertion is also valid for the analogous condition pertaining to the third factor $\tilde{N}_{tot}$.
This means that the System, made up of the three goods, will always *evolve* in order to maintain its original Ordinal condition, when achieved as a consequence of a coordinated generation of goods, so harmoniously structured from the very beginning.

Such an evolution will also be characterized by associated correlating coefficient $\tilde{\lambda}_{ij}(t)$, whose time values are appropriately defined by the differential equations associated to harmonious conditions (11), whose values at t = 0 will give the corresponding initial conditions (according to Cauchy).
Clearly, this paper cannot show a complete analysis of all the different possibilities. Nonetheless it is worth pointing out some fundamental aspects dealt with in the previous sections: i) any set of goods, when harmoniously structured, is not a simple arithmetical "sum" of the same, but it gives origin to something "extra": a *unique* and *irreducible* entity represented by their *proper* good Space, which consequently could also be termed as the "Space of Good"; ii) such a harmonious System, in the presence of a new (fourth) good, will evolve either toward an higher level of Ordinality or toward a progressive dis-Ordinality level, according to the initial conditions of the additional good considered; iii) this evidently represents an extremely important aspect for any Decision Maker in maximizing the Ordinality of the System; iv) the proposed Ordinal Approach can then suggest the best strategy that effectively maximizes the Ordinality of the System and, at the same time, reduces the exploitation of Natural Resources.

7 Odum's Emergy Syntesis and Kummel's Models

The previous approach is inherently faithful to the essence of Odum's Emergy and Transformity concepts, because the Maximum Ordinality Principle, formally expressed by Eq. (2), represents the reformulation of the Maximum Em-Power Principle once "deprived" of any reference to Classical Thermodynamics. In this sense the approach can be considered as "a harmonious dissonance" with respect to Emergy Synthesis. This is because the adjective "harmonious" refers to its adherent conformity to the "essence" of the latter, whereas the term "dissonance" refers to Classical Thermodynamics and, consequently, to Neo-Classical Economics (see Introduction).
For the same basic reasons the Ordinal approach here proposed is completely different from some other approaches such as, for instance, Kummel's Models, synthetically termed as KLE (where E stands for Energy) and KLEC (where C stands for Creativity). Both models, in fact, albeit rather innovative with respect to NCE, are always based on the concept of production function (Q), and are always dealt with in terms of TDC. Under such assumptions, the basic relationship (Kümmel et al., 1998, 2000)

$$\frac{dQ}{dt} = \frac{\partial Q}{\partial K}\frac{dK}{dt} + \frac{\partial Q}{\partial L}\frac{dL}{dt} + \frac{\partial Q}{\partial E}\frac{dE}{dt} + \frac{\partial Q}{\partial t} \qquad (15)$$

is intrinsically unable to express the holistic concept of *unique and sole thing*, because Eq. (15) is formulated in terms of a simple summation. On the other hand, "creativity" $(\partial Q/\partial t)$ cannot properly be expressed in terms of traditional derivatives, because it is not the result of a functional and necessary process. "Creativity" represents, in actual fact, that "irreducible extra" which "emerges" from any Generative Production Process.

8 Conclusions

The afore-mentioned results suggest that traditional economic maximization criteria (e. g. Pareto Optimality) should preferably be replaced by the Maximum Ordinality Principle. The latter in fact enables the Decision Maker to recognize those optimal working conditions which realize the Maximum Ordinality level of the System and, at the same time, to evaluate the corresponding optimum economic conditions (Investments, Benefits, Incentives, Natural Resources, etc.) as a consequential adherent reflex. In such a context, the traditional *Utility* functions are replaced by *Fruitivity* Ordinal Relationships, which are able to transform Economics into an Ordinal form of Economics, which can thus be termed as *Oeco-Nomics*.

In such a perspective, it is easy to conclude that: *Production becomes cleaner when Processes become Generative* and, in particular, the latter are also characterized by a progressive Ascendant Ordinality. In other words, when Decision Making progressively tends to effectively realize, in actual fact, the Maximum Ordinality conditions.

In such a case the solution to any "N good Problem" is always explicit. Consequently, there are no P vs NP (or NPC) Problems. This is precisely because, in *Oeco-Nomics*, all problems are always formulated in Ordinal terms.

9 References

Giannantoni C., 2001a. The Problem of the Initial Conditions and Their Physical Meaning in Linear Differential Equations of Fractional Order. Applied Mathematics and Computation 141 (2003) 87-102.

Giannantoni C., 2001b. Mathematical Formulation of the Maximum Em-Power Principle. Second Biennial International Emergy Conference. Gainesville, Florida, USA, September 20-22, 2001, pp. 15-33.

Giannantoni C., 2002. The Maximum Em-Power Principle as the basis for Thermodynamics of Quality. Ed. S.G.E., Padua, ISBN 88-86281-76-5.

Giannantoni C., 2004. Mathematics for Generative Processes: Living and Non-Living Systems. 11th International Congress on Computational and Applied Mathematics, Leuven, July 26-30, 2004. Applied Mathematics and Computation 189 (2006) 324-340.

Giannantoni C., 2006. Emergy Analysis as the First Ordinal Theory of Complex Systems. Proceedings of the Fourth Emergy Conference 2006. Gainesville, Florida, USA, January 17-22, pp. 15.1-15.14.

Giannantoni C., 2007. Armonia delle Scienze (vol. I). La Leggerezza della Qualità. Ed. Sigraf, Pescara, Italy, ISBN 978-88-95566-00-9.

Giannantoni C., 2008. From Transformity to Ordinality, or better: from Generative Transformity to Ordinal Generativity. Proceedings of the 5th Emergy Conference. Gainesville, Florida, USA, January 31-February 2, 2008.

Giannantoni C., 2009. Ordinal Benefits vs Economic Benefits as a Reference Guide for Policy Decision Making. The Case of Hydrogen Technologies. Energy n. 34 (2009), pp. 2230–2239.

Giannantoni C., 2010a. The Maximum Ordinality Principle. A Harmonious Dissonance. Proceedings of the 6th Emergy Conference. Gainesville, USA, January 14-16, 2010.

Giannantoni C., 2010b. Protein Folding, Molecular Docking, Drug Design. The Role of the Derivative "Drift" in Complex Systems Dynamics. Proceedings of the 3rd International Conference on Bioinformatics, Valencia, Spain, January 20-24, 2010.

Giannantoni C., 2011. Bio-Informatics in the Light of the Maximum Ordinality Principle. The Case of Duchenne Muscular Dystrophy. Proceedings of 4th International Conference on Bioinformatics. Rome, January 26-29, 2011.
Kümmel R. and Linderberger D., 1998. Energy, technical progress, and industrial growth. Advances in Energy Studies. Ed. Musis, Rome, 1998.
Henn J., Linderberger D., Kümmel R., 2000. Energy Creativity and Economic Growth. Advances in Energy Studies. Ed. SGE, Padua, 2001.
Odum H. T., 1994a. Ecological and General Systems. An Introduction to Systems Ecology. Re. Edition. University Press Colorado.
Odum H. T., 1994b. Environmental Accounting. Environ. Engineering Sciences. University of Florida.
Odum H. T., 1994c. Self Organization and Maximum Power. Environ. Engineering Sciences. University of Florida.
Poincaré H., 1952. Science and Hypothesis. Dover, New York.