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**Article**

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**SOCIAL TIME AND THE ECONOMICS OF SCIENCE**Emil Dinga<sup>1\*</sup> <sup>1)</sup>Romanian Academy, Romania

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**Abstract**

The purpose of the paper is to propose and examine a logical and epistemological tool to measure science as a specific human activity in the social cooperation network. In preparing the very approach of the main issue of the research, a short examination of the concept and typology of science is presented, including Economics. The basic target of the paper is to find and examine a structurally (as deep as possible) variable holding the potential to ensure (as a common measure, perhaps of quantic, i.e., discrete nature) the commensurability of any science. Such a tool is considered to be a species of time, that is, the social time. Essentially, it is shown that science provides a specific outcome, namely, the social time variation, which constitutes the fundamental input to any (other than science) social action/activity. This outcome is treated from an Economics account (not quite the standard Economics, but the evolutionary one), so that one can discover all implications of science(s) from an economic point of view (including, for example, the social entropy affected by the science realm). Finally, the paper proposes a sui generis market structure and functioning – the science market, including the Kuhnian paradigm, to provide a general description (both causal and pure functional) of the Economics of science.

**Keywords:** sciences, social time, social time entropy, science market, economics of science.

**JEL Classification:** A10, A12, B41

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**Introduction**

My *a priori* (that is, primitive) base of the discussion in this paper is that the economic value is, in its last resort, the time, better said, the saved time contained in the products (goods or services) as results of the economic act or activity. This statement has at least two parallels in the concepts of exformation and entropy, respectively. Exformation is information that lacks (or can lack) a communication without reducing or distorting the meaning transmitted or intended to be transmitted through that communication. In its turn, the entropy is the state of a system that quantifies the degree of disorder (from a given point of view, of course) of the system concerned. Therefore, in both cases, something is lacking: information in the first case, or the order in the second one. In an analogous way, the economic value should, in my opinion, be measured by the time consumption contained in the products, or more precisely, the economic value of a product is directly proportional to the time saved to get that product. *Prima facie*, this statement is completely contradictory with all that is known and accepted as a common understanding regarding the economic value, because the classical economic theory (including Marx’s Economics, 2009) states that the economic value is directly proportional to the (socially necessary) time spent to obtain the product concerned. This is the core of my research, and it will be analytically developed at point 2. By then, some conceptual distinctions regarding science and scientific knowledge seem to be of help, especially because the study is aimed at connecting the issue of science (particularly of economic science) to time (particularly social time).

**1. The world of sciences and Economics**

**1.1. Sciences and hermeneutics**

All social constructions, from science to morals, from institutions to revolutions, are, in one way or another, anthropomorphized. Protagoras’ claim of the human being as a measure of all things addresses this meaning. The immediate consequence is that any such social construction needs a hermeneutical framing so that its “citizenship” from the society perspective is provided only by its human meaning. What I want to say is that science has two inalienable (although inextricably connected) dimensions: a) a technical/intellectual dimension, and b) a hermeneutical dimension. Based on the second dimension, in fact, a general map of the sciences could be sketched. Table no. 1 presents a matrix-type typology (on two simultaneous criteria) of science classes, in order to highlight the place of the economic science in this typology.

**Table no. 1. A general typology of sciences (an illustration).**

Elucidates:	Relationship		
	<i>Object-object (O-O)</i>	<i>Subject-object (S-O)</i>	<i>Subject-subject (S-S)</i>
	<b>Technical sciences</b>	<b>Artistical sciences</b>	<b>Practical sciences</b>
<b>The object</b>	<ul style="list-style-type: none"> <li>- Physics</li> <li>- Biology</li> <li>- Cosmology</li> <li>- Chemistry</li> </ul>	<ul style="list-style-type: none"> <li>- Music</li> <li>- Painting</li> <li>- Sculpture</li> <li>- Literature</li> <li>- Architecture</li> </ul>	<ul style="list-style-type: none"> <li>- Critics</li> <li>- Politics</li> <li>- History</li> <li>- Metaphysics</li> </ul>

Elucidates:	Relationship		
	Object-object (O-O)	Subject-object (S-O)	Subject-subject (S-S)
<b>The subject</b>	<b>Logic sciences</b> - Logics - Accounting - Mathematics - Linguistics	<b>Praxeological sciences</b> - <i>Economics</i> - Sociology - Psychology - Theoretical philosophy	<b>Ethical sciences</b> - Religion - Morals - Social philosophy

Source: The author

Based on Table no. 1, some more usual oppositions (dichotomies) that are discussed in the philosophy of science will be briefly examined below. Of interest for the subject of research in this article is, of course, the positioning of economic science – it is, in my opinion, a praxeological science, aiming at the subject-object relationship and having as its purpose the elucidation (explication, interpretation) of the subject, for example, propensity, beliefs, behaviors, within the praxeological action.

**1.2. Theory-sciences vs. narrative-sciences**

Theory-sciences (or theory-based sciences) are those sciences that are emerging from a set of axioms or general principles, that is, from a rationality model that is pre-established or pre-elected. Their theorems or lemmas are rather necessary, so the degree of freedom regarding the results of their application in knowledge is almost inexistent. The logical consistency and the saving of effort in understanding or interpreting the associated results are enormous, but, at the same time, the “bright cone” imposed by these sciences is very narrow. In fact, the theory-sciences do not see other than is already established in their axioms or principles. The best known theory-science is Physics, but this category also includes Chemistry or Biology, and these sciences have the potential to issue conjectures that can be empirically tested (for example, in Popperian’s factual falsifiability framework). Generally, although to different degrees, the theory-sciences have hypothetically-deductive functioning.

The narrative-sciences (or narratively-based sciences) are those sciences that provide a plausible knowledge, based on an intelligible macro-story issued as rather an abduction-master (*Nota bene*: it is what the logician Carl Hempel called the fundamental potential explanation – for example the state of nature as a premise for the emergence of the state (Nozick, 1997). Although some narrative-sciences are factual (e.g., factual history), while others are philosophical (e.g., philosophy of history), all of them are framing the explanation in the “shipwake” of the evoked macro-story. The constraint of that macro-story is not as strong as the axioms of theory-sciences, but not less effective – those explanations (i.e., regional micro-stories) which do not stay under the macro-story umbrella are, usually, rejected or, at any rate, bear small credibility and support from the scientists involved.

**1.3. A priori sciences vs. empirical sciences**

The a priori sciences are considered, usually, uncontextualized from the local environment ones. For example, logic or mathematics (Husserl, 2011) are of universal applicability, while physics or biology are Earth-contextualized (maybe, to our Galaxy, as well). Biology could be, at most, of general applicability but not of universal applicability. *Nota bene*: in Table no. 1,

the a priori sciences are those logical sciences which address the object-object relationships and are aimed at elucidating the subject. Although the necessity is not mandatorily overlapped onto aprioriness (Kripke, 2021), we accept, in principle, that the a priori sciences provide necessary outcomes which, in addition, are not factually testable, but are testable only in terms of consistency. Consequently, in relation to the a priori sciences, the problem of the correspondence-truth is unintelligible – within this knowledge territory there is only correctness of statements.

The empirical sciences are all the sciences that are not a priori. They are contextualized to the local environment, and their outcomes are not necessary, but contingent. They are factually testable (either based on predictions or post-dictions) and, consequently, they are “working” with the correspondence-truth (although the syntactic consistency of the statements is required as well, and this consistency is checked previously with the factual testing). The predicate ‘empirical’ not only does it not reduce the scientificity of this class of sciences but, moreover, it is the only mark of scientificity (Popper, 1981). The most part of the current sciences are of empirical type, as Table 1 exhibits, so they address all the three possible relationships between subject and object and elucidate both the subject and the object.

#### **1.4. Epistemic sciences vs. moral sciences**

Epistemic sciences are aimed at providing intellectual knowledge that is (in essence) causal explanations. It must be noted that epistemic sciences are not only of empirical type but of a priori type, as well. For example, Aristotelian (bivalent) logic is an epistemic logic (*Nota bene*: there are many other logic theories that are not epistemic, but praxeological, modal, deontic, etc.). The epistemic sciences have the capacity to issue predictions, either factual (as the empirical sciences) or purely logic (as the a priori sciences, e.g., syllogistic predictions). The epistemic predictions can be tested within the falsifiability procedure, that is, they are working under the aegis of the correspondence-truth.

The moral sciences are aimed at providing practical knowledge that is (in essence) normative explanations. Just like the epistemic sciences, the moral ones can also be either of empirical type or of a priori type (for the last category, see Kantian proposal for a logical and philosophical theory of practical reason). The moral sciences have the capacity to issue prescriptions, either factual or purely logic. The moral prescriptions are not testable within the falsifiability procedure, so they need a new kind of “truth”, perhaps called teleological truth, with its own logic (not necessarily bivalent and not epistemic anyway).

#### **1.5. Statistical sciences vs. dynamical sciences**

Statistical sciences are those sciences that can issue predictions, based on theoretical models, only regarding the average value of populations (either of objects or subjects). All the previously discussed sciences can be of the statistical type. Generally, to deal with averages implies to use probabilities (in most cases, frequential objective ones). It is also mentioned that the social sciences can be built only on statistical bases. I do not develop here the most important and relevant logical consequence of the statistical character of sciences – namely, the impossibility or, at least, the non-conclusiveness of factual testing – but I only specify that, generally, the statistical sciences need another type of truth compared with the correspondence-truth.

Dynamical sciences are those sciences that can issue predictions on any individual of populations concerned. Moreover, each object or subject of populations has the same behaviour under the “movement law” established by the dynamical sciences. Only some of the sciences evoked before are of dynamical type (the standard in this matter is the mechanical/Newtonian physics). Dynamical sciences preserve the correspondence-truth and their predictions/conjectures are factually testable in Popperian’s framework of falsifiability (I ignore here the Duhem-Quine thesis regarding the impossibility of factually testability of a conjecture).

### 1.6. Predicates of Economics

Based on the above examinations, Economics could be eidetically defined based on the following five criteria:

- (i) *sphere* of interest: the (of last resort) entropic exchange between human beings and the natural environment;
- (ii) *finality*: praxeological, that is, studying the relationship between subject and object aiming to elucidate the subject;
- (iii) *methodology*: logical-psychological-institutional (LOPSIN methodology);
- (iv) *truth*: of teleological type (based on the *causa finalis* of the praxeological action);
- (v) *testing*: factually, both by predictions and post-dictions.

Although generally I think Economics should be Political Economics (which requires a Derrida-ian *de*-construction followed by a *re*-construction – of the current Economics), in this paper Economics will be viewed in its positivistic (that is, non-normative) hypostasis.

## 2. The social time

I would say from the beginning that I shall consider the concept of time as a pure methodological one, without any ontological predicates (analogously with the concept of probability). More precisely, time will be understood as an epistemic variable, which is “thrown” over reality (either objective or subjective or objectified) to obtain a perceptual as well as intellectual order (intelligibility) of processes that are viewed as changing phenomena, analogously to the use of a thermometer to provide an order in caloric processes.

### 2.1. The concept of time

Therefore, time simply represents a counter of change. In this context, there are many regional concepts of time: a) *clock time*: that is, an external time, perfectly autonomous in relation to the process measured; neither the time causally influences that process, nor the process causally influences the time (*Nota bene*: a presumptive impact of the process on the time consists in modifying the time rhythm/beat. So, clock time has an equal, invariant rhythm/beat – the best-known example of clock time is the absolute time in Newtonian mechanics); b) *own time*: that is, a non-autonomous time, whose rhythm/beat is depending on the process measured. How such a dependency works differs from one process to another.

The own time always is an internal or intrinsic time of the process concerned, and in fact, there is a reciprocal impact between the process and its own time. As I shall show further, there is an invariant relationship between the change of the process and the own time rhythm/beat, but this internal invariance appears as an external variation, that is, in relation to the clock time.

## 2.2. Regional times

Regional times address, in fact, the own time only, since the clock time remains a universal time, more precisely, a universal benchmark based on which all the so-called regional times are calibrated and evaluated as rhythm/beat. The following regional own times could be held: (b1) the *subjective/idiosyncratic* time (*IT*) is the time perceived by individual consciousness as the flow of idiosyncratic feelings. *IT* has different rhythms or beats/paces for different individuals, being an intrinsic device of the generic individual. *IT* has a continuum spectre (in the sense of Bergson's account); (b2) the *objective/cosmological* time (*CT*) is the time naturally assigned to matter distribution in the world/Universe (in the Einsteinian so-called space-time continuum). The rhythm of *CT* is depending on the mass regional accumulation (or, the same, gravitational value), and is evaluated through the intermediation of the clock time, in a discrete manner; (b3) the *socially objectified* time (*SOT*) is the time socially issued, as an ad hoc species generated by a social perception and evaluation of all interacting subjective times. From now on, *SOT* will be called *social time* and abbreviated *ST*.

## 2.3. Time as fundamental measure

I have asserted that time is a general measure of change. This generality addresses the concept of time as such, since, precisely for being a measure of change, time is deeply specific. More precisely, I state that any system can be characterized by its own time, that is, by its own rhythm/beat of time. This rhythm/beat is a mark/stamp that individualizes the system's identity and is generated by the functionality of the system concerned. In such a view, time should be understood as a fundamental, inalienable, and idiosyncratic sign of a given system, whatever it may be.

The fundamental character of time resides, in my opinion, in the following: in a fixed system, a given quantity of change always happens in a single unit (or, after conveniences, a multiple of that unit) of the own time of that system. In fact, here we have a kind of quantification of change, so that a unit (quantum) of change/action always needs an (own) time unit to come into existence. As a forthwith consequence of this *sui generis* quantification, it can be said that the most different types of change become commensurable with each other by intermediation of the concept of time. If, for two systems, the same time unit (hence, *TU*) is registered, then the quanta of changes in those systems are the same. *Nota bene*: in this context, the principled incommensurability of two Kuhnian paradigms becomes problematic because we can simply use an adaptation of the famous detectivistic maxim, which now should become *cherchez le propre temps* (but I will develop this idea in another communication). In this way, paradigms (either cognitive, praxeological, or practical) have a commonly shared unit of measure – the action quantum – so they are commensurable.

#### 2.4. The concept of social time

When we talk about “thought saving” provided by a (more or less) axiomatized science (but also, generally, by a well-organized and systematized science), these saving address, in last resort, the time. The “thought saving” is nothing more than time-saving – for example, Archimedes’ law of the lever allows us to avoid many attempts to find the best parameters of a particular lever, so to save time (generally, clock time).

Science is an artifact (that is, an objectification of intersubjectivity), and, although it appeals to all the three kinds of time abovementioned, it is aimed, in my opinion, as ultimate finality, to save social time (ST). Therefore, it is required to provide a more comprehensive and analytical understanding of the concept of ST.

Firstly, it must be said that ST is not an average measure, such as, for example, the famous Marxian “socially necessary labour time”. Even if the actions taken into account would be the entire sphere of human activity (not only the so-called “productive” sphere), ST is not such an average measure. *Nota bene*: according to the topic of interest in the present paper, the targeted activity, which Economics must apply on, is the scientific one or the science as a label for all human activities aimed at deciphering and describing (including modelling) causalities and/or laws.

Secondly, ST is, concomitantly, input and output of any system that is considered. This means, simply, that any system (objective, subjective, objectified) consumes, in the last instance, ST either to function or even to exist *simpliciter*. As any system is inherently connected to any other system, at least in its own bright cone (although, here, the entanglement phenomenon could be brought into the discussion, as well), it results that, in the background and in last resort, all these systems (no matter their nature or finality) are necessarily engaged into a vast, permanent, and crucial exchange of ST. In such a context, perhaps, a new approach to input-output macroeconomic analysis in terms of ST (not monetary or physical) could be of the greatest interest since it would eliminate both the “regional” constraints of currency and the equalised expressions of physical quantity.

Thirdly, ST must be understood in the most abstract way. This means at least the following:

a) All economic flows (real, financial, or nominal) have a basic expression of their measures, namely the ST (these measures are, obviously, perfect commensurable among them. *Nota bene*: although the currency also aspires to provide a common measure able to allow the general commensurability, it seems clear enough that the ST could do that much better);

b) If, as already stated, ST is not a socially weighted average, then what is it essentially? I think the ST is the minimum value of regional time (as output) in a given class of systems. In this way, the ST has the meaning of “the narrowest/weakest link” in the input-output chain of such a class of systems (for example, science exhibits its own class of systems – how analytically those classes of systems are established is not a theoretical but a pure methodological issue). Therefore, the rhythm/pace of any regional class of systems is done by its ST, more precisely, by its “narrowest link” – we could call this rhythm/pace a fundamental one, let us note with  $b_{ST}^I$ , i.e., the fundamental ST of class I of systems (further, I shall take over this concept for more analytical examinations). More than that, if we want to talk about the productivity of a given regional class of systems, a measure of it should be somehow linked to  $b_{ST}^I$ ;



c) In a black-box-ism approach (Bunge, 1998), the ST of a regional class of systems is only revealable as the outcome of the “final” node of the network that connects to each other the systems belonging to that regional class (similarly to Samuelson’s famous concept of revealed preference in the financial market (Samuelson, 1938). Of course, an important (especially conceptually) problem subsists here: the dependence of ST on the analytical degree of the regional class of systems concerned: indeed, different segmentation of those regional classes of systems are liable to deliver different STs, so the criterion of such regionalization is very important (*Nota bene*: this is the main reason for which I have presented Table no. 1 above). In fact, the problem in this case can be reduced to a question of two criteria aimed at providing a “map” of regional classes of systems: (i) the two (matrix) criteria in Table no. 1; (ii) the degree of homogeneity of individual systems that enter the regional classes. For the objective assumed in this paper, I shall consider these conditions are verified and, consequently, we have at our disposal the six classes of sciences as they are proposed in Table no. 1.

## **2.5. Production of social time – gross social time and net social time**

### *(a) Conceptual introduction*

Therefore, any regional class of systems exhibits, as an aggregate outcome, its own ST (let us count such regional classes as  $i$ , so we have  $\overline{ST}_i^t$  – that is, ST as an outcome of a regional class of systems  $i$  at the moment, as clock time,  $t$ ). Of course, any such ST is, according to point 2.4 (b), a maximum one, since it is conditioned by the “narrowest link” within the class  $i$  at the moment  $t$ . The input from outside of the regional class of systems  $i$  is noted with  $\underline{ST}_i^t$ , so the production of ST is  $\overline{ST}_i^t = \overline{ST}_i^t - \underline{ST}_i^t$ . Let us call  $\overline{ST}_i^t$  as gross social time (GST) production, and  $\underline{ST}_i^t$  as net social time (NST) production. It should be noted that the result is as desirable as  $\overline{ST}_i^t$  (which should be negative) is less in module. The result is that any class  $i$  has its own GST and NST production, respectively. However, whatever these productions are for each of the components of the class  $i$ , eventually, what counts is the aggregate outcome (either gross or net) of the ST produced (*Nota bene*: perhaps, technically, we need an initial system/node of the class that receives the input from outside the class, as well as a final system/node that sends the output to outside the class. In principle, inside that class, there can exist a lower ST than that delivered by the final system/node but what matters is  $\overline{ST}_i^t$ ).

An interesting conclusion can be inferred from the above, namely: whatever happens inside the regional class  $i$ , from the perspective of ST occurring, the last system/node of that class is the one that delivers the ST (as GST) to the environment of the class  $i$ . This means that it is possible a *sui generis* optimization of internal flows of STs, so to minimize  $\overline{ST}_i^t$  (*Nota bene*: it is easy to notice that, unlike the standard evaluation of the output – which should be as big as possible – in our case, by the contrary,  $\overline{ST}_i^t$  must be as small as possible. This “Copernican turn” is needed, since ST is, in fact, a pure productivity).

### *(b) A two-sectoral model of social time production*

#### (b1) Assumptions:

- There are two sectors in the society: sector 1 ( $S_1^t$ ) – the sector of sciences, and sector 2 ( $S_2^t$ ) – the rest of societal activities (i.e., the a-scientific activities).

- The inputs to  $S_i^\tau$  ( $i \in \{1,2\}$ ) are  $X_i^\tau$ , and outputs from  $S_i^\tau$  (at the moment  $\tau$ ) are  $Y_i^\tau$ , where  $X$  and  $Y$  are, usually, vectors.

- STs associated to inputs vector and to outputs vector are, respectively:

$$ST_i^{X/\tau} = (ST_{i1}^{X/\tau} \quad ST_{i2}^{X/\tau} \quad \dots \quad ST_{ij_X}^{X/\tau} \quad \dots \quad ST_{i(n_X-1)}^{X/\tau} \quad ST_{in_X}^{X/\tau})' \quad (1)$$

$$ST_i^{Y/\tau} = (ST_{i1}^{Y/\tau} \quad ST_{i2}^{Y/\tau} \quad \dots \quad ST_{ij_Y}^{Y/\tau} \quad \dots \quad ST_{i(n_Y-1)}^{Y/\tau} \quad ST_{in_Y}^{Y/\tau})' \quad (1')$$

- The maximum ST is, for inputs and outputs:  $st_i^{X/\tau} = \max_{j_X}(ST_{ij_X}^{X/\tau})$ , respectively  $st_i^{Y/\tau} = \max_{j_Y}(ST_{ij_Y}^{Y/\tau})$ .

- So, we have, in fact, a single scalar input, as well as a single scalar output in the inter-sectoral flows of ST, as follows (Figure no. 1).

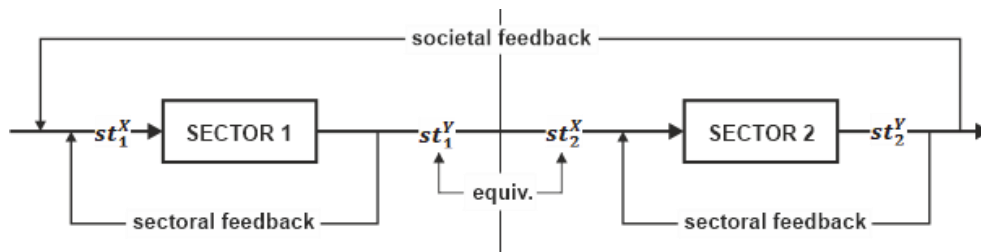


Figure no. 1. Two-sector model of production of social time.

Source: The author

(b2) Short qualitative analytics

The general resources/inputs into sector 1 are, concretely, roughly the same as in sector 2, that is, physical capital (specific material technologies), labour force, and management (information, routines, organizational culture, etc.). The crucial idea here is that the STs assigned to the three categories of input are neither additive (as, currently, they are additive by intermediation of the monetary prices, generally formed on the specific markets) nor averageable (as the Marxist concept of socially necessary time requires). In fact, the production function of each of the two categorial sectors simply particularly combines the STs of inputs to obtain the ST of output. So, from the ST perspective, the production function does not else than “calculates” the ST of the narrowest/weakest link (WL), which I have talked about. Of course, here the well-known synergy effect is acting, so there is not a direct (and, as less, a linear) proportionality between the variation of STs of inputs and the variation of the WL – so even though the result remains a vector, all its components have the same value. It should be mentioned that, if the inputs into a sector, in principle, have different ST for different components of those inputs, the output of a given sector is instead “endowed” with the same (unique) ST, regardless of its destination (for the same sector or for the “paired” one) – so, even if the output remains a vector, all its components have the same value.

Each input in the two sectors bears its own ST as an economic mark. However, the output of sectors (generated by their black boxes) is not mandatorily either at the level of the maximum,

or at the level of minimum, and, even less, at the level of an average of STs of inputs concerned. Consequently, the output's ST is a result of the production functions involved by the black boxes (*Nota bene*: things are not completely different in the standard case of monetary evaluations of inputs and outputs – see the so self-confident university handbooks). This means that the maximum ST of the output could equalize any value in the range of inputs' STs or, within that range, could take any other value.

The important issue here is that it is not mandatory that the maximum of inputs' ST be also the (maximum) value of output. However, a question arises: can be the output's (maximum) ST be larger than the inputs' maximum STs? The answer is affirmative, since the production function's performance of combining inputs depends not only on the nominal inputs' STs, but also on the certain features of those inputs related to each other: complementarity or substitutability, primness, quality and so on. Also, the management of the system concerned could deviate the output' ST far from the maximum inputs' STs. Briefly, the output's ST can take any value, either inside or outside the range of inputs' STs.

(b3) Some illustrative formalizations

Notations:

- $ST_{ij}^\tau$ : inputs of social time for sector  $i$  at the moment  $\tau$  as follows:  $j =: K$  means physical capital (including energy),  $j =: L$  means labour force,  $j =: M$  means management (including information).
- $\overline{ST}_{ij}^\tau$ : outputs of social time for sector  $i$  at the moment  $\tau$  as follows:  $j =: s$  means self-consumption (that is, consumption from own production),  $j =: a$  means consumption of ST output of sector  $i$  by (the) another sector.

Calculus:

- $st_i^\tau = F_i^{\tau-1}(ST_{iK}^{\tau-1}, ST_{iL}^{\tau-1}, ST_{iM}^{\tau-1})$ , where  $F_i^\tau$  is the production function of sector  $i$  at moment  $\tau$  (*Nota bene*: production function changes exactly with the ST change – the last is, in fact, generalized total factor productivity or, likewise, economically internalized social time).

- *Nota bene*: we shall simplify the notations, in order to easier follow the dynamic concatenations:  $ST_{ik}^\tau \equiv k_i^\tau$ ;  $ST_{il}^\tau \equiv l_i^\tau$ ;  $ST_{im}^\tau \equiv m_i^\tau$ ;  $\overline{ST}_{is}^\tau \equiv s_i^\tau$ ;  $\overline{ST}_{ia}^\tau \equiv a_i^\tau$ .

So, for the bi-sectoral economic model, we can write:

$$st_i^\tau = F_i^{\tau-1}(k_i^{\tau-1}, l_i^{\tau-1}, m_i^{\tau-1}) = C_i \cdot (k_i^{\tau-1})^{\alpha_i} \cdot (l_i^{\tau-1})^{\beta_i} \cdot (m_i^{\tau-1})^{\gamma_i} \quad (2)$$

where  $C$  is a factor of proportionality (or empirical calibration).

*Nota bene*: so, we opt for a Cobb-Douglas production function of social time, where the social time (as output) of each factor of production is associated with the elasticity of the social time output related to the involved factor of production. Of course, the analysis can be extended based on the quantitative relationships by which the three elasticities are linked to each other (the paper will ignore such developments or, alternatively will consider that  $\alpha_i + \beta_i + \gamma_i = 1$ , no matter  $\tau$ ).

(b4) Short qualitative assessment

- $st_i^\tau$  is an increasing function related to any of the three categories of input:

$$\frac{\partial st_i^\tau}{\partial k_i^{\tau-1}} = C_i \cdot (l_i^{\tau-1})^{\beta_i} \cdot (m_i^{\tau-1})^{\gamma_i} \cdot \alpha \cdot (k_i^{\tau-1})^{\alpha-1} > 0$$

$$\frac{\partial st_i^\tau}{\partial l_i^{\tau-1}} = C_i \cdot (k_i^{\tau-1})^{\alpha_i} \cdot (m_i^{\tau-1})^{\gamma_i} \cdot \beta \cdot (l_i^{\tau-1})^{\beta-1} > 0$$

$$\frac{\partial st_i^\tau}{\partial m_i^{\tau-1}} = C_i \cdot (k_i^{\tau-1})^{\alpha_i} \cdot (l_i^{\tau-1})^{\beta_i} \cdot \gamma \cdot (m_i^{\tau-1})^{\gamma-1} > 0$$

- $st_i^\tau$  is a concave function related to any of the three categories of input:

$$\frac{\partial^2 st_i^\tau}{\partial (k_i^{\tau-1})^2} = C_i \cdot (l_i^{\tau-1})^{\beta_i} \cdot (m_i^{\tau-1})^{\gamma_i} \cdot \alpha_i \cdot (\alpha_i - 1) \cdot (k_i^{\tau-1})^{\alpha_i-2} < 0$$

$$\frac{\partial^2 st_i^\tau}{\partial (l_i^{\tau-1})^2} = C_i \cdot (k_i^{\tau-1})^{\alpha_i} \cdot (m_i^{\tau-1})^{\gamma_i} \cdot \beta_i \cdot (\beta_i - 1) \cdot (l_i^{\tau-1})^{\beta_i-2} < 0$$

$$\frac{\partial^2 st_i^\tau}{\partial (m_i^{\tau-1})^2} = C_i \cdot (k_i^{\tau-1})^{\alpha_i} \cdot (l_i^{\tau-1})^{\beta_i} \cdot \gamma_i \cdot (\gamma_i - 1) \cdot (m_i^{\tau-1})^{\gamma_i-2} < 0.$$

## 2.6. Distribution/consumption of social time

By distribution of ST must be understood in the way (the quantities) in which the output of each sector constitutes inputs in the next cycle of the two sectors functioning. The hypotheses held in this matter are: a) each sector has two outflows of its output –  $\overline{ST}_{is}^\tau$  (that is, self-consumption), and, respectively  $\overline{ST}_{ia}^\tau$  (that is, the consumption of the other sector); b) the ST contained in each output of the sectors (i.e.,  $st_i^\tau$ ) objectifies its full impact just at moment  $(\tau + 1)$ , although, as known, the scientific results influence both sectors with some lags (*Nota bene*: however, such an additional hypothesis could be approached in further developments of the research). Formally, it can be written (*Nota bene*: a) parameters  $C$  are held constant for each sector; b) parameters  $x, y, z$  are relative weights with which the social time components “circulate” both from a sector to another and from a cycle to another, so that, of course,  $x + y + z = 1$ ):

- time/cycle (1):

$$\begin{cases} st_1^1 = C_1 \cdot (k_1^0)^{\alpha_1} \cdot (l_1^0)^{\beta_1} \cdot (m_1^0)^{\gamma_1} \\ st_2^1 = C_2 \cdot (k_2^0)^{\alpha_2} \cdot (l_2^0)^{\beta_2} \cdot (m_2^0)^{\gamma_2} \end{cases} \quad (3)$$

$$\begin{cases} st_1^1 = s_1^1 + a_1^1 \\ st_2^1 = s_2^1 + a_2^1 \end{cases} \quad (4)$$

- time/cycle (2):

$$\begin{cases} st_1^2 = x_1 \cdot st_1^1 + y_1 \cdot s_1^1 + z_1 \cdot a_2^1 \\ st_2^2 = x_2 \cdot st_2^1 + y_2 \cdot s_2^1 + z_2 \cdot a_1^1 \end{cases} \quad (3')$$

$$\begin{cases} st_1^2 = s_1^2 + a_1^2 \\ st_2^2 = s_2^2 + a_2^2 \end{cases} \quad (4')$$

- time/cycle ( $q$ ) (as general counter):

$$\begin{cases} st_1^q = s_1^{q-1} \cdot (x_1 + y_1) + x_1 \cdot a_1^{q-1} + z_1 \cdot a_2^{q-1} \\ st_2^q = s_2^{q-1} \cdot (x_2 + y_2) + x_2 \cdot a_2^{q-1} + z_2 \cdot a_1^{q-1} \end{cases} \quad (3'')$$

$$\begin{cases} st_1^q = s_1^q + a_1^q \\ st_2^q = s_2^q + a_2^q \end{cases} \quad (4'')$$

*Short discussion:*

It can be calculated three coefficients that quantify the following phenomena:

- Homo-catalysis generated by the science sector:  $\delta_1^q = \frac{s_1^{q-1} \cdot (x_1 + y_1)}{st_1^q}$
- Homo-catalysis generated by the a-science sector:  $\delta_2^q = \frac{s_2^{q-1} \cdot (x_2 + y_2)}{st_2^q}$
- Hetero-catalysis generated by the science sector:  $\varepsilon_1^q = \frac{x_1 \cdot a_1^{q-1}}{st_2^q}$
- Hetero-catalysis generated by the a-science sector:  $\varepsilon_2^q = \frac{x_2 \cdot a_2^{q-1}}{st_1^q}$
- Social time induced by social network into the science sector:  $\theta_1^q = \frac{z_1 \cdot a_2^{q-1}}{st_1^q}$
- Social time induced by social network into the a-science sector:  $\theta_2^q = \frac{z_2 \cdot a_1^{q-1}}{st_2^q}$

*Nota bene:* these equations could be useful to construct a bi-sectoral input-output balance.

## 2.7. Social time entropy

### 2.7.1. Efficiency, entropy, and social time

The entropy (in a generalized formulation) is a parameter of a system/process that addresses the degree of *order* of that system. Of course, the term *order* can refer to any property of the system, as the interest could be. So, it refers to such different issues as: the degree in which the energy is available (bound within accessible support) – in Thermodynamics; the probability of a sign to follow a given one – in communication; the degree to which a norm is compatible with the values of freedom and democracy – in society (Dinga *et al.*, 2020); the availability of trading strategies which can beat the market – in the financial field (Dinga *et al.*, 2022), etc.

For the sector/system called *science* (or scientific activity), the concept of entropy holds some peculiarities. Generally, the entropy signifies a spontaneous, necessary, and irreversible propensity of a closed system (as against its environment) towards an increasing structural, functional, and behavioural homogeneity. In the social field (to which science also belongs, as a macro-artifact), we have to do with, instead, not only with an open system, but with a dissipative one, as well. Therefore, to sector 1, from sector 2, come the problems to be solved,

which exert a permanent pressure on the heterogenization of the science (see, for example, the historical developments of scientific subareas, increasingly specialized/niched, starting from the ancient ‘unique’ philosophy). At the same time, sector 1, precisely in order to scientifically (i.e., generally or, best, universally) solve the problems concerned, tends to increase its structural homogeneity, through more and more synthetic approaches (namely, by creating more and more abstract and comprehensive scientific branches, e.g., the theory of systems, or the theory of evolutionism).

Consequently, two tendencies of the entropy occur within sector 1. In fact, sector 1 behaves paradigmatically (in Kuhn’s sense (Kuhn, 2008)): the problems that originated in both sector 1 (according to the internal logic of science development) and in sector 2 (according to the societal needs for solutions) push sector 1 toward increasing its entropy, in its effort to solve the challenges concerned, but this sector becomes more and more performative (namely, it acquires stronger capabilities by new scientific syntheses) precisely as a result of those challenges. It can be said that the efficacy of sector 1 is inversely proportional to its entropy, until a threshold over which the entropy decreases (while the efficacy increases) exactly caused by the new scientific syntheses evoked above. Such an efficacy (or efficiency) could be called *resolutive efficiency* (REF), and the assigned/paired entropy could be called *resolutive entropy* (REN). Regarding sector 2, the new problems (challenges) reduce the entropy (since they signify, in fact, an innovative path, which is liable to bring progress, especially for the quality of life); therefore, as much as, those problems are solved by sector 1, the entropy increases back. Analogously, for sector 2, we have a *path efficiency* (PEF), respectively, a *path entropy* (PEN). Figure 2 synoptically expresses these fundamental relationships.

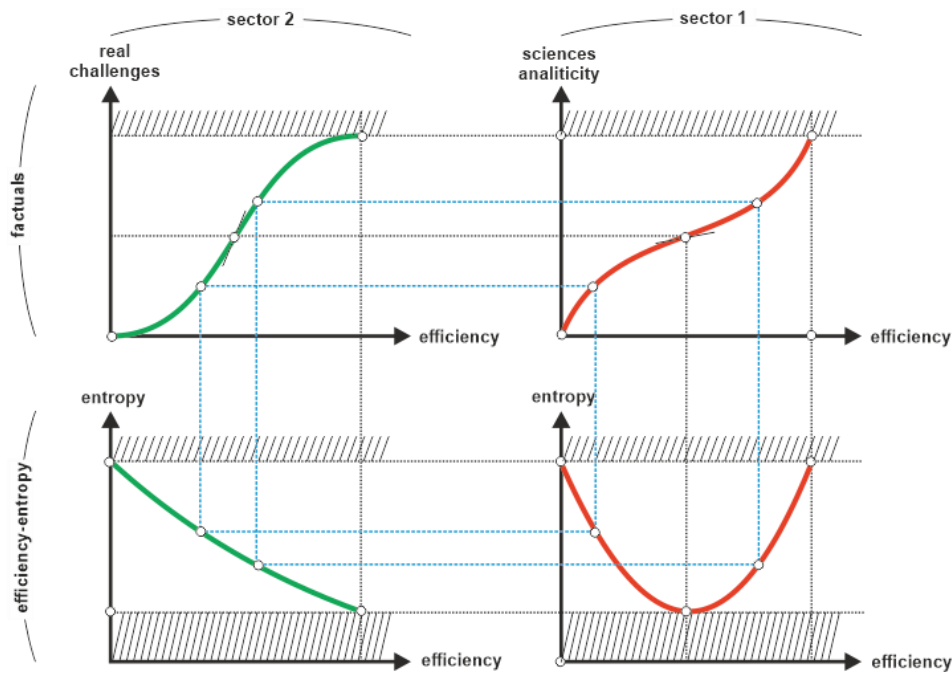


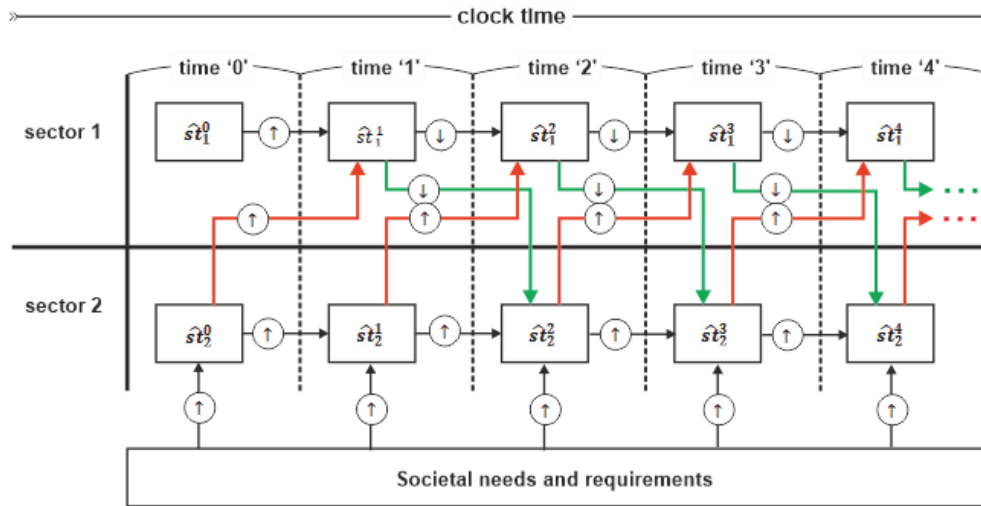
Figure no. 2. The relationship efficiency – entropy in two-sector society  
 Source: The author

2.7.2. The “mechanics”

In line with our target in this paper, it is useful to highlight the connection between entropy and social time, to arrive at the concept of entropy of social time.

- As shown, each sector has an output  $st_i$  – i.e., the maximum social time that the production function of the sector is able to get; therefore, we can say that each sector takes out its own *critical social time* ( $\widehat{st}_i^\tau$ ), at any moment, in a necessary way.
- When the critical social time increases, this is a signal for: a) a net increase of the real challenges in sector 2, which means a reduction of entropy and an increase of efficiency; b) a net increase of scientific specialization (new scientific branches or sub-branches) in sector 1, which means a decrease of entropy (till a given threshold), followed by an increase of entropy (meanwhile, efficiency is permanently increasing).
- In sector 2, at time  $\tau$ , because the increase of social needs (especially of economic nature), new products, new technologies, and new management are required, so  $\widehat{st}_2^\tau$  increases.
- As a result, based also on (3’),  $\widehat{st}_1^{\tau+1}$  increases, as result of increasing the science analyticity in order to solve the new challenges came from sector 2.
- By an (internal, *nota bene*, of autopoietic nature) self-adjustment, based on the development of new scientific synthetic (of meta view) theories,  $\widehat{st}_1^{\tau+2}$  will decrease.
- Such a decrease, following again (3’), will cause the decrease of  $\widehat{st}_2^{\tau+3}$ , and so on.
- It is obvious that, between the two sectors, a co-evolutionary process occurs; such a process should be best examined, in my opinion, under the autopoietic hypothesis of the sectors involved, including by developing the necessary concepts in case (for each sector), as: genotype, phenotype, mutations, transcriptions, translations, (genetic, epigenetic, memetic, semetic) selection, etc. (*Nota bene*: together with the input-output balance, mentioned above, such a co-evolutionary process regarding the economics of science will be approached in another communication).
- Our interest in the present paper is to identify a relationship (if possible, of causal nature) between the efficiency of each sector (which is correlated with the assigned entropy, see Figure no. 2) and their critical social time.

Based on the above, such a relationship could be synoptically represented as in Figure no. 3.



**Figure no. 3. The “motion” of the critical social time in the bi-sectoral societal model**  
 Source: The author

2.7.3. *Could there be an entropy of the social time?*

The question of whether the entropy could be assigned to the social time is relevant because, as seen above, the entropy is assigned to the efficiency of the two sectors concerned. Moreover, a new type of entropy could be identified, in a more abstract way than the current one, which is based on the availability of something, e.g., energy (see the thermodynamic entropy) or on the order of a given kind (see the financial entropy). In fact, the sought new entropy could be qualified as a *guiding entropy*. I shall make some considerations on this matter.

- in sector 2, an increase of critical social time (CST) is caused by an increase in the number of problems (in the very sense of Kuhn and Popper, here) raised by the societal challenges; in sector 1, such an increase is caused by an increase of the number of analytical (regional) sciences required to solve the increased number of problems (either own ones or came from sector 2);

- now is proved the very meaning of the denomination of the entropy assigned to CST as guiding entropy: in fact, it is talking about a self-adjusting entropy, although with a certain difference between the two sectors, namely:

- the guiding entropy (GE) in sector 2 is rather an externally oriented guiding entropy (EOGE), since it is adjusted not by the own principles/forces of sector 2, but by intermediation of sector 1 (see Figure 3). However, only a part of the problems in sector 2 are “exported” to sector 1 to be solved (we could name them as internally unsolvable problems), while another part can be and actually are solved inside sector 2;

- symmetrically, the guiding entropy in sector 1 is an internally oriented guiding entropy (IOGE), since it is adjusted inside sector 1 (see Figure 3);

- in both sectors, therefore, EG functions as a *natural automatic stabilizer* (*Nota bene*: unlike the ‘standard’ automatic stabilizers, which are discretionarily introduced by normative policies, the natural ones act spontaneously, as the concept of entropy requires).



- It can be concluded that any *CST* has its own *GE*, so the two variables are linked to each other by direct proportionality. From a theoretical perspective, like the *CST*, the *GE* cannot be absolutely measured, but only relatively, that is as a change from its previous levels (*Nota bene*: perhaps, it should be used here as a linear – not affine – relationship as  $\Delta(GE) = k \cdot \Delta(CST)$ , where  $k$  works, obviously, as a marginal *GE* related to *CST*).

### 3. Economics of science as a social time paradigm

What I have tried by now, was to suggest that an Economics of science could (or should) be an economic theory of the critical social time as this if formed and reformed in what was called sector 1 in the bi-sectoral model of the society. In the final part of the paper, some specific phenomena regarding a possible (grounded) Economics of Science will be examined, although not (yet) in their large extensionality and deep intensionality.

#### 3.1. Forming of the cost of science/scientific research

First, it must be said that the cost of science (or scientific research) is always expressed as a variation (absolute or relative, after the case) of the *CST* that enters sector 1. As shown above, the absolute level of *CST* cannot be measured (*Nota bene*: as the case with the economic value itself, by the way), but, in fact such an absolute value is neither necessary (and of usefulness), as well. More exactly, the cost of sector 1 – noted as  $c_1^\tau$  – can be formalized as  $c_1^\tau = \hat{s}t_1^{\tau-1} + \hat{s}t_2^{\tau-1}$ , where  $\hat{s}t_1^\tau$  could be considered as the fixed component of the cost, and  $\hat{s}t_2^\tau$  as the variable component of the cost (if we want to keep – harmlessly, however – the traditional microeconomic approaches in the handbook Economics).

#### 3.2. Forming of the price of science/scientific research forming

The price ( $p_1^\tau$ ) ‘delivered’ by sector 1 is of a *CST* kind, as well. More precisely, we can write  $p_1^\tau = c_1^\tau + s_1^\tau$ , where with  $s$  is noted the *critical social time saving*. It is easy to observe that  $s$  stands for the standard profit in the handbook Economics. As resulted previously, sector 1 has as behavior criterion exactly the reduction (saving) of the critical social time, by an optimal mix between specialized (regional) scientific branches and the general theoretical syntheses. In a (possible) Economics of science, the price is expected to be less than the cost, that is  $s < 0$  (of course,  $s_1^\tau = \hat{s}t_1^\tau - \hat{s}t_1^{\tau-1}$ , so  $\hat{s}t_1^\tau < \hat{s}t_1^{\tau-1}$ ).

#### 3.3. Demand and supply in the “science market”

By the syntagm *science market*, we should understand a market where the commodity traded is precisely the critical social time (*Nota bene*: to be reminded that, in any market, is always traded a single commodity). I shall make some more analytical considerations in this matter:

- Regarding the demand ( $D^\tau$ ) in the social market, its object is not a given commodity per se (i.e., *CST* as such), but some phenomenology of it, more exactly, the saving/reduction of *CST*, which was noted above as  $s$ . The bearer of demand in the science market is split into two “agents”: a) an internal “agent,” represented (as mentioned above) by the internal logic

of sector 1 (generally, autonomous related to sector 2) – let us call it *internal/domestic demand* ( $D_d^i$ ); b) an external “agent” represented by sector 2 – let us call it *external/foreign demand* ( $D_f^i$ ); so, the demand for  $s$  is:  $D^i = D_d^i \oplus D_f^i$ , where the logical constant  $\oplus$  means a logical sum, not an algebraic one, since some interferences between the two categories of demand could happen so, some synergic effects could appear.

- The bearer of supply ( $S^i$ ) in the science market is unique, namely, sector 1. This sector takes out a *CST* that is a result of challenges came from both sector 2 and itself, so, in trying to answer the  $D_f^i$ , the  $D_d^i$  is also satisfied (e.g., it is needed ad hoc improvements of methodologies or techniques or, rarer, new theoretical syntheses).

- Similarly with the demand composition, there is also a supply composition: a) an autonomous supply of *CST* (in fact of  $s$ , as already shown), let us call it *natural supply* ( $S_n^i$ ), which are inherently and spontaneously provided by sector 1, by its very nature and finality; b) a dependent on sector 2 supply of *CST* (in fact, again, of  $s$ ), let us call it *induced supply* ( $S_c^i$ ); so, the supply of  $s$  is:  $S^i = S_n^i \oplus S_c^i$  (*Nota bene*: with a similar meaning of the logical constant  $\oplus$ ).

### 3.4. Briefly, on the “science market” equilibrium

Generically, the demand and the supply of  $s$  confront within the ‘science market’, so forming the flows (formalized in 3’) in this market. Figure 4 synoptically shows the reaching of the equilibrium point of the market (*Nota bene*:  $D_d^i$  seems to behave as an order 3 polynomial – to be consistent with Figure 2 –,  $D_f^i$  has, perhaps (at least in medium-term), the form of a concave downward curve,  $S_n^i$  could manifest an exponential allure, and  $S_c^i$  has, maybe, an affine form).

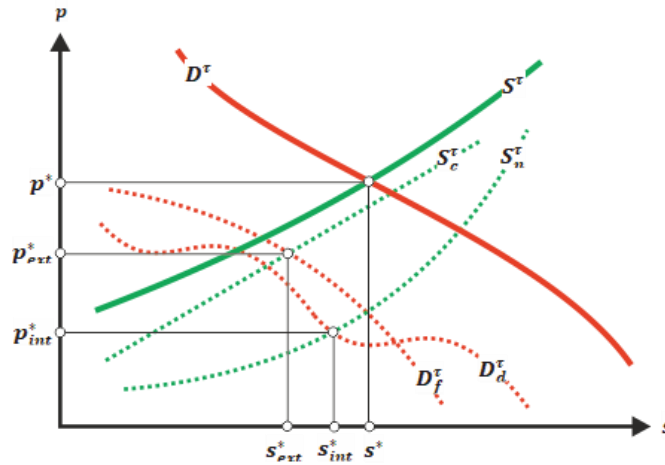


Figure no. 4. “Science market” general functioning  
 Source: The author

## Discussion

- Unlike the “standard” markets, the science market does not function as a clear *quid pro quo* mechanism (at least, *prima facie*). In other words, between the two sectors substantive flows do not actually exist, although informational ones exist. Consequently, both the demand for  $s$  and the supply of  $s$  are meanings and act in a heterodox way:

- demand acts rather as a *signal* than as a pressure, either as  $D_a^T$  or  $D_f^T$ . Obviously, from a practical point of view, simply sector 2 (and, in specific ways, sector 1 itself) asks for scientific solutions, i.e.,  $s$ , by orthodoxly paying current money for studies;

- similarly, supply acts rather as a windfall profit than a ‘classical’ offer for beneficiaries (both in sector 2 and sector 1), e.g., by publishing unsolicited scientific articles;

- information asymmetry between sector 1 and sector 2 is much larger than in ‘standard’ markets – especially, sector 2 is weakly informed about sector 1, while sector 1 could be more informed on sector 2, generally based on publicly released information;

- perhaps, the well-known ‘laws’ of demand and supply (with their allure, *ceteris paribus*, related to the price – taken over, for convenience, also in Figure no. 4) are not functioning anymore (Dinga, 2018), as suggested, as well, in Figure no. 4.

- The science market is not at all a competitive market. Although, inside the two sectors function some distinctive sub-sectors (see section Directions for further research), among which a kind of competition could arise, at the macro level we have, in fact, a bilateral monopoly (or, equivalently, bilateral monopsony), something analogous to the labour market structure.

- The price in Figure no. 4 (on the ordinate) is, obviously, the most debatable concept here; my position in this matter is as follows:

- conceptually, any price of a transaction, no matter its nature: good/service/information, etc. is, simply, an exchange rate between a unit of the commodity concerned and a number of units of a special commodity (currency, in our modern economies) which, in turn, expresses the number of units of the counterpart of that transaction;

- the price involved in the issue examined here does not address directly  $s$ , but (so to speak) the support (or bearer) of  $s$  – e.g., studies aimed at delivering a scientific solution that reduces the  $CST$ ; therefore, the price is completely exterior to  $s$ ;

- so, it should carefully avoid believing that, in the science market, sector 1 exchanges its  $CST$  with the  $CST$  of sector 2, for example;

- based on the last two allegations above, it results that the price in the science market does not express the utility of  $s$  ‘bought’ by sector 2 (or, as seen, even by sector 1); perhaps, it is correct to draw the conclusion that this commodity traded in the science market (namely,  $s$ ) is a non-utilitarian commodity (or, in the ‘worse’ case, is of a symbolic utility nature) – see, here, Robert Nozick’s suggestions on the concept of symbolic utility (Nozick, 1993).

### Conclusions

A possible *Economics of Science* must not fall into the trap of a new branch of Economics that applies to a specific field of human activity, namely the scientific one. If so, we would have not more than a Management of Science (by the way, such a discipline already exists although, in my opinion, about science can be talked about only from four perspectives, all avoiding the managerial approach: a) *historical* (Kuhn); b) *psychological* (behaviourists, including neuro-scientists); c) *logical* (Popper); d) *evolutionary* (my incipient proposal in the present paper).

Since science (as a whole) necessarily provides time savings (in thinking, understanding, praxeological actions, and practical interactions), the keystone of Economics of Science should be *social time*, more exactly, as shown above, the critical social time and, even more, the saving of the critical social time (the *s*). This recursive appeal to the concept of time (the only non-regenerable resource at the societal level) obliges us to connect the social time with the entropy, but, of course, a completely revisited entropy related to the known ones (thermodynamic, informational, financial).

Perhaps the inalienable *symbolic utility* of the *s* will lead the research on Economics of Science in a phenomenological direction (in Husserl's sense), in which perception and representation are crucial in general hermeneutics of objectifying *s*.

Production, distribution, consumption, demand, and supply of *CST* (or, in fact, *s*) have to be further analytically (including quantitatively) developed, and I hope the sketch provided in this paper could feed such a process. I am afraid, however, that the current mathematical instruments (especially the differential calculus) are not too appropriate for an Economics of Science, and, perhaps, new operators (including topological and, at any rate, evolutionary types) should be thought/invented in this matter.

### Directions for further research

The interested researchers in my approach communicated through this paper are suggested to examine, besides of their own inspiration, the following issues, as well: a) a more analytical decomposition of the two sectors, so a finer analysis of demand and supply of *s* be identified and quantified. The very structure of the science market should also be examined, including both Kuhn's paradigmatic view, and Lakatos's research program view (1978). So, maybe, a very specific new paradigm of the science sector could be built, this time, from an evolutionary perspective. For example, sector 1 could be 'broken' into: 1) fundamental research; 2) development research; 3) applicative research.

I think the symbolic utility should be much more developed in order to assign it to the concept of *s*.

An input-output analysis of *CST* circulation at the societal level, based on a more analytical structure of the society on sectors/branches, could be of scientific interest as well.

Perhaps the *Amfiteatru Economic* journal will take the initiative to host, as the editor (at a prestigious international publishing house), the elaboration of a handbook on Economics of Science that would put together the most remarkable and innovative suggestions in the matter, from across the world.

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