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RATIONALITY IN ECONOMICS – THE THERMODYNAMICS APPROACH AND EVALUATION CRITERIA

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ABSTRACTS: *Rationality is one of the most over-used words in economics. Behavior can be rational, or irrational. So can decisions, preferences, beliefs, expectations, decision procedures, and knowledge. There may also be bounded rationality. And recent work in game theory has considered strategies and beliefs or expectations that are "rationalizable". The scope of this paper is to present the rationality in economics with the thermodynamics approach and evaluation criteria. The main aspiration of this study is fivefold: 1) First we begin our description of a thermodynamics model of economics with the simplest example. 2) After that we introduced some important perception of rationality and uncertainty in economics. 3) Then we construct the mathematical model for a private ownership economy with finite sets of commodities and producers of equilibrium notions. 4) Find out the rationality and evaluation through the existence theorem for a vector of prices by using some solid evidence. 5) Finally we constructed the evaluation approach to the study of economics process by using of thermodynamics concepts, and this paper end with conclusion.*

KEYWORDS: Rationality, Thermodynamics, Econophysics, Market Equilibrium

INTRODUCTION

Lately, a large number of scientists from the field of physics started to study social systems and mostly economic systems, trying to apply methods and formalisms developed for years in their field. This effort was considered successful and gave birth to the correlation between Physics and Economics. Although not being a novelty, the existence of this relationship has been widely acknowledged [1]. However, only in recent years, the interaction of the above two scientific sectors led to a new interdisciplinary research field: what is now referred to as *econophysics*. High-frequency finance, financial risk and correlations, and complexity in finance are some fields where physics can be used in Economic theory. The tools-models which are used by physicists in economics are, among others, statistical physics, thermodynamics, solid state physics etc.

"Rationality" has played a central role in establishing the hegemony of contemporary mainstream economics. As the specific claims of robust neoclassicism fade into the history of economic thought, an orientation toward explaining economic phenomena as "rational" has become the touchstone by which mainstream economists recognize each other. This is not so much a question of adherence to any particular conception of rationality, but of taking the rationality of individual behavior as the unquestioned starting point of economic analysis. As we shall see, mainstream economics has room for various concepts of rationality ("full rationality," "bounded rationality," "substantive rationality," "procedural rationality," to list a few) and for vigorous debates over their relative merits.

The concept of rationality connects economics firmly to the Hobbesian-Lockean tradition of political philosophy, which purports to explain the political and economic organization of modern society as the necessary outcome of the interaction of naturally constituted rational individuals confronting each other as competitors for scarce resources. To avoid the terrible consequences of anarchic struggle, these rational individual actors are supposed, according to this "just so" story, to agree to the institutions of property and political authority that constitute the framework of modern society. A hallmark of these institutions is that they are in principle democratic and egalitarian (everyone has an equal right to vote or to hold property) but lead inexorably to sharp inequalities in economic well-being. An economic science whose philosophical starting point was not rational individual action would create an embarrassing discord with this political tradition. The whole point of the Hobbes-Locke "discourse" (to use the jargon of postmodernism) is to rationalize real inequalities of power and economic well-being as unavoidable consequences of the interaction of naturally constituted rational individuals confronting each other as equals. Economic science has a place in this grand project only insofar as it can relate itself to the same philosophical foundations.

The aim of this paper is to introduce a thermodynamics approach to the rationality in economics and evaluation criteria.

ENTROPY AND TEMPARATURE IN MODELS OF ECONOMICS

First we begin our description of a thermodynamics model of economics with the simplest example [2]. Let an economic system consist of N agents, among whom the income, constant for the system as a whole, is distributed. We assume that there are many ways to distribute income, and we are incapable to foresee all possible alternatives. This assumption fully corresponds to Hayek's concept of market [3] in which the market is described as an arena of discoveries of new procedures and operations. For ultimate simplicity, we assume that the income is quantum, i.e., presented in integers (which is natural, as the smallest unit of currency is operational in economics).

Hence for each value of the total income E it can correspond a quantity of modes of income distribution between the agents, as a characteristic function $n(E,N)$ of this value. This function is called the statistical weight of the state with income E.

At this stage we can introduce the concept of equilibrium. The idea is that two systems (under the above hypothesis) are in *equilibrium*, if the distribution function of income does not change when they enter in a contact, hence, there is no income flow between the systems. By a "contact" we understand here an "open list" of possible modes of redistribution. It is remarkable that it is possible to calculate the statistical weight regardless of uncountable variety of various institutional limitations imposed on the agents' incomes, so functions $n(E,N)$ may be different for different systems.

The actual income is irrelevant for the analysis, although it is possible that the restrictions on income are present anyway. Let one system with the total income E_1 have N_1 number of agents and the other, with E_2, N_2 number of agents respectively. The system which is constituted by subsystems $n_1(E_1,N_1)$ and $n_2(E_2,N_2)$, induces total income E_1+E_2 and a number of agents N_1+N_2. The next goal is to find the right conditions which can describe a state of equilibrium. Under the conceptualization of this paper, equilibrium means no flows between the systems.

In order to build up an appropriate theory, we have to adopt one more, extremely important, hypothesis on the nature of the systems under investigation. Namely, we assume that *all elementary states of income distribution have the same probability*.

The reason for that is symmetry of states. As it is the fact in probability theory and in statistics, it is assumed equal probability of elementary events because there is no reason to prefer one event over other. It is vital for the theory, to include all probable states of distribution. Changes of function $n(E,N)$ will introduce changes to results obtained by this model.

In order to identify the state of equilibrium, it is required to find conditions by which the income is not redistributed between the interacting systems. Let's consider a redistribution of income as an interaction takes place. Let ΔE be a certain part of income which, passes from system 1 to system 2. Hence, the states of the systems change and their statistical weights correspond now to: $n_1(E_1-\Delta E, N_1)$ and $n_2(E_2-\Delta E, N_2)$.

According to principle of equal probability, the most probable state of the compounded system is the one with the greatest statistical weight. The aim of this paper is to seek the maximum of the function $n_{tot}(E_1,E_2,N_1,N_2)$, under the restriction of constant total income E_1+E_2. Furthermore, by no transfer of agents from one system to another, the statistical weight of the integrated system is given by:

$$n_{tot}(E_1,E_2,N_1,N_2)=n_1(E_1,N_1)n_2(E_2,N_2). \qquad (1)$$

Since $E_1+E_2=Cons\tan t$, it follows that $\Delta E_1=-\Delta E_2$.

Instead of seeking the maximum of n_{tot}, we can seek the maximum of $In n_1 + In n_2$ we drive the condition on the maximum. It is very simple:

$$\frac{\partial In\, n_1(E_1, N_1)}{\partial E_1} = -\frac{\partial In\, n_2(E_2, N_2)}{\partial E_2} \qquad (2)$$

So, two systems are in equilibrium, if they are characterized by the same value of parameter $\frac{\partial In\, n(E, N)}{\partial E}$.

In thermodynamics, the logarithm of the statistical weight is called entropy (of the system), and its derivative on energy is the temperature,

$$\frac{\partial In\, n(E, N)}{\partial E} = \frac{1}{T}. \qquad (3)$$

In order to reach the state of equilibrium, the interacting system should be at the same temperature [4].

Now, under the above assumptions, it is needed to examine the accuracy of this approach to the economical systems. An economical system is in state of equilibrium if it is almost homogeneous and it does not imply flows from one of its subsystems to another. However, it is supposed, that the homogeneity still exists only if there is no separation into such small parts so that no major income flows are noted. A likewise assumption can be made for an economic systems. The thermodynamic model induces two important parameters; entropy and temperature. With no information about these variables it is not possible to find the correct equilibrium conditions for the system. The system is in the state of equilibrium only when its subsystems have the same temperature, but it is not possible to calculate the temperature cannot without knowing the entropy.

RATIONALITY AND UNCERTAINITY IN ECONOMICS

If the prices are formed not as a result of maximization of utility but due to the fact that certain states of the system turn out to be far more probable than the other states (have greater entropy).

Here we introduce a very important distinction concerning the types of knowledge on the situation and the types of economic decisions. The first ones are subdivided into “micro-knowledge” and “macro-knowledge” and the second ones into “micro-decisions” and “macro-decisions”. Without making this distinction it is impossible to discuss the problem in general since the character and possibilities of application of “micro-knowledge” and “macro-knowledge” are totally different and the difference in uncertainties the subject of economic activity encounters with in the domain of “micro-decisions” and “macro-decisions” are cardinal.

The owner of a shop or manager of a small firm in their search for acceptable deals is confronted with uncertainty of prices.

The prices are different in different places and since there are many possible sellers the uncertainty of the situation is related first of all with the fact that not the whole information on the market is available. Somewhere perhaps nearby there is a big lots seller capable to sell at a price lower than the ones known to the shop's owner but to find this seller in the chaos of market is sometimes very difficult.

The "micro-knowledge" is first of all the knowledge about such perhaps rare cases, the knowledge where and when one should turn in order to obtain the goods at a low price and to sell it at high price. Such knowledge is based on the connections and is a result of participation in an informal informational network. However perfect the formal system of market information would be the informal contacts and operative knowledge will always give an advantage at least because the information cannot be instantly included into the formal commonly available net and even it is, one has to be dexterous in extracting it. There is always a certain time lag between the moment of availability of a possible deal and the general spread of this information whereas the resources for making a deal may be exhausted faster than the official information becomes available. The macro-knowledge is an understanding of the global situation on the market, the knowledge of general tendencies in the developing of prices, availability of resources, possible consequences of the decisions that influence the market situation as a whole. The character of uncertainty for the "macro-knowledge" and "macro-decisions" is totally different than on the "micro" level. In many ways the economic "macro-knowledge" is determined by the ideas on the character of the economic equilibrium, in other words, the equilibrium metaphors used in the analysis of the economic situation. The character of rationality differs accordingly with the differences in the character of knowledge on the micro and macro levels [5].

The insufficiency of the model of the rational choice to explain economic phenomena becomes more and more obvious especially in connection with the growing interest to the study of economic institutions, in particular, property rights. In his time, R. Coase [6] pointed out that the economic equilibrium depends on the prices of transactions whereas the prices of transactions are directly related with the property rights, [7, 8]. Therefore the work of Coase initiated in economics an interest to the study of social institutions. It is not difficult to find out that institutionalized processes of decision-making are regulated not by a rational choice between alternatives with the help of utility functions but certain routine rules to a large extent traditional.

Thus in economic theory in addition to the "instrumental rationality" related with utility one more type of rationality appears (the "procedural" in terminology of Hargreaves–Heap). H. Simon intensively studied the procedural rationality both in his works on theoretical economics [9] and in connection with his activity related with artificial intelligence. H. Simon connected the appearance of procedural rationality with the restriction of computational possibilities of humans (theory of "bounded rationality"). In other words, being unable to compare all the possible alternatives H. Simon relies on the procedures formed from experience and they become conditional agreements that form the structure of social institutes.

Chess play is a good metaphor for an explanation of this situation: one cannot evaluate and compare all the moves allowed and one is forced to use the standard schemes, debuts, difficult combinations, general positional principles, and so on. It seems that the problem is more serious here than the near restricted ability for calculations. We think we have to admit that life is not a play with fixed rules. The list of alternatives is open: the alternatives of actions can be created by our mind. But in this case there should appear at least one more type of rationality, which we would like to call ontological rationality. There should exist certain rules that regulate the inclusion of alternatives into the list and in principle regulating generating alternatives, [10, 11].

This can be only performed if we rationalize the fact that the world in the perception of a subject possesses certain ontology. In other words, there exist certain ways to perceive what is real and what is essential and should be included into the consideration. There should also exist mechanisms for generating alternatives. Here obviously metaphors and examples are of huge importance, [10].

Apparently Hargreaves–Heap had something close to this conception introducing the notion of "expressive rationality". He wrote that the expressive rationality is defined by the universal human interest in understanding the world in which we live. It is thanks to our purposefulness we have to give sense to the world: the world must be rationally described if we want to act in it. We have in mind the necessity of a cosmology which answers the question on the meaning of this, on the foundations for that, on the interrelations of an individual and the society and so on, [5].

A MATHEMATICAL MODEL OF ECONOMICS EQUILIBRIUM

We consider a private ownership economic ε with finite sets H, J of commodities and producers, and a set A of consumers that will possibly be infinite. The commodity space is $\mathbb{R}^H$ and an element x of $\mathbb{R}^H$ is called an action, or simply a consumption, or a production if the agent is, respectively, a consumer, a product.

The set of a consumer is assumed to be positive finite complete measure space $(A, \mathcal{A}, \nu)$, where $\mathcal{A}$ is a σ algebra of subsets of A, and ν is a σ additive positive measure on $\mathcal{A}$ such that $A(\nu) = 1$. An element $E \in \mathcal{A}$ is a possible group of the consumer also called a coalition, and $\nu(E)$ represents the fraction of consumers which are in the coalition E. The first example of a measure space of consumers is the case originally considered by [12], with $A = [0,1]$, $\mathcal{A} = \beta[0,1]$ the σ algebra of Borel subsets of $[0,1]$ and ν the Lebesgue measure on $[0,1]$. This framework encompasses also the case of a finite set A of consumers, by taking for $\mathcal{A}$ the set of all subsets of A and for ν the counting measure on A, defined by $\nu(E) = \#E/\#A$ for every $E \subset A$. The standard reference on economies with a measure space of consumers is [13].

Each consumer a is endowed with a consumption set $X(a) \subset \mathbb{R}^H$, a strict preference relation $\prec_a$ on $X(a)$ and an initial endowment of commodities $e(a) \in \mathbb{R}^H$. Given the price $p \in \mathbb{R}^H$, and the wealth $w \in \mathbb{R}$, the budget set of consumer a is defined by:

$$B(a,p,w) = \{x \in X(a) \mid p.x \le w\}. \quad (4)$$

The preference relation $\prec_a$ will be assumed to be irreflexive and transitive, and the mapping $a \mapsto e(a)$, from A to $\mathbb{R}^H$, to be integrable. This allows us to define the total initial endowment of the economy to be $\int_A e(a)d\nu(a)$.

A consumption allocation specifies the possible consumptions of every consumer, hence is a mapping $x : A \to \mathbb{R}^H$ such that $x(a) \in X(a)$ for almost every (a.e) $a \in A$ and it is further assumed to be integrable. We denote by $L^1(A, \mathbb{R}^H)$ the set of integrable mappings from A to $\mathbb{R}^H$ and by χ set of consumption allocation, which is thus formally defined by:

$$\chi = \{x \in L^1(A, \mathbb{R}^H) \mid x(a) \in X(a) \, for \, a.e. \, a \in A\}. \quad (5)$$

The production sector of the economy contains finality many producers represented by their production sets $Y_j \subset \mathbb{R}^H (j \in J)$. The producers are owned by the consumers and the ownership shares of the consumers are given by integrable real – valued functions $\theta_j : A \to \mathbb{R}_+ (j \in J)$ satisfying $\int_A \theta_j(a)d\nu(a) = 1$ for every $j \in J$.

The private ownership economy ε is thus summarized by the list:

$$\varepsilon = \{\mathbb{R}^H, (A, \mathcal{A}, \nu), (X(a), \prec_a, e(a))_{a \in A}, (Y_j, \theta_j)_{j \in J}\}. \quad (6)$$

Next the equilibrium with slack (or with dividend), which was introduced with finitely many consumers by [14], in a fixed price setting, and then in a standard Arrow-Debreu model by [15, 16, 17].

An element $(x^*, (\varphi_j^*), p^*)$ in $\chi \times (\mathbb{R}^H)^J \times \mathbb{R}^H$ is said to be an equilibrium (respectively quasi-equilibrium) with slack (or dividend) $\delta : A \to \mathbb{R}_+$ of the economy ε if

a. Preference Maximization

For a.e $a \in A, x^*(a) \in B(a, p^*, w^*(a) + \delta(a))$ where $w^*(a) := p^*.e(a) + \sum_{j \in J} \theta_j(a) \sup p^*.Y_j$ denotes the Walrasian wealth, and $(x \in X(a) \, and \, x^*(a) \prec_a x)$ imply $w^*(a) + \delta(a) < p^* \cdot x$; [respectively $(x \in X(a) \, and \, x^*(a) \prec_a x)$ imply $w^*(a) + \delta(a) \le p^* \cdot x$];

b. Profit maximization

For all $j \in J, y_j^* \in Y_j$ and $p^* \cdot y_j^* = \sup p^* \cdot Y_j$;

c. Marketing Clearing

$$\int_A x^*(a)dn(a) = \int_A e(a)dn(a) + \sum_{j \in J} y_j^*. \qquad (7)$$

It is worth pointing out that the above definition does not require the (quasi equilibrium price to be nonzero as in the definition of a Walras (quasi-) equilibrium, which, with our notations, is exactly a (quasi-) equilibrium $\left(x^*, \left(y_j^*\right), p^*\right)$ whose slack d is null and whose equilibrium price p^* is nonzero. In the following, we shall also say that $\left(x^*, \left(j_j^*\right), p^*\right)$ is equilibrium with slack if we do not explicit refer to the slack function $d : A \to \mathbb{R}_+$. One notice that every equilibrium that every equilibrium with slack is clearly a quasi-equilibrium with slack.

Now present the second equilibrium notion considered in this article, which only differs from the Walrasian´s one, by the weaker market clearing condition. More precisely, we impose that the total equilibrium excess demand be less than or equal to zero, for the order relation $\leq C$ defined by a disposal cone C of $\mathbb{R}^H$, which is assumed to be closed, convex and pointed, that is, such that $C \cap (-C) = \{0\}$. we recall that order relation $\leq C$ is standardly defined by $x \leq C$ if and only if $y - x \in C$.

A free disposal equilibrium (respectively quasi-equilibrium) of (e, C) is an element $\left(x^*, \left(y_j^*\right), p^*\right)$ in $c \times \left(\mathbb{R}^H\right)^J \times C^+$ satisfying $p \neq 0$, together with

a. Preference Maximization for a.e. $a \in A, x^*(a) \in B\left(a, p^*, w^*(a)\right)$, where $w^*(a) := p^* \cdot e(a) + \sum_{j \in J} q_j(a) \sup p^* \cdot Y^*$ denotes the Walrasion wealth, and $\left(x \in X(a)\ and\ x^*(a) \prec_a x\right)$ imply $w^*(a) < p^* \cdot x$; [respectively $\left(x \in X(a)\ and\ x^*(a \prec_a x)\right)$ imply $w^*(a) \leq p^*.x$];

b. Profit Maximization for all $j \in J, y_j^* \in Y_j\ and\ p^* \cdot y_j^* = \sup p^* \cdot Y_j$;

c. C-Marketing Clearing $\int_A x^*(a)dn(a) - \int_A e(a)dn(a) - \sum_{j \in J} y_j^* \leq c0. \quad (8)$

When $C = \{0\}$, a free disposal (quasi-) equilibrium of (e, C) is exactly a Walras (quasi-) equilibrium of e. We point out that, we did not assume that then value of the equilibrium excess demand is null, that is

$$p^* \cdot z^* = 0 \text{ where } z^* = \int_A x^*(a)\,dn(a) - \int_A e(a)\,dn(a) - \sum_{j\in J} y_j^*.$$

One easily checks that this condition holds under the additional assumption that the consumers preferences are locally nonsatiated.

Next we consider [17], coalition production economy $e_c = \left\{\mathbb{R}^H, (A, \mathcal{A}, n), \left(X(a), \succ_a, e(a)\right)_{a\in A}\right\}$, where $Y(a) \subset \mathbb{R}^H$ denotes the production set available to consumer a and $Y_A := \int_A Y(a)\,dn(a)$ the total production set of the economy e_c.

We now define the notion of a weak equilibrium and assume that C is a pointed, closed, convex cone of $\mathbb{R}^H$.

An element $\left(x^*, y^*, p^*\right)$ in $c \times \mathbb{R}^H \times \mathbb{R}^H$ is said to be a weak equilibrium of $\left(e_c, C\right)$ if there exists a mapping $d : A \to R_+$ such that

a. Preference Maximization for a.e. $a \in A, x^*(a) \in B\left(a, p^*, w^*(a) + d(a)\right)$, where $w^*(a) := p^* \cdot e(a) + \sup p^* \cdot Y(a)$, and $\left(x \in X(a) \; and \; x^*(a) \prec_a x\right)$ imply $w^*(a) + d(a) \le p^* \cdot x$; ;

b. Profit Maximization for all $y_j^* \in Y_A \; and \; p^* \cdot y_j^* = \sup p^* \cdot Y_A$;

c. C-Marketing Clearing $\int_A x^*(a)\,dn(a) - \int_A e(a)\,dn(a) - y^* \le_c 0.$ (9)

We point out that we did not assume that the weak equilibrium price p^* is nonzero. The weak equilibrium $\left(x^*, y^*, p^*\right)$ is said to be a Walras quasi – equilibrium if the slack d is zero, the market clearing condition is equality, and the equilibrium price is nonzero.

RATIONALITY AND EVALUATION

As a result of mathematization of the neoclassical economics the "invisible hand" practically disappeared from the economic theory being reduced to the existence theorem for a vector of prices. The powerful metaphor of self-regulating of the market by means of individual interests which convinced A. Smith that in economics, unlike political sciences, a principle of spontaneous equilibrium acts provided an ontological justification of the economic theory for more than a century. A gradual dissolving of this metaphor in abstract mathematical constructions could not but worry theoreticians. F. Hayek returned, as we saw above, to the idea of "invisible hand" [18] suggesting to consider the evolutionary process as such an "invisible hand".

In 1950, A. Alchian published a paper [19] in which on the model level he showed how the evolution can replace human rationality. Alchian's initial position was that market uncertainty devalues instrumental rationality. He suggested to consider the process of natural selection as a means that determines which type of business activity survives and which does not. As a filter of evolution, Alchian suggested to consider the value of profit as a result of economic activity provided the successful patterns of business activity are copied by other participants of the economic process which guarantees proliferation of the corresponding pattern.

Alchian's work continues to provoke animated discussions until now [20]. Certain positions of his work were criticized: in particular, the possibility to reproduce the pattern [21] the assumption on sufficiency of the positive profit as a filter of evolution [22] but general very high evaluation of his work is based on the belief that Alchian indeed managed to return to economics the strong version of the "invisible hand".

In this way again now on the level of modern science we obtain a mechanism that establishes a rational order by a means not depending on the degree of rationality of particular participants of the process. This order is not a result of somebody's plan and is achieved by decentralized activity. Alchian's works demonstrated great possibilities of the information theory in economic analysis.

Alchian's ideas heavily influenced the development of institutional economic theory inworks of O. Williamson, D. North and others [23].

Indeed, despite an obvious attractiveness of the idea to take into account in the economic theory of the prices of transactions, property rights, and so on, it was totally unclear how to perform this in the framework of the neoclassical model of the rational choice. The difference of the institutionalized behavior from the behavior in the frameworks of the models of the rational choice is in the practical difficulty to ascribe any utility value to institutional procedures based on conventions. Even if one performs this inside the intra-institutional behavior it is still totally unclear how to relate such a utility with the effectiveness of the institution as a whole.

The idea to consider evolutionary process as a global understanding of sort which guarantees rationality by selecting and eliminating the rules of behavior unable to compete gave a theoretical foundation for the institutional analysis comparable with its force of conviction with the neoclassical equilibrium theory but essentially surpasses it in applicability to study real economic institutions. The institutional scope in theoretical economics created a considerable revival of the interest to the ideas of the "Austrian school" practically completely forgotten in 1950–60s.

Nevertheless, the evolutionary approach did not quite solve the problems that the economic analysis of market processes faced when took into account such factors as the restriction of information, restrictions in behavior related with the cultural tradition, taking into account of the prices and transactions, and so on. The heart of the problems consists in the utmost labor consuming feature of the modeling of evolutionary processes and feasible to perform only for very simple systems. Moreover, for solutions of such problems there are no developed analytical tools. Mainly evolutionary models are being demonstrated by computer simulations. This does not preclude one to make important theoretical deductions but the poverty of the analytical apparatus clearly manifests the weakness of the approach.

The evolutionary analysis deals with micro-knowledge and micro-decisions but cannot say practically anything on macro-knowledge and macro-decisions. Meanwhile it is impossible to deny the role of macro-decisions. It goes without saying that a certain spontaneous order is being developed in the process of evolutionary selection. But what to do in the cases when one has to "correct" the activity of the "invisible hand" which depends itself on certain macro-parameters, such as for example financial and taxation law, the practice of licensing of certain types of economic activity, and so on.

The evolutionary theory can hardly help in this case. The uncertainty problem and insufficiency of information on macro-level exists nevertheless and is represented perhaps at a greater scale than on micro-level. Our book is devoted to the development one more, thermodynamic, way to introduce the "invisible hand" to economics.

CONSTRUCTION OF THE EVALUATION APPROACH

In order to apply the evolutionary approach to the study of economic processes, one has first of all to have a clear structure of the evolutionary theory. This theory contains two extremely important but weakly related aspects. The first aspect concerns the birth of innovations in the system and the second one the mechanism that selects innovations.

In the theory of biological evolution, the first aspect caused a huge amount of disputes. The distinction between the principal versions of the evolutionary theory — Darwinism and Lamarkism — is related with the different understanding of this aspect of the theory. In Darwin's theory innovations are totally random whereas in Lamark's theory they are the result of education. At present we have no direct experimental testimonies in favor of inheritance of features obtained. But this does not mean at all that Darwin's theory has no difficulties.

The main difficulty of Darwin's theory is how to explain appearance of a complicated construction as a result of random mutations: such a construction consists of elements which can be only created by separate independent mutations but it gives a preference in the selection only when all the necessary elements are already present and assembled into a functioning mechanism such as a hand or an eye.

We do not have to discuss these problems here since thankfully the economic theory does not have to speak about a birth of a new structure (this is a result of human activity) but the selection problem stands in full height. Essentially the selection problem is a purely thermodynamic problem. One has to determine what is the selection of the "organisms" or the "nutritional niches" in order to understand for example how the restriction of the number of "nutritional niches" affects the distribution of the "organisms" or the appearance of new "organisms" with different properties modifies the general distribution over the "nutritional niches".

It is not difficult to see that in the process of selection evolutionary stable states are being created and we can identify them with the equilibrium states of thermodynamic systems. Since in the evolutionary approach to the economic theory there is no need to introduce notions of generations, inheritance and genes [24] the evolutionary theory applied to economics becomes much simpler than in biology.

Here we only speak about the mechanism that filters institutional innovations. As A. Alchian observed, this is a pure problem of information theory [Alc]. But due to the practical identity of the information theory and thermodynamics the problem of innovation filtrations becomes a problem of search for an equilibrium distribution function for economic "organisms" over certain "micro-parameters" determined by the structure of the evolutionary filter. Consider one more example how this idea works. Suppose we have N firms each of which being characterized by a certain annual profit e. Define the structure of the filter as follows: the profit should be positive. This is sufficient in order to construct the distribution of firms according to their incomes under the equilibrium that is, at temperature T and the migrational potential $m(T)$.

The meaning of the approach consists in a way to define the distribution function of the firms according to their incomes having given the spectrum of possible values of the income and assuming that each of these values can be "populated" by any number of firms and also taking into account that the system is in equilibrium.

The equilibrium is understood here in the sense that if we separate the system into parts according to the parameters not related with the study of income distribution (for example, considering geographical location and assuming that this parameter and the income are independent) then the distribution function is preserved under such partition of the system. In this case the preservation of the number of "organisms" or the income is inessential. We only need an empirical assuredness in the existence of the invariant distribution function for the corresponding equilibrium parameters in our case - the temperature and migrational potential.

We can consider this system as a number of systems that appear and disappear during an infinite number of equal time intervals. If we observe the stability of the distribution function of the "organisms" over the parameters of the filter this is equilibrium.

To analyze such a system the technique of the large statistical sum can be applied. In this case separating one of the states of the income and computing for it the large statistical sum we obtain

$$Z = \sum_{n=0}^{\infty} l^N e^{-n\frac{e}{T}} = \frac{1}{1- l e^{-\frac{e}{T}}} \qquad (10)$$

We consider the spectrum of possible states consisting of positive equidistant quantities

$e_n = Ne_0$. We have selected the discrete version of this spectrum to simplify the solution of the model problem.

For the probability function of a particular state of the income being filled we get

$$\langle n(\varepsilon)\rangle = \frac{\sum_{n=0}^{\infty} n x^n}{\sum_{n=0}^{\infty} x^n} \qquad (11)$$

Where $x = \lambda e^{-\frac{\varepsilon}{T}}$.

Computing this expression we obtain for above equation identical to the expression for the Bose-Einstein distribution function in the statistical physics

$$\langle n(\varepsilon)\rangle = \frac{1}{e^{\frac{\varepsilon-\mu}{T}} - 1}. \qquad (12)$$

Recall that T is equilibrium defined from the equation

$$\frac{\partial S(E)}{\partial \varepsilon} = \frac{1}{T}. \qquad (13)$$

We can compute the number of ways to fill in the income level of the systems in large placing N firms in order with the fixed level of income and therefore can compute the temperature and the migrational potential μ determine it as earlier from the condition

$$\sum_{\varepsilon} \langle n(\varepsilon,\mu)\rangle = N. \qquad (14)$$

We have obtained a very interesting distribution function. It is well known that in the systems with Bose-Einstein statistics an effect of "Bose-condensation" is observed. Namely, at low temperatures the particles condensate on the base level of the energy of the system. It is not difficult to see that in our case the same will happen.

We obtain the following expression for the occupation of the zero-th level of income:

$$n(0,T) = \frac{1}{e^{-\frac{\mu}{T}} - 1} = N_0. \qquad (15)$$

For $T = 0$, $N(0,T) = N$ we can obtain the value of migration potential μ on T

$$\mu(T) = -T\ln\left(1 + \frac{1}{N}\right) \qquad (16)$$

or $\lambda = 1 - \frac{1}{N}\left(\lambda = e^{\frac{\mu}{T}}\right).$ (17)

Having known the occupational function of the levels we can compute how many particles (firms) will occupy the non-zero levels of income:

$$N_1 = \sum_{n=1}^{\infty} \frac{1}{e^{\frac{\varepsilon n - \mu(T)}{T}} - 1}. \qquad (18)$$

Now we can obtain the value of the temperature of ´´Bose Condensation´´ starting from the fact that at this temperature the number of particles on the base level of the system is equal to the number of particles on the excited levels:

$$N_0(T_0, \mu) = N_1(T_0, \mu) = \frac{N}{2}. \qquad (19)$$

We have two equations to determine two parameters: T_0 and μ_0 where μ_0 is defined in terms of the occupational of the base level

$$\mu_0 = -T \ln\left(1 + \frac{2}{N}\right) \qquad (20)$$

And T_0 is found from the equation

$$\frac{2}{N} = \sum_{n=1}^{\infty} \frac{1}{e^{\frac{nT\varepsilon_0}{T_0} + \ln\left(1+\frac{2}{N}\right)} - 1} \qquad (21)$$

To estimate this expression we can replace the sum by the integral assuming ε_0 very small and in principle compute $T_0 = \varphi(N, \varepsilon_0)$.

Further having calculated the mean income E of the system we may obtain the dependence of the temperature on the value of the income for given N_0. This procedure means that the equilibrium condition can be expressed in terms of parameters T, μ equally well as in terms of parameters E, N.

Here only one deduction of the model is essential for us, namely at a finite non-zero temperature the lowest level of income will be occupied by a ´microscopic´ portion of the firms, i.e., in the asymptotical limit for N large we have

$$\frac{N_0}{N} \approx 0(1). \qquad (22)$$

Now suppose that conditions slightly changed for example one has to pay an additional tax for each transaction. This means that the income of each firm will diminish by a fixed value. We obtain the well-known effect of a ´´crash´´, an essential portion of existing firms cease to exist.

Observe again that the main peculiarity of the considered model is the Bose- Einstein occupation function of the values of the spectrum of possible income.

CONCLUSION

From the above discussion we description of a thermodynamics model of economics with the simplest example and it's extend to the thermodynamics approach to the rationality in economics and evaluation criteria. Then we constructed the mathematical model for a private ownership economy with finite sets of commodities and producers of equilibrium notions. Following that, we have found out the rationality and evaluation through the existence theorem for a vector of prices by using some solid evidence. Finally we constructed the evaluation approach to the study of economics process by using of thermodynamics concepts.

Here, we saw that under certain condition the system become unstable with respect to small modifications of external parameters though it is in equilibrium. Under a small increase of the price of transactions the ´´macroscopic´´ number of firms dies out.

The outcome of this research is how to use statistical thermodynamics for analysis of the performance of a filter of the evolutionary process and showed that the survival in the evolutionary theory can be described in the frames of the thermodynamics model and thus establishes a relation between the evolutionary and thermodynamics approaches to the description of economic processes.

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