Economy as a Dissipative Structure

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0. In the first part, I propose to introduce, into economics, the notion of "dissipative structure" and point out some consequences of this analysis. In the second part, I will discuss one proper feature of economic analysis. It is the question of "bounded rationality" or, in a word more familiar to mathematical scientists that of computing complexity. Finally, I will argue that new direction of economics which departs from the equilibrium theory as the framework of economic analysis.

1. The theoretical framework of economics has long been that of "equilibrium". This notion appeared as early as the first decade of the 19th century when mathematicians started to formulate economic laws after physical sciences. In the last quarter of 19th century, French economist Léon Walras presented a new method for economic analysis. In 20th century, his method called "general equilibrium theory" became the most powerful research program and most economists of this century wanted to analyze any economic phenomenon in this theoretical economic analysis.

2. Many protests and contestations have been voiced out against equilibrium theory. Some argued that it neglects the increasing returns to scale which underlies in the development of modern industries. Others contested the maximizing principle which is always supposed in the formulation of economic behaviors, both for consumers and producers. In 1970's, many eminent economists criticized the state of the art of economic science and proposed to abandon a equilibrium analysis. But, this has not been done, partly for lack of new framework and partly for fear of us loosing ready made formulae for economic behaviors.

3. New image of systems theory is requested and I think this new image should be the notion of "dissipative structure". Professor Prigogine, in his early days of his research, was interested in non-equilibrium phenomena and remarked to the dissipative structure, which appears both in space and time. The importance of

dissipative structure is evident, if one once knows that any living systems and subsystems are far from equilibrium but that they are all dissipative structure.

4. Most simple example of dissipative structure is given as the flame of a candle. Once lid, a candle continues to burn unless all wax is consumed or the oxygen is exhausted. The heat of the flame melts the wax, which climb up into the wick and evaporate as vapor and burn. This is the mechanism how the candle flame reproduces itself.

5. Dissipative structure sometimes takes the form of stationary state but it is very different from equilibrium. The latter is sensitive to boundary conditions. In the case of candle, non-lit candle is normally in equilibrium. The temperature of the flame is equal to the temperature of the flame is very different from the surrounding air. The speed of candle consumption is determined by the speed of wax which evaporates into the flame and the speed is in turn determined by the speed of wax which evaporates into the flame and this speed is in turn determined by structure of the flame itself.

6. The concept of dissipative structure is important for economics, because it makes possible to have new idea how economic system works. In the equilibrium framework, boundary conditions are imposed as constraints of the system. In the dissipative framework, boundary conditions are not directly relected to the speed of the consumptions or the extent of employment. It is instead the internal structure which determines volumes and speeds of economic quantities.

7. Most simple example is the extent of cultivated field. When there is a large surface of cultivable field and there is relatively small population, it is easy to see that whole surface is not necessarily cultivated. Some part which can be cultivated by the population will be cultivated effectively.

8. Similar situation occurs for the amount of employment. It is not the amount of labor force which determines the amount of employments, but the activity level of the economy as a whole. This activity level is internally determined by something like effective demand and so on. Keynes was the first person to realize that, in economy, it is not the boundary condition or the amount of resources which determines how much of the resources are used. This is the essence of the Keynes's theory of

employment.

9. 50 years have passed after Keynes went to other world. During these years, many efforts had been made, in vain, to harmonize Keynesian macroeconomic theory with the neo-classical micro-economics. This is a natural outcome. The micro-economics, which is based on equilibrium framework, denies the existence of internal structure such as dissipative structure. Unless we are emancipated from the framework of general equilibrium, there will be no breakthrough for a new economics.

10. If the problem is only the existence of internal structure, the economics system can be characterized as self-organizing system. But, the economy is not only a self-organizing system. Viewed as an ecological system, it is a system which constantly brings resources in and cast waste off. Economic activities are based on the constant flow of energy and materials. So the economy is also a dissipative structure.

11. Now, I want to bring your attention to a more proper aspect of economic analysis. It is the question of complexity. Nowadays, the complexity is the topical theme. It is argued in many fields, ranging from abstract dynamical systems analysis to the brain studies and others. So, you may think my statement strange. Complexity is no proper topic of economic science. It is true. But, in economics it is necessary to distinguish three layers for complexities. The first layer is the system's complexity. Most of the natural and engineering sciences focus their attention to this layer of the complexity. The economics is more concerned about the second layer of complexity. It is the question of computing complexity which underlies in any consideration and decision-making. The third layer is epistemological in its character. It is the question of complexity which limits our efforts to understand any object whatever. So, it is more related to epistemology than to economics and natural sciences.

12. However may they seem unrelated, al three layers are, in fact, different aspects of the came mechanism. A system is complex because its behavior surpasses our ability of analysis. Epistemological complexity emerges from the limits of our intellect. Economic agent faces the same situation. He or she tries to find out a best solution but this maximum problem often requires too long a time of calculation. The only feasible choice is to find out a shortcut. This is related to the limits of our reasonings

and calculations.

13. The proper difficulty of the economics is that the complexity is the real condition for the economic agents. This is not true for physical and chemical sciences. In the engineering sciences, maybe the robotics is concerned with the same kind of problem. In order to make a robot work, it is necessary to install a controlling sub-system which works in real time. So the designer is required to invent a simple but workable self-controller. Ethology and human behavioral sciences are all conditioned by this limit of rational calculations, or in another word by bounded rationality.

14. If we consider the boundedness of our rationality, it becomes rather evident that our behavior is not directed by a decision made once for all. It is a continuous sequence of adaptive adjustments, which will be organized according to rough program of purpose pursuit. Consequently, the theoretical framework of the economics should be reorganized as process analysis. Equilibrium analysis has been the obstruction for the economics to proceed to this old but still new direction.

15. The notion of dissipative structure will be helpful to change the state of arts of the economic science. It provides us a new image of self-reproducing systems. It will orient our reasoning to a new direction. On the opposite side, if unbounded rationality is assumed, then the general equilibrium reasoning will remain convincing to many economists. So the problems of complexity are related to dissipative structure viewpoint in such a way that the two will help each other to promote the new construction of economics.