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A NEW LOOK AT THE PROBLEM OF MACROECONOMIC SYSTEM EVOLUTION

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Abstract: There are many approaches, techniques and tools related to the process of forecasting macroeconomic system evolution (development); however, the history of economic science shows that all of them have been strongly influenced by classical physics methodology. The paper analyzes the modelling possibilities of the long-term macroeconomic system evolution based on the results obtained in the past few years in modern physics, synergetics, the theory of nonlinear dynamic systems, the theory of irreversible processes far from the state of thermodynamic equilibrium, etc. The paper discusses the basic general-system rules and laws of development in the context of the macroeconomic system evolution modelling. It shows the time structure of this process drawing attention to its continuous-step character and the quantitative-qualitative changes taking place in it. It focuses attention on the determinism and stochasticity of the macroeconomic system development process as well as on the role of complexity and nonlinearity, stability and instability in the course of this process. Special emphasis is put on the need of changing the traditional way of thinking of economists and considering economic problems frankly from a stochastic point of view.

Key words: macroeconomy, development, qualitative-quantitative changes, classical physics, modern physics, synergetics irreversibility, determinism, stochasticity.

1. INTRODUCTION

In recent years an increasing amount of attention has been directed towards obtaining improved methods for macroeconomic evolution analysis and a large number of models of macroeconomic system (MES) evolution have been proposed in literature. It is known that use of these models has, on occasion, proved fruitful and rewarding, but it is also well known that it has, not infrequently, proved misleading and led to improper decisions and undesirable consequences. A serious limitation of classical theories of economic development as general tools for the description of MES evolution lies in the fact that their methodology is based on the principle of mechanistic determinism. As a consequence of this, classical approaches to the modelling of MES evolution assume an unambiguous and inflexible link between past and present, and result in models which reflect only quantitative aspects of macroeconomic development. The quantitative aspects of economic phenomena are examined by political economy with the help of mathematical and statistical methods, but these methods, however important, should not be overestimated. Any economic phenomenon has qualitative and quantitative aspects, which are in close connection and interdependence, in dialectical unity. The qualitative aspects express the essence of economic processes and prevail over and determine the quantitative ones. In their turn, quantitative changes sooner or later lead to the emergence of qualitatively new phenomena in economic relations. So, although mathematical methods play an important role in the research on the qualitative aspects of economic problems, both on the microeconomic as well as on the macroeconomic level, they cannot be dominant in the examination of the long-term MES evolution. Thom (1975, p.322) states that "... very few phenomena depend on mathematically simply expressed laws ..." and that "...even when a system is controlled by explicit laws of evolution, it often happens that its qualitative behavior is still not computable and predictable..." Therefore, it is not sufficient to formulate and to study the problems of MES evolution in a purely mathematical way. Such an approach, isolated from the qualitative changes in the MES, would be a very dubious basis for scientific prevision of the most probable changes in the state, structure and dynamics of the macroeconomy, of social requirements and production possibilities, of the trends of technical progress, of the size and composition of the population, of natural resources, etc.

The purpose of this paper is to give a critical assessment of the usefulness of quantitative methodology as a tool for the analysis and modelling of long-term MES evolution, and to sketch the outline of a new quantitative-qualitative methodology that might ameliorate the major weakness highlighted by the assessment. The approach is based on the conceptual apparatus of systems analysis, synergetics, thermodynamics of irreversible processes far from equilibrium, bifurcation and catastrophe theory, etc.

2. INTERACTIONS BETWEEN ECONOMICS AND PHYSICS

There are very important interdependencies between economics and physics. According to Tintner and Sengupta (1972, p.9), "the history of economics (...) shows that this social science, which has attained a certain amount of maturity, has been profoundly influenced by contemporary developments in the natural sciences, especially physics". Johansson, Batten and Casti (1987, p. 1) make a similar point: "On occasions, economic theory and modelling has adopted concepts and research strategies from the natural sciences, in particular from classical physics. A growing circle of economic theorists have recently been inspired by some other developments within the natural sciences. (...) Approaches and concepts introduced in the models are inspired by recent contributions to physics, chemistry and theoretical biology. Moreover, techniques for rendering the analysis of dynamical systems more tractable have been imported and adapted from the natural and engineering sciences. however, the problems so addressed are firmly rooted in the economic discipline with a special focus on technological change, business cycles, economic development and grawth" In recent decades we can identify many other economists and mathematicians who have tried to analysis the influence of Newtonian physics on economic theory (Schumpeter, 1954; Blaug, 1962; Franksen, 1969b,1974; English ,1974; Willems, 1974; Bereziński ,1980; Bereziński and Kruś 1986 ; Zurawicki, 1987 a,1987b; Bereziński and Petriczek ,1987). In particular, English was concerned with extending fundamental laws of Newtonian mechanics into the domain of economic. Speaking of interdependencies between these disciplines he says (English, 1974, p.279-280): "In the physical sciences certain causality relationships have been found to be invariant and as a consequence were formulated into laws that always hold true under certain well defined conditions. Very often the underlying principles on which the laws hold were not understood until long after the law was formulated. In the meantime the usefulness of the relationships was valid in that they satisfactorily explained observed phenomena. (...) While controversies have occurred in physics they have lasted only so long as it took to show that the physical phenomena could be explained in alternative ways provided that the constraining conditions are adequately described. The fundamental consition is that the phenomena are always predictable within limits of statistical variations with their measurement. In economics no such happy state of affairs seems to exist as yet. In almost every aspect of economic theory one finds strong differences of opinion on the validity of opposing hypotheses. These develop emotional adherents to one school or another. (...) The very fact that controversy can exist at all is evidence of a lack of valid theory. As soon as it is possible to demonstrate a single exception to a theory, that theory is by definition invalidated. Thus a valid economic theory is incontrovertible and not subject to debate".

These quotations show quite transparently that the development of classical economics was strongly inspired by problems based on phenomena in the fields of classical physics and engineering. In a typical classical physics problem, the variables of the system are seen to satisfy a system of well- defined deterministic relations. All parameters of the problem can be assumed known or accurately measurable, and one seeks to determine the relations between them in order to predict exactly what will happen in similar or analogous circumstances in the future. Until recently economists were primarily concerned with just such deterministic problems, problems that could be solved by the methods and techniques of classical deterministic mathematics.

Clearly, however, these deterministic methods and techniques are not altogether suitable for the economic science, which typically presents problems involving uncertainty or randomness and variability. It is therefore inevitable that economists should be concerned prominently with such stochastic disciplines as theories of probability,stochastic processes and statistic, cybernetics and synergetics, statistical physics, ect. These disciplines are the natural tools for the analytical investigation of problems arising in the economic science. It is now no longer exclusively classical physics and engineering, but also modern physics, chemistry, biology and such relatively young interdisciplinary sciences as synergetics, that signal new promising directions for economic research.

A particular question that arises concerns the future relation between economics and modern physics. Tintner and Sengupta (1972, p.10-11) say: "It is not our intention to criticize economic deterministic models, just because they are (somewhat feeble) imitations of classical deterministic physics. It is perhaps unavoidable that all other sciences are powerfully influenced by the most successful science, and this was undoubtedly physics in the 19th century. (...) But if we contemplate contemporary rather than 19th century physics we must observe a great change. True enough, relativity theory is deterministic and constitutes perhaps a powerful ending of classical physics. But since the rise of quantum theory modern physics has otherwise become stochastic, that is, uses the results of probability theory. This makes the results of classical physics not useless. The law of large numbers assures us that, if the number of particles is large (and for macro-systems it is enormus), deviations from the mean values (mathematical expectations) will be small. This explains the continuing success of the methods of classical physics in engineering. Similarly, we might argue that deterministic economics must be considered as dealing with the mean values (mathematical expectations) of the random variables, which really characterize the economic system. (...) But is this assumption realistic ? (...) We propose to follow the example of modern physics and to consider economic phenomena frankly from a stochastic point of view, that is, treat economic variables as random variables".

The origin of mathematical economics, involving physicalization and mathematization of economic phenomena on the basis of quantitative laws, is connected with Newtonian dynamism, i.e. with the differential conception of motion. The outstanding representatives of classical economics regarded the establishment of immutable economic laws as the most important task of this science, believing them to be the foundation of economics. Consequently, the development of economics, of its fundamental theories in the first place, was - to some extent - like the reduction of its theoretical content to the foundations of classical physics, especially classical mechanics. No wonder that the existing models of economic development are purely qualitative models which purport to substantiate the interrelation between the technico-economic categories of reproduction and the rates of its expansion. But these models are too rough approximations to the process of economic development and reflect nothing but the qualitative effect of technological progress on economic growth. The extremely abstract character of the models of economic growth and the narrowness and unrealistic character of the initial prerequisites are the principal reasons why theory of economic growth is in deep crisis today.

We have already mentioned that the ideas of most economic theoreticians have been vitally influenced by classical deterministic physics. But during the last decades physics itself has changed. Modern physics has become stochastic "but the bulk of economic theorizing still persists in the construction of deterministic models, especially in the field of economic development (...) . There seems to be a cultural lag of more than 50 years between economics and physics (Tintner and Sengupta,1972, p.28).

In modern physics, the idea of development permeates all its branches and areas. In the light of this discipline the development of economic systems is governed by the general and objective laws of dialectics. . These are the laws of development by passage of quantitative changes into qualitative ones, interruption of gradualness, leaps, negation of the initial moment of development and negation of this very negation , and repetition at a higher level of some of the features and aspects of the original state. From the standpoint of modern physics, the development of economic systems, both on the micro and macro level, is a process where the essence of dialectics manifests itsels in the most diverse forms. The correct dialectico-physical approach to the study of economic development differs from all earlier theories of economic growth in that it regards development as the result of the internal contradictions between the progressive way of economic development and backward economic basis, between the need to use foreing private capital and its adverse effect on the national economy, etc.

From the view-point of modern physics, the description of the development process which assumes that the past and the future play the same role is wrong. The belief in this conception would result in the necessity to recognize the second law of thermodynamics as the obligatory law of economic development. In accordance with this law the direction of economic development should be clearly determined by the direction of the growth of entropy, by the desire to bring the economy to the state of thermodynamic equilibrium. The achievement of this state would mean the transition of economy to the most unfavourable position, as the state of thermodynamic equilibrium is the state of full spontaneity. Therefore, economic development should not follow the law of entropy growth. The course of economic development should entirely differ from the direction which results from the laws of classical physics. Economy is a consciously organized system kept in a state which is far from the state of thermodynamic equilibrium. Besides, it is a large-scale system requiring the coherence of the processes taking place in it, the coherence which is necessary for economic life.

According to classical physics the fundamental laws of physics are symmetrical in time. The adoption of this rule would mean the acceptance of the reversibility of economic processes. In the light of modern physics and synergetics all development is an irreversiblle process in the result of which economy, as an open system, has the ability to continuously organize coherent structures and to selforganize.

Economic development takes place in time. Classical physics offers very poor models of development, too simple in relation to reality. These models are based on the statement that if the state of economy was sufficiently known at a certain moment, the future states of economy could be foreseen and the past states reproduced. There is no need to explain that this kind of forecasting in economy is impossible. It is not true that the current state of the economy contains the full information about its past and future. The situation is quite different: the future of an economy is not a component of its past. Therefore, the future state of an economy cannot be precisely forecast. It is only various possible development scenarios that can be foreseen.

We have another comment connected with the notion of time in classical and modern physics as methodologies of modelling development processes. One should be, first of all, aware of the fact that in classical dynamics time always appears as an external parameter of a system without any separate direction. Classical dynamics does not render it possible to draw a distinction between the future and the past of a system. This can be done only on the ground of thermodynamics which considers research objects in the context of their continuous formation. The second law of thermodynamic introduces a special physical concept - entropy which assigns a direction of time (time aa arrow). Entropy determines the difference between the past and the future of a system. Apart from the external time, introduced within classical thermodynamics, modern thermodynamics introduced the conception of another time as an internal variable., characteristic of a given system. With this approach to time and with two states of a system, the state with a corresponding higher value of entropy can be considered as older. The allowance for these facts in the modelling of economic development processes is an inevitable necessity. The irrevesibility of development processes is the basic form in which stochasticity manifests itself in a macroscopic scale. Stochasticity is characteristic of every macroscopic phenomenon and system. Their internal time is unseparably related to the fluctuation processes which take place in macroscpic phenomena and systems. By fluctuations we understand the deviations of dynamic system characteristics from their average values.

3.STOCHASTIC DETERMINISM OF ECONOMY

All of the phenomena taking place in an economy are causatively conditioned. But one should not draw a false conclusion from this true thesis believing that there are only necessary relations in an economy. This is not the case. Randomness plays a specific if only limited part in economy and its development. If necessity expresses only significant relations between economic life elements and a permanent trend in the development of economy , the behaviour of every single element in the economy is influenced by significant relations and trends and many other factors. Randomness has no foundation in significant properties of economic life elements and in significant relations between them. Unlike necessity it is not prepared by the hitherto, historical course of economic development. A random phenomenon in economiy and in its development is the phenomenon that can occur under certain circumstances but does not have to. It can occur in this or another way.Randomness in economy and its development is a form for necessity to manifest itself.It does not stand in opposition to necessity but complements it. It happens so because all general properties of economy and its development, all regularities show through unitary properties and relations.

The rule of stochastic determinism is of key methodological significance for the research on the MES development forecasting and shaping. This rule shows that the construction of the long -term MES development forecast is the penetration through events and random relations into what is necessary. It is also the discovery of the objective regularities of system development and their formulation in the form of laws, which make it possible to understand the genesis of the existing state and draw conclusions as to further MES development. In the light of this rule the MES development is a determined process. Yet, this is not Laplacian determinism, negating the objective character od randomness and treating the variety of causes and effects in economy as mechanistic interaction without taking into account the quantitative aspects of economic phenomena. It is necessary to adopt the principal of stochastic determinism which is based on the recognition of various types of causality in economy depending on the character of economic regularities. The Soviet economist , Suslov (1978, p. 56-57) criticized the deterministic trend in economic modelling drawing attention to the absolute necessity of recognizing probability as one the main conceptional categories in economic science. He said: "Our literature expresses the point of view which rejects probabilistic processes in social life as well as the possibility to use probabilistic methods to get to know this social life. To justify this point of view it is said that the movement of individual phenomena in social life is not disorderly and random but results from human conscious activity. These arguments are far from convincing. Human conscious but undetermined behaviour does not exclude randomness in social processes (...). If we remember that, as a rule, conclusions are formulated and decisions made in the conditions of incomplete information ,it becomes clear that social phenomena cannot be understood in any other way but only within the framework of probabilistic conception. Society is a complex, dynamic system which develops under the influence of both necessity (which makes it deterministic) and many random factors (which provide it with random properties)".

4. COMPLEXITY AND NONLINEARITY OF THE MES DEVELOPMENT PROCESS

The shaping of the long-term MES development is a complex process, that is, a process among whose elements there is at least one decision-making subprocess. Numberous and various direct and indirect interactions take place among these elements. This complexity is characterized by the irreversibility and stochasticity of MES evolution. The first property expresses the fact the mathematical model of MES evolutions is not symmetrical in relation to the algebraic sign of the time variable. The second property is the expression of the fact that this process is, continuously, subject to more or less random deviations from the assumed trajectory, due to the social-economic-ecological environment. Considering their duration, the deviations can be subdivided into short - and long-lasting ones in relation to, for instance,the considered range of time. The influence of these deviations on MES development is not the same. It should be remembered that although by means of the averaging operation we can eliminate the study of the direct influence of short, random deviations from the assumed MES development trajectory on the system development process, we must not ignore their contribution into the formation of whole,symetric, macroscopisc properties of the development process. This is very significant because it is these short deviations and the necessity of their efficient removal that result in the dissipation of all kinds of energy (mechanical, chemiacal, human, organizational, etc.) accumulated in the system.

Considering the irreversibility of the MES development process the long-lasting deviations can assume a system character, particuraly when they are large. Under their influence the MES can pass into an undesirable state.It is necessary to continuously follow the course of the system development and prevent it from both the perament presence of short and seemingly insignificant deviations and the occurrence of long-lasting deviations. Any success in this respect will,first of all,depend on the correctness of the MES development strategy and the resulting trajectory of the purposefully produced changes in the state of this system.

The study of the long-term MES development is aimed at determining the most rational systematic mode of purposeful changing of the macroscopic properties.It is generally believed that in view of the fact that in the macroscopic description we are dealing with average values,the role and significance of random deviatons disappear in this description. This opinion in not always true. It particularly does not apply to the development of the systems of purposefull operation (including MES), where random deviations are of considerable significance. The closer the state of the system to the point of the multifurcation (in a particular case- befurcation) of the development trajectory, in which it is necessary to make a conscious choice of one of the alternative development paths, the greater the significance of random variations.In the neighbourhood of the multifurcation point the statistical law of large numbers stops applying. This law makes it possible to operate on average values and to use a deterministic description. The decision determining the further course of the MES development is, from this point of view, a conscious step to prevent the effects of the law of large numbers acting in the multifurcation point neighbourhood.

What we see an important feature of MES development is the nonlinearity of this process. A typical model of this process is a suitable nonlinear differential equation (usually a deterministic one). According to the opinion held to date this model can be used for the clear definition of the state of the development process at any moment provided that we know the initial condition. Modern physics and synergetics have shaken this point of view showing that there are nonlinear deterministic processes which are unforcastable in this sense that even a very small change of the initial condition can result in obtaining a quite different trajectory and that in a long period of time the solution of differential equations describing these processes can behave in a chaotic way (Haken, 1983). The phenomenon of chaos is one of the most interesting problems of the modern theory of nonlinear dynamic systems. The results of the study of this phenomenon obtained to date throw a different light on all of the problems related to the long -term forecasting of the development of purposefully acting systems and processes. The nonlinearity of the MES development process is closely connected with the fact that the process in purposefully kept far from thermodynamic equilibrium. As opposed to the situations close to the state of thermodynamic equilibrium, with one stable state of the process corresponding to them, the real MES development process is characterized by many stable states (multistability). These states depend not only on initial values but on the whole history of MES development. Thus ,what should be recognized as methodologically incorrect is the elaboration of forecasts for long-term MES development on the basis of an arbitrarily chosen period of watching the process trajectory in the past (e.g. on the basis of the time series characterizing the process behaviour in the past few years with ignoring the deeper past,particularly the periods of economic slumps followed by transition periods which are always accompanied by structural changes in economy. The future trajectory of the MES development is not a simple extrapolation of the time series (multidimensional) showing the course of this process in the past. It is necessary to consider the whole time series becoming longer with the passage of time, treat it as a set of information about the development process, identify development mechanisms which result in this and not any other form of the series, find the causes of this and not any other behaviour, determine the nonlinearity form of the development process in various periods, assess the degree of the process coherence with the series illustrating the behaviour of other elements of the country's economic system, identify the periods of progress and regression, etc. It is only on the basis of such a detailed and complex analysis of the historical MES development that we shall be able to find the tendencies and counter tendencies for this process in association with alternative scenarios of the country's economic development.

5. STABILITY AND INSTABILITY OF THE MES DEVELOPMENT PROCESS

Long-term MES development is not a pure process of the growth of quantitative characteristics. What essentially characterizes the MES are the qualitative changes taking place in it (technical, technological, organizational, structural, etc.). With the passage of time the systematic change in the value of the MES parameters is accompanied by slow qualitative changes until the moment has been reached when, with a given system quality, there is no chance for further quantitative changes.

The continuity of the system development is broken , the quantity changes into quality which is expressed by the occurrence of the transition period, in which the so-called development leap takes place. The MES reaches a new quality with the process of monotonic quantitative changes repeating but on a new qualitative level. The MES development process can be expressed by the sequence of development cycles occurring alternaively with transistion periods. Gradual quantitatively-qualitative changes of the system characteristics take place in development cycles with the MES undergoing a leap transistion onto a qualitatively different level after each cycle has been completed. The leaps in the MES development process can take place spontaneously but they should occur at the moments and in the mode which is most desirable from the point of view of the MES and the whole economy. Therefore ,from the standpoint of controlling this development. it is important to study the mechanisms which govern the quantitatively- qualitative MES changes and particularly the relation between MES development stability and instability (appearing with certain values of the control parameters). Both the stability and instability are the driving factors of MES development. Since MES development is an irreversible process, its hyperstability would cause the supression of all deviations from the state of equilibrium , making development impossible. The development process would take place permanently in the state of equilibrium or in the states very close to it. In order to pass into another state the MES development process must loose stability at some moment,that is, become instable.On the other hand,this does not have to be constant instability, because it would exclude the ability of the MES to adjust itself to the changing conditions in the environment.

6. CONCLUDING REMARKS

The present paper has been aimed at providing a comprehensive picture of the problems related to the long-term forecasting of MES development with particular emphasis on these elements which, in the light of modern physics and synergetics, can be subject to mathematization (periods when the law of large numbers does and does not work, nonlinearity, dynamics, randomness, quantitative-qualitative changes, stability and instability, structural changes). The following conclusions can be drawn from the discussion presented in this article:

1) The models of the MES development process should represent the spiral character of this process and quantitative-qualitative changes taking place in it.

2) The models should show the continuous-step character of the development process and should reflect the openess, complexity, nonlinearity, dynamics as well as the irreversible and stochastically determined course of this process.

3) In view of the fact that in the process of long-term MES development the relatively long cycles of statinary, balanced and stable development alternate with much shorter transition periods in which radical structural changes take place, it is necessary to elaborate separate cooperating models for development cycles and transition periods.

4) The application of econometric models for the forecasting of the MES development trends within long time ranges must result in errors, because in the transition periods, in which qualitative leaps take place in the MES, the law of large numbers stops acting.

5) The usefulness of econometric models for MES development forecasting inside development cycles is even higher when their duration is shorter and the development process more stable within these cycles.

6) Since MES belongs to the systems of purposeful operation, the stochasticity of MES long-term development should not be seen as pure randomness but as the distortion of necessity.

7) What turns out to be a significant and necessary element of forecasting long-term MES development is the study of the mechanisms governing this process in the past, identification of development cycles and transition periods with their duration as well as the identification of the MES evolution tendencies and counter tendencies in different phases of its historical development.

8) What we see as the driving force of this development are the contradiction between linearity and nonlinearity, between the desire for stability and instability of the MES development.

Modern physics, synergetics and mathematics have at their disposal the formal apparatus making it possible to show all significant properties of long-term MES evolution. What we see as particularly useful in this apparatus are the theories of bifuraction and catastrophes, the qualitative theory of dynamic systems including deterministic systems characterized by stochastic behaviour(deterministic differential equations of chaotic dynamics), the theory of irreversible processes being far from thermodynamic equlibrium, statistical physics and quantum mechanics. We know that the abstract apparatus of these disciplines seems to be too complicated for economists. We understand the difficulties in modifying the traditional way of thinking of economists, based on classical physics, and with breaking away from the traditionally accepted and time - honoured system of concepts of the economic science. Anyone who starts studying economic phenomena from the point of view of modern physics, synergetics and mathematics, encounters a kind of psychological barrier. Nevertheless, we feel certain that for contemporary economists acquitance with the fundamentals of these disciplines is necessary because of greatest importance for the future development of the economic science and the need to consider economic problems from the modern point of view.

The paper merely outlines the idea of application of these disciplines in modelling long-term MES development. Further studies on this subject are being carried out in the theme "Modelling of complex processes of the country's development for the needs of forecasting" in the Systems Research Institute at the Polish Academy of Sciences.

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