ECONOMIC SYSTEM AND INDETERMINISM

1 Economy as a Dynamic System

DEFINITION OF AN ECONOMIC SYSTEM

If one would like to avoid the difficulties of this way of defining the system, then he may respond to the question, "What is the given system?" by paraphrasing the mathematicians' answer to the question, "What is mathematics?" "Mathematics," they respond, "is what mathematicians study." Thus economy is that which is studied by economists.

Another definition of an economic system that follows a thornier path arises from the methodology of the systems approach described in the introduction to the book.

First of all, there is no "given once and for all" definition of an economic system. Attempts to formulate one ultimate definition give way to a pluralistic mechanism of search for the most relevant definition (Katsenelinboigen, 1989). The gist of this search mechanism is the following: the initial stage involves the construction of a possibly expanding set of definitions. Subsequently, specific investigative objectives determine the choice of the most pertinent definition from the set. If the definition is found lacking over the course of a given investigation or the objectives of the analysis shift, then the employed definition is replaced by another one borrowed from the above mentioned expanding set of definitions.

Then, following the systems principle of expansionism, one could generalize the definition to delimit a suprasystem that embraces a given system.

The suprasystem can be arranged in two ways, functionally or structurally.

Immersion of a system into a functionally organized supra-system explicitly distinguishes a set of implied elements comprising the system. Our particular case spotlights the fact that an economic system is a system whose participants are people.

In principle, economic considerations apply not only to mankind, but also to animals, insects, and even to the realm of self-acting systems in the inorganic world (Heinrich, 1979; Pryor, 1981; Rozonoer, 1973). We shall consider a subset of definitions that enlist people as participants of an economic system.

In our particular case, immersion of an economic system into a functionally structured suprasystem entails the discernment of the various interrelations between the economic system and the social system and nature that interact with it directly. Our subsequent analysis is predicated upon this implied interface between the economic system and its suprasystem.

The next step is to employ the systems methodology to construct a set of plausible definitions of an economic system (limited by the above qualifications). The constructed definitions ought to take the following aspects into account: function, structure, process, operator, and genesis. Every definition of a given system can be formulated from a different perspective.

One can concoct a rough definition of an economic system and then compare it with the existing definitions. This approach might reveal certain deficiencies of the existing definitions as well as rectify those of the newly devised ones.

The method that I picked is different. I began with a critical examination of the prevailing definitions of economics from the standpoint of the above mentioned aspects of a system. In the end, we arrived at one possible generalized definition of an economic system. That most of the existing definitions incorporated just one of the relevant aspects justifies this approach.

Now, the systems methodology directs us to pick one (or several) definition from the diverse set of previously constructed ones. In case we are dealing with several definitions, each definition must be inspected in terms of some particular aspect of analysis in order to distinguish certain features peculiar to it. We can then construct a new definition that represents a combination of the discovered characteristics.

However, I was deprived of this choice, for I am not familiar with any attempts described in the literature to construct a definition of a given system following the charted method. As a result, I can only advance my own definition of an economic system. So, let us embark upon an analysis of the existing definitions from the various perspectives of the systems approach.

From the functional point of vie, *Encyclopedia Americana* (1986) attempts to define economy as a system that produces and distributes material goods, energy, and services. “Economic systems are forms of social organization for producing goods and services and determining how they will be distributed.” But what about such services as national defense? Is the direct output of this area military

or economic? Perhaps the economy is restricted only to the production of goods directly necessary for survival in our struggle with nature? How then to delineate these goods? To what degree is music necessary for survival? Is it not sometimes more valued than material goods?

From the structural point of view, the economic system is defined by the *Great Soviet Encyclopedia* (1978) as the totality of all the sectors of production. "Economy. National economy or some part of it incorporating particular branch(es) and modes of production."

From the process-oriented point of view, the economy is understood as a system in which limited resources are allocated (Moffat, 1976). In many economic publications this definition of the economy is not given directly, but rather via a definition of the theory that studies it, that is, through a definition of economics. "ECONOMICS. Most definitions are similar to: examining the allocation of limited resources for the satisfaction of UNLIMITED WANTS of man" (p. 94). But people are concerned with the distribution of limited resources in all their activities. Therefore this can scarcely be considered the hallmark of economics.

Kenneth Boulding (1970) sought to give a more specific operational definition of the economy, stressing the method of resource distribution. This he considers to be exchange: "the economy of the econosphere . . . consists primarily of that segment of the sociosphere which is organized through exchange and especially commodity exchange" (p. 11). The exchange of goods, as a particular case of exchange, according to him assumes relations under which "I will give you something that you want if you will give me something that I want" (p. 10).

In this instance only the market represents the economy. At the same time Boulding (1970) notes that each organization in society, even if its internal operation is based on nonexchange principles, is an economic actor inasmuch as it participates in the exchange of goods. In that sense a centrally planned system is an economic system only to the extent that the state represents one of the participants in relations of exchange within as well as outside the country.

But condition of exchange is not sufficient to define an economy. Relations of exchange have their place in many other aspects of human activity as well. Thus in a notable number of sociological works, social relations are interpreted as relations of exchange (Hingers & Willer, 1979). The detailed particularities of relations of exchange must still be elaborated in order for them to satisfy the demands of definition as an economic system.

According to another work by Boulding (1968), relations of exchange can be considered economic if they satisfy the necessary condition of being "relatively clear and measurable." But even with

this more limited concept of exchange the definition of an economy proffered by Boulding seems to me to narrow the class of economic systems because it is limited only to market-type mechanisms.

One could generalize the concept of economic relations stemming from interactions among specialized participants and these relations as "relatively clear and measurable" transfers of goods independent of the social relations resulting therefrom. In this case all the same processes that in Boulding are accomplished via horizontal mechanisms (markets) could just as readily be handled by vertical mechanisms, most particularly by centralized planning making heavy sue of such institutions as prices and money.

An economic system is sometimes (*Encyclopedia Britannica*, 1983) defined from the same process-oriented point of view as the aggregate of all institutions that organize economic life. "An economic system may be defined as the sum total of institutions and patterns of behavior that organize economic activity in society." Taking this into account, it is possible to introduce the concept of an economic mechanism and say that it is characterized by the sum total of institutions that are based on the type of economic relations defined earlier.

As far as the operator aspect of defining an economy is concerned, that is connected with the emphasis on the substances used to carry out economic processes, that is, natural resources, capital, and labor. Thus, in one definition of an economy (Farjounn & Machover, 1983), the stress is placed on human labor as the decisive particularity of economic processes.

> Labour is, *par excellence*, the essential substance of an economy, and should therefore be taken in economic theory as the fundamental yardstick. . . . The science of economics, taken in the most general sense, is concerned with the study of the social processes and structures by means of which and through which social labour is organized and performed, and the output of this labour distributed and allocated to various uses (p. 85).

I do not wish to negate the enormous role that labor plays as a factor in economic processes. However, its exaggeration and the underestimation of the role of the other factors can lead to the construction of economic theories that prove internally contradictory. This observation is completely applicable to the labor theory of value. It is no accident that the authors of the above definition of an economy seek to reinstate this theory using rather modern analogies from physics.

Finally, let us turn to the genetic aspect of defining an economic system, although by itself it apparently has no impact on this

definition. At the same time it shows that a definition of an economy does not have to be associated with a rigid, hardened system. As economic relations in the sense indicated above broaden, so the area encompassed by our definition of an economic system expands. For instance, the realms of education and medicine were long regarded as outside the scope of economics. The creation of such disciplines as "the investment in the human capital" assigned this realm to the potential sphere of economics. The orbit of economics is constantly expanding to include the multistage sphere of R&D. At one point, when science and invention were the task of a few scattered individuals, when the time lag between basic science and its practical implementation was considerably longer than today, economic science concerned with the economy proper tended to focus on the application of the inventions in the production of final products. Today the R&D sphere is fast becoming subject to economic analysis. This shift is evidenced in the work of Edwin Mansfield (1977), a well-known expert in the economics of innovation.

In summation, an economic system can be defined as that part of the human social system in which the production of goods (material as well as nonmaterial) takes place within the framework of limited natural resources, labor, capital, and knowledge, with the economic mechanism predominating. In this connection it is important again to underscore that the economy as a system cannot be reduced to an economic mechanism. It includes a plethora of various mech-anisms, such as administration, but the economic mechanism predominates.

NORMAL AND PATHOLOGICAL ECONOMIC SYSTEMS

Development of an economic system requires an appropriate mechanism of performance; without it the system is doomed to disintegrate. This brings us to a rather interesting classification of economic systems — healthy and sick on the one hand, and normal and pathological on the other.[1]

A healthy system is a system that operates according to the will of the people, provided, of course, they are not oppressed by the authorities. A sick system is a system that deviates from the will of the people. No doubt this condition is very difficult to verify, but let us for the moment assume that the distinction is valid. In some cases this requirement can be verified; for instance, if the system decreases the amount of material goods while people seek an improvement in their material well-being, this system could be considered sick.

Another dimension is the normality-pathology duality. Pathology, as manifested by socioeconomic systems can be defined (Gharajedaghi, 1985) in the following way: "The inability of lack of

desire in a government/management of a social system to remove a persistent obstruction to development that can be removed by a change in either (a) the way the system is organized and/or (b) its social or physical environment" (p. 71). What distinguishes a pathological system from a normal one is the inability of the former (within the means available to it) to maintain normal operation and handle adverse situations. Sickness is not equivalent to pathology, which refers to the inability of the system to treat its ills.[2]

The two dichotomies mentioned above (healthy-sick, normal-pathological) give rise to four possible combinations, only one of which is logically inconsistent — an economic system that is at the same time both healthy and pathological.

Let us extend this classification of economic systems to capitalist and socialist systems in particular. In terms of the classification given above, the Marxist view of capitalism is that it is both unhealthy and pathological. Capitalism is plagued by such ailments as economic crises, unemployment, homeless people, inflation, prostitution, and crime that cannot be rectified within the system and condemn it to failure. Marxism generally regards the socialist system as being both healthy and normal.

Of course, this view of social systems is rather radical. Let us add a few shades to the Marxist black and white picture of the world and try to pinpoint both advantages and disadvantages inherent in these two types of systems. Under this more moderate approach (still within a Marxist framework) the flaws of capitalism — its ills and pathologies — would eclipse what could be called its healthy and normal features. Under socialism, the reverse is true.

This view of the world reached its peak of popularity in the 1930s. The deep economic crisis that engulfed developed capitalist countries in conjunction with World War I, which preceded it, and a general degradation of morals were a result of the development of capitalist countries and can in no way be attributed to any communist plot. At that same time Soviet Russia was starting a program of rapid industrialization with mushrooming cities, a deficit of labor power, and optimistic songs sung by millions. That all these "accomplish-ments" were accompanied by the destruction of a strong peasantry and a subsequent bacchanalia of political trials over the so-called "enemies of the people" was viewed by liberals as some unavoidable by-products associated with growth. In other words, liberals saw capitalist ills as a confirmation of the pathological nature of Western societies whereas those suffered by the USSR were considered temporary evils associated with growth — ills of a normal society. In retrospect it is easy to see how difficult it was for liberal intelligentsia to understand which structure is pathological and which is normal. Also all the afflictions plaguing the Western world were exposed in the free Western press, which only aggravated the apocalyptic mood

aroused by current events. At the same time, the Soviet press was subject to rigid control by the party apparatus. Deaths of millions of people were tightly concealed, so extreme liberal circles may have even considered news of genocide in the Soviet Union as a hoax fabricated by the enemies of the new regime.

Now in retrospect 70 years of history have shown which system, from the standpoint of a Western liberal, is normal and which is pathological. The Western world has managed to overcome at least the critical stage of its diseases although they are still present and continue to cause much distress. Soviet society has fallen into an era of stagnation.

BREAKS IN THE ECONOMIC NETWORK

Creative Nature of Processes Unfolding in the World

Economic literature is replete with notions of the economic system as, primarily, a system based on a fixed set of products and the means of their production, which can function within the framework of complete and noncontradictory mechanisms. Mean-while, the economy is a dynamic system. It is host to processes of evolution related to creation of new products and the means of their production; at the same time the processes of evolution do not in themselves have to be complete and noncontradictory. Study of the processes of evolution in the economic system can be aided by their perception in the general context of the world's development.

Metaphysically, one may approach the dissection of the world around us through the premise of its perfection in the sense that there is completeness and noncontradictoriness in the mechanism of its functioning. In this case, imperfections in the world are merely the result of the imperfection of our epistemology of comprehending the world; hence, the researcher's task consists of finding the kind of epistemology that would allow the discovery of the world's perfection. That was precisely what characterized Leibnitz and Einstein where the physical world was concerned. An analogous approach has often been suggested during the construction of new socioeconomic systems. Notions of human perfection and the existence of paradise on Earth, coupled with the extremely imperfect organization of existing human society, nurtured the creators of socioeconomic utopias, who claimed to use the scientific method in dealing with the development of society.

Metaphysical notions of the perfection of the world around us can turn out to be heuristically precious for the formation of quite important conceptions. Einstein's theory of relativity is the best example of this. At the same time, considerable dangers lurk within

these given notions, particularly when they are applied to the world around us as a whole. They often create the illusion that the world's perfection can be discovered with one last stroke and then all problems will be eliminated forever and ever. The oft-proclaimed completeness of physics or the dream of building a communist society can serve as examples of attempts to discover such a completed notion of the world.

Examination of the world can also be approached on the basis of the metaphysical premise that the world around us is imperfect but evolving. Here, in turn, two extreme viewpoints are possible. According to the first, the world's mutability can be attributed to the fact that within the framework of extant methods of interaction not only are the known structures repeated, but also, due to accidental breakdowns in these methods and external accidental changes, accidental new objects are created. At the same time, scant attention is paid to the changes of methods of interaction on the basis of metamethods of changing these methods.

According to the second extreme viewpoint, a creator completely regulates the mutability, that is, completely and noncontradictorily accords what is being created (new and old) with what had previ-ously been created. It might even be recommended that this regulating not be exposed, for the ways of the creator may turn out to be inscrutable.

However, one may admit the premise that between these two extreme ways of changing the world there are internal evolution mechanisms of various types, leading to the creation of the new, but with incomplete and contradictory regulation. In other words, in the world there are always ongoing changes and creation of the new, and this mutability will always contain discrepancies — incompleteness and contradictoriness. These discrepancies are only removed in certain relatively enclosed portions. The ever increasing participa-tion of physicists, and inorganic scientists in general, in the study of the evolution of the inorganic world promises significant discoveries in this respect. A global theory like the Big Bang, as well as specific works dealing with various portions of the inorganic world, for example, the evolution of minerals (Zhabin, 1980), constitutes attempts to probe for new approaches to the development of the inor-ganic world. Of course, methodologically speaking, these attempts are based on deterministic notions of complete and noncontradictory cohesion of the world. Were we to speculate, it would be admissible to discuss the mechanisms of creativity in dealing with the inorganic world akin to the creative evolution of the living world, according to Henri Bergson (1911), on the whole and of human society, in particular.[3]

However, the relative slowness of the unfolding of processes in the inorganic, and even in the biological, world hinders their

comprehension as creative processes. In the economic system the evolution proceeds incomparably faster and more visibly, and it is, therefore, much easier to discover all sorts of complexities of creative processes there. Everything said above leads me to the idea that the dynamic world of the economic system can be viewed as accelerated photography of general evolutionary processes in the world around us. This approach feeds the hopes that economics will not just be, for the most part, a consumer of ideas from other sciences but that, in turn, ideas derived from economics will to an ever greater extent fecundate other sciences (Tugan-Baranovskii, 1973).

Needless to say, such metaphysical notions of the basis of evolution of the world are an act of faith. They are quite speculative as far as the physical world is concerned; they are considerably more substantiated for the biological world, and will probably prove to be justified, for the most part, for the economic world.

Below I would like to explore some of the causes of the appearances of gaps in the ties of the economic system with its suprasystem and, to an even greater extent, within the economic system, moving from the premise that economic systems are characterized by omnilateral mutability both with respect to external resources and the forces guiding it and to the internal changes taking place within it.

External Breaks of the Economic System

First of all I would like to touch on the changes in the guiding forces of the economic system, that is, the predispositions of people in time (as well as in various countries).

These guiding forces will be distinguished on the basis of whether in a given society the resolution of human problems is sought through the change of the environment — extrovert culture — or through changing the Individual's inner world — introvert culture. However, no matter how the guiding forces defining economic dynamics may be assigned, there remains the question whether they can be tied together into a single complete and noncontradictory network. This is relevant for both the past and the future. In dealing with the past, it remains unclear whether such networks can be constructed with the information available. That there is no single complete and noncontradictory conception of the economic history of humanity is testimony to the difficulty of constructing such a network. But even if such a network could be successfully constructed, when considering the conditions of equifinality it would be far from saying that this network necessarily reproduces what had taken place. At issue is only the creation of a complete and noncontradictory system. Furthermore, can a network like that be constructed for the future? Is it possible to give a forecast

for the entire boundless future and to possess the decisive rule that would guarantee that changes will proceed only in a given direction? Is it possible to at least know all events ahead of time far enough (or to possess the decisive rule guaranteeing the direction of changes) that, no matter what events take place beyond the visible horizon, they ill not exert any influence on our behavior in the period limited by this horizon?

Thus, in the conditions of people's predispositions changing in an uncertain manner and their changes of values of various benefits, be they spiritual or material, aimed at military might or improving the standard of living, it is apparently difficult to construct a single network of changes in human values eternally applicable.

Everything said about the absence of complete regulation in the changes in human values is also relevant to changes stemming from another external source — nature. At the same time the latter changes can be even more unregulated and unexpected because it is not clear how the eternally changing world can influence the inputs of the economic system on our planet.

However, I would like focus on the internal changes in the economic system related to its scientific and technological aspects (including organizational changes among the latter). This intention is motivated not just by the enormous role of these processes in the development of the economy; it also possesses important general methodological significance.

INTERNAL BREAKS IN THE ECONOMIC SYSTEM

Two Sources of Development of the Economic Network

Our analysis of the role played by the economy's inner processes in instrumenting complete and consistent reticulation of its subdivisions follows an outline and incorporates a number of highly simplified assumptions.

Initially, an economic system could be represented as a system in which the production of final goods — from consumer goods to military means — is carried out directly. This means that a person, using his own body, wrests from nature the products he or she needs. Remnants of this kind of process still survive — I refer to the collection of wild berries, mushrooms, and the other gifts of nature. This kind of system of production consists of a number of parallel links, brought together in the person of the individual worker. Thereby a link (Ashby, 1956) is a unit of the economic system com-prising the what, the from what, the by what methods, and the operators (the combination of man and tools) — all part of the process of transformation.

As man developed, or perhaps at the time of our very origin, multilink production chains formed between nature and the final product. They are characterized by increasingly refined technologies composed of many stages in the processing of nature's material and the creation of many intermediate products before the final good is obtained. These chains were engendered primarily by the production of tools, among these second-order tools, that is, tools for making other tools.

However, the production chains thus formed were in many ways isolated, parallel, and comparatively short. Making both the tools used in them and the intermediate products versatile transformed this mass of production chains into a unified network.

Inasmuch as this network was at the start sufficiently transparent, a change in any one of its links could be directly connected with the results in terms of final production. As such networks grew, became more complicated, and there appeared in each link degrees of freedom as to the production of different goods and consumption of different resources, it became no longer possible to directly relate the changes in each of the links with the results. In response to this, more refined methods were created enabling us to measure indirectly the influence of changes in any arbitrary link exerted upon the final outcome. This kind of projection allows for an autonomous development of a given link. In other words, it enables a given link to select from its feasible space of alternatives the path that comprises a constituent fragment in the chain of effective development of the network as a whole. Subsequent integration of this complex economic network is conducted via horizontal and/or vertical mechanisms. At this point the actual mechanism (hori-zontal, for example, market, or vertical, for example, planning) that integrated the network is completely irrelevant. The existence of invariants is crucial. One such invariant is the institution of prices. Prices guide the movement of each separate, autonomous, self-acting link in the direction of coordination with the development of the system as a whole. Prices are able to fulfill this function because they are global parameters reflecting, in condensed form, information about all aspects of the Economy's performance.

In general, a network can be developed by moving backward from the goal to find the ultimate criterion of development for the entire network. In moving from the goal back toward the beginning, the network's set of feasible spaces is defined.

One of the revolutionary steps in the history of human consciousness occurred at the moment when our development had reached such a stage that we could ask ourselves, "Why not begin parallel development from the start? More exactly, why not develop a network in parallel taking any arbitrary link as a starting point, assuming it impossible to construct any local criterion that would

allow that link's development to be tied in a complete and consistent manner to the rest of the intercoordinated network?" This kind of parallel approach (akin to digging a canal from both ends) could reap tremendous rewards. You see, at the earliest stages of development, that is stages closer to nature, the network contains some links that produce more universal goods. If the modernization of these links could be achieved earlier, it could accelerate development of the system.

However, these tremendous gains exact a heavy toll. The problem is that at the beginning the potential benefits may not be entirely clear. This means that the immediate connection does not exist between the starting link and the rest of the world, or in terms of our preceding discussion, the stage of development individual links have achieved is not complete and consistent with the existing network. For this reason the development of the starting link easily could be fruitless or reach a dead end.

The two-fold source of development — from the beginning and from the end, coupled with the described inconsistency of the process of development of the network both from the beginning and from the end — is not the exclusive prerogative of the economic system. These features are characteristic of the creative process in general. In fact, in a number of areas of human endeavor, this two-fold source of creation was tapped much more amply than in economics.

Before I proceed to discuss the two-source origins of development drawing upon the history of the field and the relevance of the results for the analysis of the economic system, I'll try to formulate the notion of the measure of development of a given field. First, we must uncover the degree to which the development of a given field is directly subordinated to the solution of the applied problems arising in that field, that is, to movement from the end point, and the degree to which in this field the abstract building blocks and operations are defined and their combinations researched (movement initiated at the beginning).

Obviously, both approaches are more developed where the given field is more developed. In contrast, if in a field of activity only one approach has been developed, that field is still at an earlier stage.

The matter becomes considerably more complicated in finding weights of each approach that are probably indistinguishable from the long-term perspective and may hold different value at some particular stage of development. On the one hand, the respective weights depend on the extent to which a lack of fundamental indi-vidual pioneering ideas or lack of a deductive scheme, designed to conceptualize the findings in the R&D sphere, impede development. The rival factor, which also affects the assigned weights, is the amount of the available resources. But no matter how these approaches are tallied up, it is apparently acceptable to say that the

most developed scientific or artistic fields are mathematics, painting, and music because both approaches are represented in them to the highest degree.[4]

On the Depth and Breadth of the "Two-Source Origins" of Development of the Economic Network

One could assume that as the network develops, the breadth of duality increases. This is supported in particular by the fact that the rate of growth of the fields of fundamental science have outstripped that of production to such an extent that a new area has emerged — engineering. Until the day when science exercises a directly decisive influence over the development of production, it will continue to be allocated too few workers and resources. Given these conditions, the field of science may be ignored except to utilize the innovations it produces as they emerge.

In this connection it may also be noted that the paradigm of the development of economics is in many ways comparable to that of biology. In biology the Darwinist model has held sway for the past century. According to this paradigm, the source of change in a system is random mutations; the main element is natural selection, which follows the principle of survival of the fittest; and existing mechanisms reinforce inherited traits.

For a long time economics made use of an analogous paradigm. It was assumed that technological and organizational change occurred spontaneously and in an isolated fashion (even a barber could obtain a spinning loom, the machine that played such an enormous role in the industrial revolution). The main control is the competitive market mechanism that winnows out the less fit innovations. The presence of organizations reinforces the results of this selection process and provides for its regeneration.

Under the influence of new conditions the paradigm in biology is changing. The development of molecular biology and the uncovering of genetic structures is allowing us to observe the internal mech-anisms of change. They are connected with such discoveries as jumping genes, retroviruses, introns, and z-genes. These discover-ies do not negate the mechanism of random mutation but merely restrict the realm of its applicability. At the same time it is becoming clearer that conflict and competition for survival as well as cooperation and collaboration play a role in the mechanism of natural selection. Finally, successes in genetics are letting us better understand how selected-for traits are reinforced.

Something analogous is going on in economics. It is becoming clear that a new sphere within the economic system is being recognized. It is connected with the development of science (both fundamental and applied). This does not negate the role of random

inventions and minor changes. They continue to coexist with science, comprising an important part of the sphere of improvement. As far as selection from among the innovations is concerned, the forces of collaboration and cooperation are at work alongside those of conflict and competition. This is especially pronounced in the formation of all sorts of professional societies and clubs. Finally, a great variety of different types of organizations is being created to support the regeneration of the process itself.

One could assume that as this or that area of human activity develops, the depth of duality of the network decreases, that is, fewer links remain that are not closely connected to their results. Take, for example, science. At first it was developed in universities and academies. Meanwhile, in recent decades science has started to be intensively developed in firms as well. Initially in the private sector it bore mainly an applications-oriented character, but gradually there, to, it began to delve into more basic issues. This shift in the relation of companies to basic science has been dictated to a large extent by the circumstance that the number of links separating fundamental science from its application has been sharply reduced.

An extremely vivid turnaround in this respect took place during and after World War II. Take, for example, the enormous successes in technological development after World War I, the development of the automobile industry, aircraft construction, and tractor building. All this to a large extent was the result of engineering genius. Of course, in the final analysis scientific ideas were the basis for all these innovations. But too many intervening links lay between science and production for the inventors and the industrialists to establish direct connections. The creation of the atom bomb was in this respect a new phenomenon. Outstanding scientists and engineers worked together in order to produce it because, without the direct incorporation of fundamental scientific findings, it would have been impossible to solve the engineering problems.

This kind of reduction in the number of links between fundamental science and its embodiment in the form of final products has also occurred because applications have become possible on deeper levels. What is called fundamental science, including pure mathematics, belongs precisely to the research of deep layers. Therefore, because of the development of physics, biology, and artificial intelligence, a correspondence is emerging between the discoveries in the realm of pure mathematics and their applications. The development of the theory of elementary particles, of molecular biology and genetic engineering, and of cognitive processes in psychology and their connection with the newest trends in mathematics are all examples of this bridging of science and its applications.

Of course, some gaps still exist between basic science and its applications, but the quantity of extra links existing between them

has been remarkably reduced. This major turning point in the history of science could be very dangerous because it compresses the lag between basic research and its application. However, even a small number of links creates problems in relating basic research to its applications. Chess players realize how difficult it is to solve Loyd's problems, although they know the solution exists and that it can be achieved in a limited number of moves — three or, at times, even two.

All these deliberations regarding the causes of gaps in the economic network lead us to the problems of survival, growth, and development.

SURVIVAL, GROWTH, AND DEVELOPMENT

The principal approach to searching for the best value of the beautropy function must reveal the conditions under which the search is conducted and then find the set of methods best adapted to these conditions. The counterapproach is to devise a uniform method of search, that is, a general method of solving the problem. This leads us to the following rather rough classification (Ackoff, 1981) of the dynamics of an economic system denoted by three categories (logical variables) — survival, growth, and development.

From the functional point of view, survival represents an extreme case with emphasis placed on maintaining a minimum level of vital parameters comprising the system. Growth presupposes an increase (as judged by a preset criterion) in the values of parameters already incorporated into the system. Development is concerned with creating favorable conditions for the future, in other words, with creating the potential of the system that may give birth to a new system with an even greater potential.

The functional definition of development given above has a direct connection with the previously discussed breaks in the economic network. If such breaks have not taken place and if it has been possible to link all parts of the system, the category of growth (and its extreme case, survival) could be sufficient to characterize the dynamism of an economic system. The other approaches to the definition of development also confirm the last statement.

From the structural point of view, survival is aimed at preserving the existing objects; growth indicates an increase in the number of existing objects; and development implies a variety of objects (with new ones appearing in the course of development) as well as their interrelations.

From the process-oriented point of view, survival is a search for a stationary state; growth must facilitate the creation of a complete and consistent mechanism of coordinated growth of the sought-for variables; and development implies the creation of a mechanism that

supports both the creation and the resolution of incompleteness and inconsistency in the existing mechanism.

From the point of view of evolution, survival, growth, and development are all interrelated but are, at the same time (at least to an extent), independent characteristics.

Let me clarify this point. A economic system can indeed survive in a stationary state for a long time. Take, for instance, the various tribes of Africa or Australia. They have managed to survive for many hundreds of years while living in a rather stationary state. Their success can be attributed to a number of factors: their religion, which reconciled an individual with death (disappearance of the body) — both his own as well as his close ones; population growth limited by means of birth control, wars, and, especially, disease having a very significant effect on the size of the population; and the ability to generate positive emotions directly by means of some easily accessible stimulants, such as drugs. All this was accomplished in the absence of any technological changes in the means of production (in some instances, technological innovations were explicitly prohibited). Particularly interesting in this respect is the history of India, a country that for the last 2,000 years and up to the present has followed a similar course of development.

Now try altering one major component without making corresponding changes in all the others, and the system is doomed to degrade, if not perish altogether. An example of this situation is the rather recent demographic boom resulting from medical interven-tion involving many countries and many tribes that have thus far lied under rather stationary conditions. Moreover, an economic system that, because of a scarcity of resources, cannot rely on a purely extensive growth of its components to develop must resort to technological improvements and, therefore, face problems associated with development.

For this reason, long-term survival is impossible without growth, and long-term growth presupposes development. Proceeding in the backward direction, it is obvious that long-term development as well as long-term growth require survival. There is still a question of whether long-term development is necessarily accompanied by growth. This seems indeed to be the case if only because long-term development presupposes survival, and survival is impossible without growth.

The categories of survival, growth, and development being interlaced does not alleviate the problem of their respective priority in analyzing the workings of an economic system. Widespread is the view that the key objective is survival, both for the economy as a whole as well as its individual sectors (and the firm in particular). Naturally, survival is vital, because it is the prerequisite of all else. We can even look at growth and development from the standpoint of

survival. Nevertheless, I am a proponent of the primacy of development with growth and survival allotted a subordinate role. One reason for this is the psychological role of the mind-set that exerts a tremendous influence on the focus of the decision makers.

Perhaps, a specific example will clarify the point. A few years ago I happened to meet some leading executives from the Clark Corporation. At the time, the firm was suffering a deep crisis and was, in fact, on the verge of bankruptcy. Under the circumstances, survival would seem to be the most pressing aim thus focusing the attention of the firm's top echelon upon eliminating all unnecessary current expenditures. However, the mind-set of the firm's leader, James Rineherd, a man who has successfully combined academic and practical thinking, was geared toward development; survival was viewed only as a prerequisite. As a result, cutbacks initiated by the firm were carefully screened so as not to cutback the firm's future. Naturally, firm leaders realize this vital provision. But it takes an unusual gift to actually implement the idea of development, especially when the firm is threatened with bankruptcy, and to make survival and growth aims subsidiary.

This raises a very pertinent question: "Why distinguish between the notions of economic growth and economic development?" One reason to do so is suggested in the above-mentioned book by Ackoff (and Gharajedaghi, in collaboration with Ackoff), namely the need to differentiate between the quality of life and the standard of living. The first category corresponds with development; and the second one, with growth. While these two notions are interrelated, higher quality of life does not automatically imply growth of the standard of living — a person can sacrifice material well-being in order to improve the quality of life.

The present work focuses on the process of development. Analysis of the means of development of the economic system and of the respective methods of measuring it constitutes the core of the book. The remarks I have made at the beginning of the section regarding the multifaceted systems approach, especially its structural facet, may baffle the reader. The thrust of the book is upon all these diverse aspects of the process with respect to development.

NOTES

1. The elaboration of these definitions is largely due to Russell Ackoff and arose as a result of the collaboration between him, Jamshid Gharajedaghi, and me in the course we taught (on social pathology) in the winter of 1982 at the University of Pennsylvania.

2. Equating pathology with illness is not uncommon as demonstrated vividly by Kenneth Boulding's definition of pathology: "Pathology is the study of ill health and can easily be extended to the study of the ill health of the society — that is, conditions that are almost universally recognized to be bad" (1981, p. 17).

3. A growing number of physicists (Johnson, 1989) believe that one cannot confine the study of the physical world to just the categories of matter and energy; in their opinion, the category of information, too, should be introduced into the study of the development of the physical world.

4. In mathematics both-ended development is visible over the course of practically its entire recorded history. One of these ends was the need to solve practical problems, land surveying in particular; the other was the desire to explain the harmony of numbers as such. In Egypt the development of mathematics was driven by practical needs, such as geodesy and construction of pyramics. Greek mathematics, Euclidean and Pythagorean in particular, professed aloofness from reality and the purity of mental constructs. Pythagoreans espousing the credo that "the world is ruled by numbers" despised any kind of application. Only in the nineteenth and twentieth centuries, on a deep level of penetration into mathematical structures, did the two approaches begin to fuse together to achieve cross-fertilization, for example, with number theory, analysis, and theory of probability. Naturally, this is not to say that in mathematics there are no loner any unexplained links between these two approaches.

For a long time painting developed predominantly as a representation of the concrete. Gradually, as the artists' understanding deepened, they began increasingly to move away from concrete elements in their work. This, for example, is clearly evident in the evolution of Vincent Van Gogh's painting by comparing his *Boots with Laces* with his *The Abandoned Quarry*. It is more important for me to stress that along with the painting of concrete objects there also developed painting based on the combination of abstract elements and colors. Although great artists achieved this, for a long time it was considered subordinate. Apparently only in the twentieth century, beginning with the work of Wassily Kandinsky (1946), did abstract painting start to win its right to independence. This latter development has led to archmodern art beginning to synthesize abstract and concrete structures, to the mutual enrichment of both. For example, in a number of pictures by Michail Shemiakin, a delightful synthesis — using the motif of Russian folklore — is evident between the, to some extent, concrete structures of Hiezonymas Bosch and the abstract structures of Kandinsky.