Chapter VIII

On Measuring the Cost of Inaction

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The measurement of social cost in monetary units requires the existence of a set of prices and a social discount rate that reflect societal values. In the context of measuring the cost of environmental degradation, market prices do not adequately reflect societal values. One approach to this problem is to internalize external costs in order to make market prices more appropriate;[1] an alternative approach, and the one developed in this paper, is to recognize the subjectivity of values and to engage the society directly in expressing values. In this approach, it is the role of the scientific community to determine a set of evolution paths that are deemed to be feasible from the perspective of scientific laws and the availability of technology; it is the role of the society, or at least the institutions delegated by society, to choose from among the feasible paths. The evolution paths may reflect varying degrees of sustainability,[2] environmental degradation, and economic development.

This paper proceeds by first identifying the characteristics of the socio-economic and ecological systems that must be considered in addressing the issues of environmental degradation and sustainability, and then by examining the implications of these characteristics for analytic methods. The "design approach" to socio-economic analysis is presented as an approach that may be appropriate for examining the sustainability of future evolution paths. The design approach emerged from the research associated with the development of the Socio-Economic Resource Framework that was carried out at Statistics Canada and more recently at the University of Waterloo over the last ten years. In turn, the design approach has implications for data collection programs. These are discussed in the final section.

Nature of the Underlying System

Socio-economic and ecological systems may be characterized by their complexity, evolutionary nature, and externalities.

Complexity

These systems exhibit complexity in three ways. First, they are complex in composition, spanning a wide range of human activities and naturally occurring processes. Second, they are complex in structure in that there is a high degree of interdependence among the processes; as well, the relationships are often non-linear, involving thresholds and cumulative phenomena. Finally, they are complex in terms of their dynamics. Some processes operate very slowly, for example, those concerned with geologic transformations; others quickly, for example, certain chemical reactions and biological processes.

Evolutionary

Systems that are open to free energy and whose states may be far from thermal or chemical equilibrium, are evolutionary. When these systems are far from equilibrium, they may pass through a bifurcation or singularity from which emerges a new structure or a higher level of organization.[3] The emergent structure is not predictable from past states of the system, but will depend upon the learning accumulated by the agents within the system. In the words of Ervin Laszlo, "Evolution is always possibility, never destiny. Its course is logical and comprehensible, but it is not predetermined, and thus not predictable."[4]

Externalities

An externality occurs when the actions of one agent affect the well-being of a second agent without compensation. The agents may be remote from each other in both space and time. Clearly, the existence of externalities is a factor of major importance in environmental problems. The actions of one generation may very well affect the well-being of future generations just as the sulphur emissions associated with production in one nation may adversely affect the well-being of another.

Implications

The characteristics of the underlying socio-economic and ecological systems have important implications for analytic methods, as does emphasis on the concept of sustainability as a desirable property of economic development.

The high degree of interdependence among human activities and ecological processes implies that partial analysis may not be legitimate because important feedbacks are apt to be neglected. As well, the concept of sustainability applies to the system as a whole not just to individual components. Put another way, the system as a whole can exhibit the property of sustainability even if some of its constituents do not.

Sustainability is a quality that is attributed to an evolution path; as such, it is fundamentally a dynamic concept. The impact of actions on sustainability, taken now, can only be judged in the context of an analysis that extends into the future. The time horizon must be long enough to encompass processes that are relatively slow moving and cumulative phenomena.

Because of non-linearities in the system and the relatively long time horizon of the analysis, extrapolative methods, with their emphasis on states and inertia, cannot be used.

The pervasiveness of externalities has a profound implication on analytic methods. The existence of externalities implies that individual welfare functions are not independent and therefore not additive. One individual may increase his level of well-being at the expense of another. The additivity of welfare functions is a necessary condition for market prices to reflect societal values.[5] If market prices do not reflect societal values, it follows that (a) there are no neutral or objective measures of value, (b) aggregation over space and time using value based weights is not legitimate, and (c) there are no objective criteria for choosing from among alternative evolution paths.

The Design Approach to Socio-Economic Modelling

The design approach to socio-economic modelling applies concepts from general systems theory and control theory to socio-economic analysis.[6] A design approach model consists of two components: a user who is a surrogate for the society of which the user is a member, and an open simulation framework that represents the processes of the system and their historical evolution. The user interacts with the framework in order to increase his understanding of the system by exploring future alternative trajectories. Exploration is a learning process; the user learns through interaction with the modelling framework and, in turn, the learning is accumulated into the framework. Consequently, the user becomes an integral part of the system being represented as the source of novelty.

Design approach models are unlike most economic models which place the user outside the system. Such models presume that the future of the system is knowable to the extent that the model captures the laws of motion of the system. Traditional economic models are fundamentally deterministic in that the user cannot influence the future. The user is merely an observer.

In contrast, the design approach is based on the presumption that the future will be influenced by human actions. Actions reflect choices that are made on the basis of accumulated learning. Accordingly the future is, in principle, not knowable in that it is not possible to predict what has yet to be learned. The design approach is intended to support decision-making through enhanced understanding; it is not intended to predict or prescribe.

The concept of process is fundamental in the design approach; the observed states of a system are a manifestation of the underlying processes.[7] Two kinds of processes are distinguished: those that transform materials and energy and those that transform information. The former constitute the machine space of an economy; the latter the control space. The human-designed processes that inhabit machine space are coordinated through control space.

When processes are not properly coordinated, tensions may arise. It is the role of the model user to explore the various means of resolving tension and to provide the feedback which will assure consistency among machines. The process of identifying tensions and resolving them incorporates the experience, imagination, and learning abilities of the user. Tension is conducive to creativity.[8] Tensions arise when metaphors or theories contradict expectations; they result either in improved theories or in greater understanding and consequently refined expectations.

The strategy of representing processes or groups of processes as independently executable models with feedback through the user is a practical way of handling a large amount of compositional detail without resorting to linearity. The strategy of treating elements that change slowly as stocks and of keeping track of the evolution of stocks by means of stock/flow accounting identities gives rise to interesting dynamics and extends the time horizon of the analysis. Finally, the strategy of separating physical transformation processes serves to isolate values and makes it possible to approach the problem of externalities.

The Socio-Economic Resource Framework (SERF) is an application of the design approach to modelling. SERF represents about 250 processes that constitute the physical substrate of the Canadian economy. These processes are grouped into 43 independently executable submodels. They are linked so as to highlight tensions between the supply and disposition of labour and between the supply and disposition of energy and natural resources.[9,10]

Data Collection Programs

With the emphasis on processes and in the absence of a macro theory, there is a need for three kinds of data: data to quantify the relationships of process models (process data), data to count or measure the number of instantiations of each process (inventory data), and data to indicate historical including present states of the system (state data). Process data and inventory data are needed to represent the underlying system. State data is needed for calibration as well as for monitoring. It is desirable that parametric data be independent from state data. It is to be noted that, in general, parametric data cannot be inferred from state data for lack of degrees of freedom.

As well, it is evident that flows and stocks must be measured in physical units, rather than, or at least in addition to, value units. The currently accepted practice of deflating a time series of values, the product of prices and quantities, by an index of price change, as a surrogate for physical quantities is generally unacceptable. A constant dollar is an abstract concept; relationships among variables expressed in these units have no intuitive meaning and are not easily verified. Furthermore, this practice makes it difficult to represent principles of mass balance and the thermal and chemical laws governing physical transformations. The practice is particularly inappropriate for measuring stocks as the value of a stock is an artifact of accounting practice in that there are at least a half dozen different conventions for measuring their value in the absence of a market price.

Process Data

For processes that occur within artifacts that have been designed for the purposes of production, parametric data may be available from the process of design, for example, the engineering literature. In other instances it may be necessary to instrument a small sample of processes in order to estimate the needed parameters. What is needed is a data base of process descriptions. The feasibility of developing a process data base was explored in the context of input-output type models.[11] For naturally occurring processes, parametric data must be drawn from the appropriate sciences.

Inventory Data

Measuring the instantiations of processes is simply a counting or inventory taking problem. There are a variety of methods for taking inventories of land, water, forests, and natural resources. Census methods are used to count people, families, dwellings, and household artifacts. However, apart from a few artifacts such as automobiles that must be registered, there are few systematic programs for counting stocks (in spite of the fact that we live in a society that is rich in artifacts). For example, there are few measures of productive capacity.

State Data

Most data collection programs are oriented toward state data; for example, programs to measure ambient environmental states, and programs of economic statistics. By themselves, these programs are only capable of supporting extrapolative analysis or comparative static analysis and as such they cannot provide an adequate base of understanding to support social decision making. As noted above, economic statistics programs tend to measure state variables in value units. However appropriate this information may be for macro-economic analysis its usefulness is limited for the purposes at hand.

From the discussion above, it is clear that existing systems of economic and environmental statistics are inadequate from the perspective of measuring the cost of inaction, especially if sustainability is to be an important criterion in making choices. The current emphasis on states and structure must be augmented by an emphasis on processes and inventories. Quantities must be distinct from values.

Notes

1. J.H. Dales, *Pollution, Property and Prices* (Toronto: University of Toronto Press, 1968).

2. The World Commission on Environment and Development, *Our Common Future* (New York: United Nations, 1987).

3. I. Prigogine, and Isabelle Stengers, *Order Out of Chaos: Man's New Dialogue with Nature* (Toronto: Bantam Books, 1984).

4. E. Laszlo, *Evolution, The Grand Synthesis* (Boston: Shambhala Publications Inc., 1987).

5. F. Hirsh, *Social Limits to Growth* (Cambridge: Harvard University Press, 1976).

6. F.D. Gault, K.E. Hamilton, R.B. Hoffman, and B.C. McInnis, "The Design Approach to Socio-Economic Modelling," *Futures* (February, 1987).

7. F. Capra, "Criteria of Systems Thinking," *Futures* (October, 1985).

8. D. Bohm, and F.D. Peat, *Science, Order and Creativity* (Toronto: Bantam Books, 1987).

9. R.B. Hoffman, "Overview of the Socio-Economic Resource Framework" (Statistics Canada Working Paper, March, 1987).

10. Statistics Canada, *SERF Version II Reference Manual* (January, 1987).

11. F.D. Gault, R.B. Hoffman, and B.C. McInnis, "The Path to Process Data," *Futures* (October, 1985).