"Summary of article by Malte Faber and John L.R. Proops: Interdisciplinary Research Between Economists and Physical Scientists: Retrospect and Prospect" in Frontier Issues in Economic Thought, Volume 1: A Survey of Ecological Economics. Island Press: Washington DC, 1995. pp. 70-73

Social Science Library: Frontier Thinking in Sustainable Development and Human Well-being

"Summary of article by Malte Faber and John L.R. Proops: Interdisciplinary Research Between Economists and Physical Scientists: Retrospect and Prospect"

Problems of environmental pollution and energy shortage have stimulated interdisciplinary work between economists and physical scientists. This cooperation has resulted in many economists developing an understanding of the physical underpinnings of economies, and many physical scientists realizing that problems of pollution and energy shortage have social and economic aspects. However, this cooperation has led to some mutual incomprehension and hostility between the disciplines as well. Interdisciplinary research and cooperation between economists and physical scientists are urgently needed, although they will be difficult to carry out.

Economists and Physical Science

Economists have a long tradition of employing concepts and methods from the physical sciences. Physical analogies have been used by Proops, Walras, Edgeworth, and Samuelson, among others. Analogies have been drawn to the central concept of thermodynamics - entropy - in measuring industrial concentration, inequalities of income and employment, and geographic concentration. Another analogy used has been that of "gravity models" in regional economics. There is a move to supplant mechanical analogies with "organistic" analogies, because the economy is more like a self-regulating and developing organism than a mechanical system.

The use of analogies has not been the only method of interaction between the two disciplines. Jevons[1] (1865) considered the importance of coal to the British economy and its shortage as a constraint upon industrial activity. Georgescu-Roegen[2] (1971) has stressed the irreversibility of the productive process and the long run constraints on economic activity due to finite exhaustible resources. These authors are concerned with the physical limits to social activity; for example, fuel reserves and environmental pollution have interested economists in recent years.

A third and more general relationship between economics and thermodynamics is also being explored. In this case, the question is whether economies can be viewed as similar to dynamic structures, which maintain a constant relationship with their environment via active internal processes.

Physical Scientists and Economics

In the early days of the energy crisis, a view commonly held by physical scientists was that value must derive only from energy, as energy is the only factor of production that is, in principle, nonsubstitutable. However, with many studies showing that labor and capital can, to some extent, substitute for energy, and that energy can be augmented in production by technical progress, physical scientists have come to see that energy is not the only factor in modern economies worthy of study.

Energy, Time, Irreversibility, and Entropy in Economics

All physical processes relevant to the functioning of economies require energy, involve time and are irreversible, but these concepts have not been given the attention that they deserve in economic theory. Dynamic economic analysis does include the time factor, but it does not deal with the irreversible nature of physical processes. The concept of entropy can incorporate these three aspects simultaneously, and it can be applied to an analysis of resources and the environment. In addition, rather than dealing with time as a mere parameter, the thermodynamic approach forces one to consider real, irreversible time.

Koopmans (1951) introduced the postulate of the irreversibility of economic processes: "It is not possible to run some or all activities at positive levels such that the joint effect of the net output is zero for all goods."[3] This postulate essentially suggests that the manufacturing of commodities cannot be reversed in time. This irreversibility follows from the Second Law of Thermodynamics. Economists have also shown that an implication of the Second Law is that you cannot get an output without an input. Georgescu-Roegen has extended this idea to argue that outputs can be obtained only at a greater cost of low entropy. While economists are beginning to accept irreversibility as an axiom, the physical meaning of irreversibility has yet to be fully internalized in the conceptualizations of most economists.

A knowledge of thermodynamics offers many new insights into an understanding of issues in environmental and resource economics. Energy can be divided into useful energy - that contained in foodstuffs and fuels directly used for man's subsistence - and primary energy sources - e.g., solar or fossil energy. Primary sources of energy can be transformed by man into useful energy. Until the beginning of the 19th century land was used to transform solar energy into useful energy. As populations increased, land became scarcer in Europe. Over the last 150 years, industrial development has required the extraction of fossil fuels and minerals as the principle source of useful energy. Thus land becomes a limiting factor in an even broader sense, i.e., as a surface, as a supplier of resources, and as a receiver of pollutants. Economists have paid attention to the first aspect, but not to the other two. Since the extraction of resources and the disposal of waste increase the entropy or the disorderliness of the system, entropy can be used to connect theories of environment and of resources. The thermodynamic approach is also a way for economics to build a biophysical foundation to understand long run, macro-level issues, for which the price system does not provide a complete solution.

Physical Constraints, Technical Progress and Social Change

Economists perceive limitations to economic activity as essentially social in nature. Physical scientists see economies as limited by physical constraints. Both of these viewpoints are valid. Physical constraints generate social responses in the form of technical and social adjustments which move the economy away from the constraint. Thus social transformations, technical change and physical constraints form a web of recursive interrelationships. Analysis of social and economic activity must integrate technical progress, while physical constrains must be seen as not only influencing human activity in the long run, but also as prominent determinants of social change.

Interdisciplinary Research: Difficulties and Some Tentative Solutions

While the urgency of interdisciplinary work is accepted, psychological and institutional factors impede such cooperation. Some of these factors include:

1) discouragement from peer groups - either fellow economists or physical scientists - as work across disciplines is viewed as less "serious" than work within a single discipline;

2) often harsh criticism of such research, as the criteria used to evaluate new interdisciplinary work is the same as that used to evaluate research in an established field;

3) difficulty in finding researchers to collaborate with;

4) differences in the languages and foci of each discipline that make communication difficult;

5) shortage of journals that publish interdisciplinary research; and

6) time-consuming learning needed to begin cross-over work in a new field.

In the long run it is necessary to establish a wider vision by dissolving established conceptual frameworks. In the meantime, more interdisciplinary conferences, symposia and seminars must be conducted to bring together interdisciplinary researchers. Training towards interdisciplinary work should be given at the elementary, undergraduate and graduate levels.

Notes

1. W.S. Jevons, *The Coal Question*, (London: Macmillan, 1865).
2. N. Georgescu-Roegen, *The Entropy Law and the Economic Process* (Cambridge, Massachusetts: Harvard University Press, 1971)
3. T.C. Koopmans, "Analysis of Production as an Efficient Combination of Activities," in Activity Analysis of Production and Allocation, ed. T.C. Koopmans (New York: J. Wiley, 1951), 48; cited by Faber and Proops, 604.