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A Cybernetic Approach to Economics

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Since the meltdown of the global financial system in 2008 triggered by the sub-prime mortgage bubble in the United States, there is an emerging consensus, even among economists, that there is a need for new economic thinking[2] (See Stiglitz, 2010 & Kaletsky, 2010). The economic thinking that has prevailed in postwar capitalist societies is based on the neo-classical – Keynesian synthesis, hereafter mainstream economics.

Judged from within its own frame of reference, mainstream economics has been enormously successful. Over the postwar years in North America and Europe, economic growth measured in terms of GDP, has been sufficient to deliver increased prosperity and to maintain near full employment.

However, judged from outside of its own frame of reference, it is clear that mainstream economics has failed to address the following issues:

- Impending ecological limits exemplified by peak oil and climate change
- The conflict between the goals of economic growth and sustainability
- The inadequacy GDP per capita as an indicator of social well-being or prosperity
- The instabilities associated with financial bubbles
- The growing inequity in the distribution of income both within and between nations

New economic thinking must be capable of addressing all the issues above. Further, it is recognized that all five issues are interrelated. Actions taken to resolve one issue often have the consequence of aggravating other issues.

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2. See for example the Institute for new Economic Thinking established by George Soros in 2009 in response to the collapse of financial institutions in 2008.

Why has mainstream economics been unable to address these issues? This is the question for the next section of this paper.

Mainstream Economics

The neo-classical – Keynesian synthesis frames economics as a constrained global optimization problem: maximize utility subject to the availability of labor and capital. Consumers and producers are utility and profit maximizers respectively. Production is the value added to freely available natural resources by the use of scarce labor and capital. This is the worldview articulated by Paul Samuelson in his *Foundations* (Samuelson, 1947). For this formulation to be valid, the following three conditions must be met.

1. Individual consumer utility functions must be separable and convex, therefore additive, giving rise to downward sloping demand curves.
2. The cost curves of individual producers must be U-shaped giving rise to upward sloping supply curves or supply curves that have the property increasing marginal costs.
3. The economy is not constrained by the availability of sources and sinks for materials and energy.

In this formulation, supply and demand curves intersect to provide market-clearing prices that reflect objective societal values. Utility is indicated by value added or gross domestic product.

There are important implications that follow from this mathematical framing of economics. Market prices are valid as weights for aggregation, thereby enabling a macro-economics based on accounting identities among a small number of highly aggregated macro-economic variables such as production, consumption, savings and investment. As well, the values that are objectively revealed by market prices can be used to compare social costs and benefits, thereby legitimizing social cost-benefit analysis.

- Insofar as labor is a limiting factor full employment is not only possible, but is assured when the price of labor reaches its equilibrium or market-clearing level. It follows, then, that employment may be relied upon as the main means for the distribution of income.
- Technological change may be safely treated as an unexplained residual, and in many macro-economic models is represented by the variable *time*.
- The dominant mode of behavior of economic agents is competitive. The U-shaped cost curves insure *perfect competition* among a large number of firms. Individual firms are price takers and have no power to influence market prices.

- The role of government, if anything at all, is to assure that all agents play by the rules of the game. In the Keynesian version of mainstream economics, market failure caused by *money illusion* may give rise to less than full employment. This condition may be resolved by government intervention consisting of demand stimulation using monetary and fiscal policy.
- Further, if it is assumed that the factors of production, labor and capital, are immobile, international exchange of products leads to increased welfare—the theory of comparative advantage.

Why The Failure?

It is clear in today's world that the conditions for framing economics as a global optimization problem are not met: Individual welfare functions are interdependent; cost curves exhibit increasing returns to scale in many markets, and; biophysical limits are important. However reasonable the conditions may have been in the first half of the 20th century, they are not reasonable approximations of today's realities.

Externalities
External costs are thought to be as important as the costs internalized in product prices. The actions taken by individual producers and consumers do affect the well-being of producers and consumers not party to the market transactions. Using scarce natural resources, releasing pollutants into air and water, emitting carbon dioxide into the atmosphere are all examples of important externalities. This means that welfare functions are interdependent. In the absence of a social welfare function, economics cannot a global optimizing problem.

Power
The concentration of economic power in an ever-decreasing number of global corporations indicates that cost curves exhibit the property of increasing returns in many market segments.[3] The concept of power, which plays no role in markets with a large number of producers, is obviously important when individual producers can and do influence both prices and the rules of the game.

Biophysical Limits
Finally, it is clear that ecological limits to economic growth are important.[4] Deforestation, desertification, the loss of soils, the collapse of fisheries, diminishing biodiversity are all indicators of limits. Peak oil and the finiteness of the atmosphere as a sink for carbon dioxide emissions suggest the immediate importance of ecological limits.

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3. The phenomenon of increasing returns is the subject of a book by economist Brian Arthur (1994).
4. The potential importance of bio-physical limits was identified in *Limits to Growth* (Meadows, Meadows, Randers, & Behrens, 1972).

Labor and Capital
A further difficulty arises because the concepts of labor and capital as sources of value in mainstream economics are too heterogeneous to be useful.[5] Labor, perhaps better thought of as person hours, provides mechanical energy, control, and know-how to processes of production. But mechanical energy is available to those processes by the combination of physical capital (an engine) and a non-human energy source. The story of the industrial revolution involves the substitution of fossil energy for human energy. The information revolution involves the substitution of automated or machine based controllers for human controllers (Beninger, 1986). Neither of these revolutions could be seen through the lens of the classical concept of labor. The concept of capital is equally heterogeneous, as capital may refer to produced physical goods such as buildings and machines or to financial capital which is the capacity to acquire goods now and into the future (Boulding, 1978).

If economics is inappropriately framed as a global optimizing problem, what are the elements of what might constitute new economic thinking? How should economics be framed? These are the questions addressed in the next section.

Economics Reformulated

It is proposed that economics is more appropriately framed as a *management of the commons* problem: the allocation of the benefits to be derived from a finite natural resource base to the population to be supported by it (Hardin, 1968). The amount of benefit to be derived from the commons depends upon the existence and effectiveness of the processes needed to transform the natural resource of the commons into goods capable of yielding the services needed by people. Production in this framing of economics consists of the transformation of materials using energy and know-how subject to on-going control (Beninger, 1986; Boulding, 1978). There are two elements to the problem: determining and limiting the level of use of the commons to that which can be sustained without degradation and; establishing mechanisms for allocating the right to use the commons among producers and allocating the benefits to be derived from its use among consumers.

The emphasis on management makes the proposed economics a problem of cybernetics. Indeed, as all humans bear responsibility for managing the commons, it is a problem of second order cybernetics. Effective management of the commons has three necessary ingredients: a well-defined objective; an understanding of the processes that constitute production from the commons; and, continuing observations of the state of the commons. The task of management is to control the production processes in such a way that the objective is met. Management bases its decisions on its understanding and on continuing observations of the states of the system. To the extent that actual outcomes differ from desired outcomes, management may adapt by

5. “The classical economic taxonomy of factors of production into land, labor and capital is too heterogeneous to be useful; know-how, energy and materials are a much more useful taxonomy in understanding productive processes” (Boulding, 1978, p. 4).

adjusting the settings of the controls or by refining its understanding of the system. The understanding of the commons is referred to as the system model. The system model is subject to Ashby's law of requisite variety which may be stated as follows: For effective control, the variety in the systems model of the controller must be equal to or greater than the variety in the controlled system. We cannot regulate our interaction with any aspect of reality that our model of reality does not include (Beer, 1973; see pp. 18-34).

Framing economics as a management of the commons problem recognizes implicitly the potential both for bio-physical limits and for externalities. As sources and sinks for materials, the commons are limited by the finiteness of our planet. The appropriation of the use of a finite commons by one individual or group may preclude its use by other individuals or groups, thereby adversely impacting on their utility. It follows that the concept of externalities is central in this formulation.

The concept of equity or justice becomes important, as the allocation of the benefits to be derived from the commons is an issue if the allocation is to be perceived as just or fair. It is not clear that granting ownership of the commons to producers and allowing them to set and charge market prices results in an equitable distribution of benefits.

Competitive behavior or individual optimizing behavior is clearly insufficient as it may lead to the overuse and destruction of the commons. Cooperative behavior that involves sharing or agreeing to rules that result in sustainable production from the commons and a just allocation of the benefits is an important component of behavior. Boulding distinguishes three major classes of social organizers; the threat relationship, the exchange relationship and the integrative relationship (Boulding, 1978). Mainstream economics emphasizes the exchange relationship to the exclusion of the integrative.

Governance has a much larger role in the proposed economics than establishing and enforcing the rules under which exchange takes place. The sustainable yields from the commons must be determined and enforced. This involves investing in natural science to enhance the understanding of the naturally occurring systems that constitute the commons and how they are impacted by human activity. It also involves making investments in the know-how needed to transform the yields of the commons into the services needed to support human activities. Governance also has a role to play in determining and effecting a distribution of the benefits from the commons that is perceived to be just.

In the proposed framework, the accumulation of knowledge or know-how is an important determinant of economic well-being. The accretion of know-how is an evolutionary process and the outcomes of evolutionary processes cannot be predicted.[6] According to Boulding:

> There is in fact a very simple nonexistence theorem about prediction in evolutionary systems and especially in Social systems. These are essentially based on some form of knowledge or know-how;

6. "When we get to societal evolution the paramount role of knowledge is clear" (Boulding, 1978, p. 33).

> we cannot predict what we are going to know or what know-how we are going to have in the future, or we would have it now. (Boulding, 1978, p. 18)

Insofar as the future of evolutionary systems is not determined by laws of motion of the system, uncertainty is a fundamental property of such systems. The concept of uncertainty in evolutionary systems is developed by Ilya Prigogine (1997) and F. David Peat (2002).

The framing of economics as a management of the commons problem owes much to the worldview of Kenneth Boulding as articulated in his masterpiece *Ecodynamics*: *A New Theory of* Societal *Evolution* of 1978.

An important implication that follows from the framing of economics as a problem of the management of the commons is that economic systems must be seen through the lens of complex adaptive systems. In the absence of a legitimate theory of aggregation, the problem is compositionally rich: multiple commons consisting of a wide range of naturally occurring processes yielding resources with differing physical properties; an equally large number of processes and process chains for transforming materials and energy; and, a large number of economic agents that own, control and influence the commons. Complexity also arises because of potential non-linearities in the relationships among the variables.

Unlike global optimizing problems, which have elegant mathematical properties and lend themselves to analytic solutions, complex systems may be best understood using simulation techniques (Berlinski, 2000; Casti, 1997). The human mind, by itself, is incapable of understanding complex systems as it is said that, at most, the human mind can grasp systems involving only seven variables. However, the human mind can be augmented and complemented by an appropriately designed computer based simulation model such that the human mind is the source of novelty or learning and the model provides extended memory and computational capacity.

Considerations for the Design of an Economics Simulation Model[7]

As an evolutionary system for which prediction is of little interest, the new economics should be more about learning than prediction. Put another way, the system must be open to human learning and adaptation. The focus of the model should be the representation of the constraints within which the evolutionary processes must unfold and the exploration of viable pathways within the space delimited by the constraints (Laszlo, 1987). Exploration is a learning process with the result that model use generates new understanding and the model user is an integral part of the model as the source creativity. Learning is facilitated in models whose feedback structures are incomplete. Models that are over-determined in terms of their control variables let model users see disequilibrium or incoherent scenarios and let them explore alternative responses to the disequilibrium. Evolutionary processes are characterized by constant disequilibrium (Boulding, 1978). Higher and unpredictable levels of order

7. Joel de Rosnay's Macroscope presents a full discussion of a design for such a model (de Rosnay, 1979).

can arise in open evolutionary systems far from equilibrium (Prigogine & Stengers, 1984).

In order to handle ecological limits and sustainability, the new model must incorporate a full representation of the stocks and flows of materials and energy and the processes that transform resources, land, and energy sources into the goods and services required for human uses. This accounting must be done using energy and mass units and with sufficient compositional detail to recognize that materials and energy differ in their physical and dynamical properties.

In order to be capable of addressing sustainability, the new model must operate over a much longer time horizon than is the practice for macro-economic models. Typically, a macro-economic model is considered to be long term if its time horizon is five years; the new model must operate over a time horizon of fifty years or more. Ideally its span would cover two roll-overs of most stocks. To be relevant over such a long time horizon, the physical components of the model must be coherent with the first and second laws of thermodynamics, and this represents a set of constraints on the physical substrate of the economy.

A more nuanced concept of prosperity requires stock as well as flow variables. Adequate stocks of public social infrastructure from which services can be provided, such as schools, roads, hospitals, are as important a component of prosperity as private stocks such as houses, cars, appliances, and home computers.

The sine qua non for exploring the phenomenon of financial bubbles is the concept of debt. What is needed are the variables contained in balance sheets that indicate the assets, both financial and real, against which debt is issued. A fully articulated set of income and balance sheet accounts subject to the usual accounting identities are financial constraints that limit the behavior of economic agents.

Not only must the distribution of income be an integral part of the new economic model, but the distribution of wealth must be included as well. A full discussion of the implications the growing inequality in the distribution of income is presented by Wilkinson and Pickett (2010) in a recently published book entitled *The Spirit Level*.

At the highest level of abstraction, it is useful to identify two sets of processes, those that involve the transformation of materials and energy, both naturally occurring and purposeful, and those that involve the transformation of information that constitute a mind-space or self-conscious control force that guides human activities. (Schellnhuber, 1999).

An approach for modelling the biophysical processes in both the naturally-occurring and human domains may be found in the concept of activity analysis (Koopmans, 1951; Georgescu-Roegan, 1971), its application in input-output modelling (Leontief, 1986) and in materials and energy process-product modelling (Ayres, 1972, 1978), the design approach to socio-economic resource modeling (Gault, 1987), and the stocks and flows models of CSIRO (Foran, 2005; Turner & Poldy, 2001). Indeed, the need for a new biophysical paradigm in economics has been articulated by Hall, Lindenberger, Kumel, Kroeger, and Eichner (2001); and Hall and Klitgaard (2006).

The mind-space is inhabited by institutions that interact with one another and exert control over the biophysical space through the institutions of ownership and governance. There is a large body of literature in what is called institutional economics that documents the complexities of the behaviors of institutions (Burns, 1985; Galbraith, 1958 1967, 1992; Hirsch, 1976; Keirens, 1983; Arthur, 1994; North, 2005; Saul, 1995; Stiglitz 2007, 2010).

Afterthoughts

Mainstream economics has led to a policy regime that is dedicated to the pursuit of economic growth, full employment, increasing labor productivity, high levels of savings and investment and competitiveness. The new economic thinking outlined in the preceding pages leads me to the conclusion that these pursuits are at best misplaced and at worst perverse. The pursuit of growth in production disregarding the bio-physical limits imposed by the finiteness of the planet Earth poses a clear threat to the future of humankind.

We should be much more concerned about the productivity of the commons than the capacity of labor to add value. The binding constraints are the capacity of the commons. Overall, as energy from non-human sources and automated control systems have displaced humans as a source of energy and control, there is no shortage of labor. There is no guarantee that full employment can be achieved in the future and therefore its use as the means of allocating access to the benefits of the commons may have to be augmented by other mechanisms. The challenge will be to find a way of decoupling access to goods and services from employment.

The pursuit of ever more savings and investment has been driven in part by the need of many private enterprises to reduce (internal) costs. Since payments to labor constitute the largest single element of cost for most enterprises, investments have been directed to the deployment of labor saving technologies in order to substitute non-human sources of energy and automated control for labor. These investments have, in fact, reduced employment and reduced the effectiveness of employment as a mechanism to distribute income.

Fostering competitiveness through privatization and deregulation makes little sense in face of increasing returns as competition for market share inevitably leads to dominance by a small number of large enterprises.

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