Economic Theory for the New Millennium

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***Abstract**: Traditional mainstream academic economics, by trying to be a science, has failed to answer major questions about real-life economic behavior. Economics should become a systems profession, such as management, engineering, and medicine. By closely observing the structures and policies in business and government, simulation models can be constructed to answer questions about business cycles, causes of major depressions, inflation, monetary policy, and the validity of descriptive economic theories. A system dynamics model, as a general theory of economic behavior, now endogenously generates business cycles, Kuznets cycles, the economic long wave, and growth. A model is a theory of the behavior that it generates. The economic model provides the theory, thus far missing from economics, for the Great Depression of the 1930s and how such episodes can recur 50 to 70 years apart. Simpler system dynamics models can become the vehicle for a relevant and exciting pre-college economics education.*

Today I will discuss an alternative to the methods that now dominate the field of academic economics. As seen by most people outside the profession, economics has failed to adequately explain what happens in the real world. A new way to examine economic behavior can grow out of the principles and practices that have been emerging from the field of system dynamics. The usual economic literature presents economics as a science, with economists trying to emulate the hard sciences such as physics. Those attempts to force economics into the mold of a science have not been satisfying. As a result of trying to pose as a science, the field of economics has become substantially detached from real-world behavior, and has tended toward a closed theoretical discipline disconnected from the world it tries to explain. Instead of being a science, I suggest that economics should become a systems profession. As a systems profession, economics would be parallel to management, engineering, and medicine, each of which is based on underlying sciences. An economics systems profession would be based on underlying sciences such as psychology, decision-making, and nonlinear feedback dynamics. As a systems profession, economics would then reach beyond its basic sciences to understand and redesign economic systems.

Historical Evolution

Academic economics has evolved away from real economic behavior over the last fifty years. In the beginning, economics started from direct observation and theorizing about business activity, but since, in its effort to appear as a science, economics has drifted toward a conceptual

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structure that is narrow, is based on unrealistic assumptions, emphasizes equilibrium conditions, and is committed to mostly linear mathematical methods.

The culture of academic economics is revealed by a survey of economics doctoral students in which one question asked what would put the student on the fast track. The numbers of responses for three areas of endeavor are in the table.[1]

Important to fast track	Very important	Unimportant
Excellence in mathematics	87	2
Knowledge of economic literature	10	43
Knowledge of the economy	3	68

By contrast, the early economists in the 1800s did look at businesses and overall economic dynamics, but they were limited to discussion and intuitive analysis of their theories. They did not have the ability to convert theories into simulation models that would reveal inconsistencies, weaknesses, errors, and mismatches between the theories and reality.

The descriptive approach still prevails in the institutional branch of economics, but institutional economics has lost popularity in academia. By the mid-1900s, descriptive theorizing was perceived as unscientific and efforts arose to lay a more solid foundation through applying mathematical methods and statistical analysis of historical time-series data. However, mathematical analysis is severely limited and is mostly confined to linear and simple concepts. The mathematics that evolved in the last half of the 1900s has been unable to address important dynamic issues. Such failures of traditional analysis are revealed by there being no widely accepted theory even for causes of simple short-term business cycles, and there has been no consensus explanation for the Great Depression of the 1930s.

Transition to System Dynamics

I believe economics needs to return to theories based on observation of the real world, and then test and improve those theories in simulation models. In doing so we can respond to the challenge by William Baumol in his book, *Economic Dynamics:*

> "In this part of the book we shall begin by considering some earlier economic thought..... By the classical economists we shall here mean those writers on economic theory who worked largely in England during and after the time of Malthus and before the time of John Stuart Mill, among the most famous of whom were Ricardo, James Mill, McCulloch and Senior.... We consider these older dynamic systems simply because, although imperfect, they represent an approach of which there are few recent examples.... for the approach is of a

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1 Klamer, Arjo, and David Colander, 1990. *The Making of an Economist.* Boulder, CO: Westerview Press. 210 pp. , p. 18

magnificent cast, ambitiously attempting to analyze the growth and development of entire economies over relatively long periods of time—decades or even centuries." [2]

In response to Baumol, we can look at a computer run from the system dynamics model that I feel is becoming a general theory of economic behavior. The model does analyze growth and behavior over centuries. Figure 1 is a computer simulation over two hundred years.

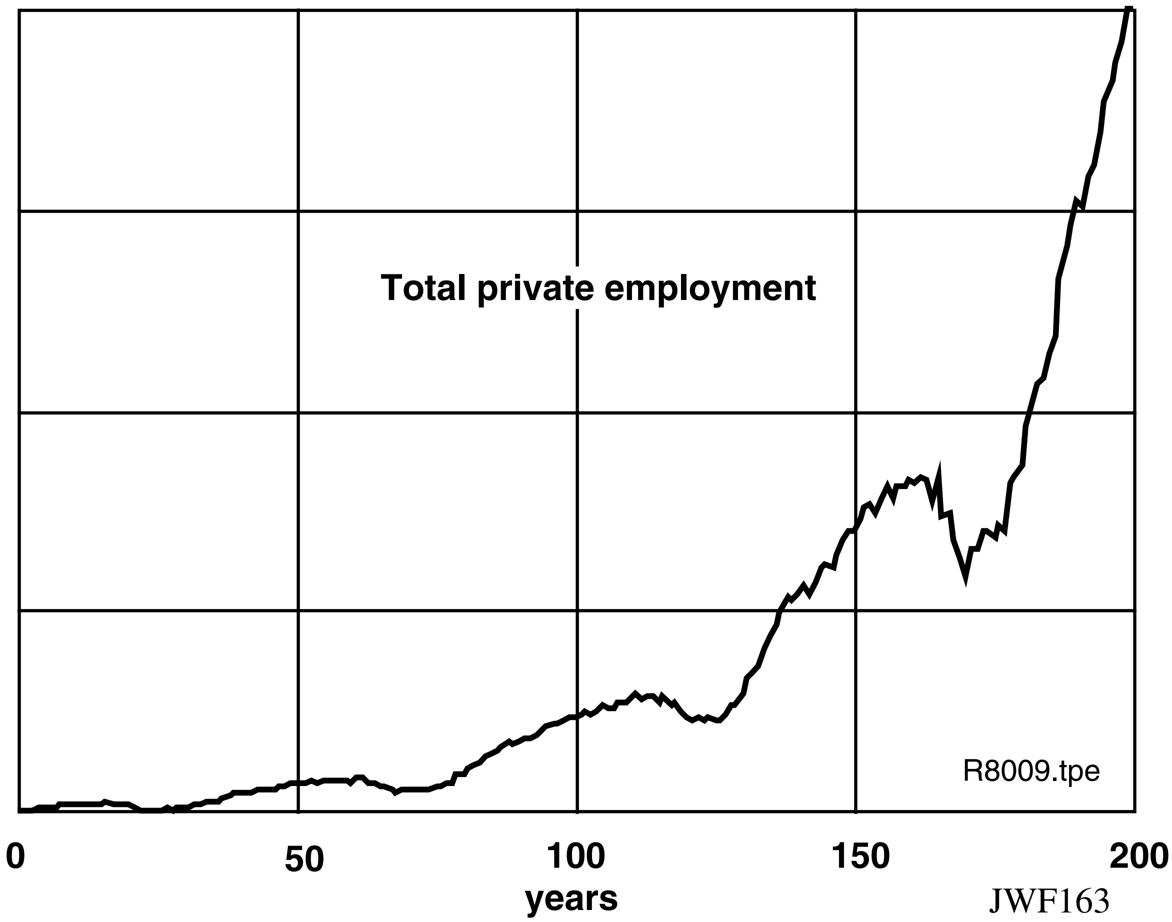

Figure 1. Computer simulation over 200 years.

All behavior is endogenous. There are no exogenous driving variables, as are so often inserted into traditional econometric models. A strong growth trend in employment results from rising population. A major superimposed fluctuation with peaks some 50 years apart causes the major depressions. Short-term business cycles cause the much smaller ripple. Here, the business cycles are probably too small compared to the actual economy, but business cycles are indeed minor relative to the powerful long fluctuations. Business cycle dynamics are weak in the current model because it does not yet contain product distribution structures such as operate in

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[2] Baumol, William J., 1970. *Economic Dynamics: An Introduction.* (3rd ed.). London: Macmillan. 472 pp. , pages 13-14

the familiar "Beer Game."[3] I do plan to add those structures to make business cycles more realistic.

One often sees assertions about how fast economic change is occurring and how one could not create a model with constant policies that would be valid over 200 years. However, if one models from a sufficiently fundamental level, I believe that there is a structure that is almost unchanging. Most of the highly visible changes are superficial. For example, communication speeds have indeed risen rapidly, but the important system structure has changed little—the length of time for buildings to become obsolete, the tendency of people to speculate by extrapolating current conditions into the future, the fact that production involves both labor and capital plant, the existence of some kind of financial system that can create credit and loans, and the long psychological delays in people adjusting to changed economic conditions.

The small number of oscillatory modes in Figure 1 result from entrainment. If the model is linearized and its eigenvalues are calculated, there are as many eigenvalues as the number of levels—over 200. Many eigenvalues come as pairs representing oscillatory modes, but they do not appear in their wide diversity in a simulation. Oscillatory modes that are close to one another in periodicity coalesce into a single observable fluctuation. In this economic model there can appear business cycles (three to ten years between peaks), Kuznets cycles (around 25-year periodicity), and the Kondratieff or long wave cycle (some 50 to 75 years between peaks). All theoretically present dynamic modes are swept together into sets of oscillations that are far enough apart to avoid entrainment.

The Economic Model

The system dynamics economic model has been developed over several decades. Initially it was to have been much larger than the current simplified model, which now has somewhat over 200 levels and 1400 auxiliary equations.

In the early stages of model development, we often had as many as a dozen people working on it. In retrospect, the group was often too large for efficient progress. We failed to apply an insightful comment once made by a programmer in another setting.

Many years ago I was pressing a corporate president to try a radically different way for organizing computers to process business information. In about the third meeting with him and his chief programmer the president became interested enough to ask his programmer how long it would take to try the idea. The technician's answer was, "My assistant and I can do it in four months, if you give us another helper, we can finish in five months. With five more staff it will take a year. With a team of ten, it will never be finished."

Initially we had sections of the model assigned to different people. As a result, each part became much more complete and elaborate than required for a total assembly intended to emphasize the fundamental behavior modes of an economy.

I have worked part time in the last several years to simplify the structure, sharpen its focus, and to make the model more robust.

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[3] Sterman, John D., 1992. Teaching Takes Off: Flight Simulators for Management Education. *OR/MS Today* (October), 40-44.

Some people have questioned the need for such a large and complex model. Indeed, many applications in education and in policy design might be better handled with a collection of far simpler models. But I have felt that it is important to have a model in which the major modes of economic behavior exist simultaneously for examining how the different modes may interact. In a nonlinear model, the superposition theorem does not apply, the different modes do not exist separately, and do not simply superimpose on one another. After the larger system is understood, it will be desirable to revert to much simpler special-purpose models. We have made simpler models to deal with issues like foreign trade and the exchange value of the dollar.

The Model as a General Theory

Initially, the model was seen as representing the United States. The project was called the "System Dynamics National Model." Thinking of the model as applying only to a specific country is contrary to the philosophy that I have come to embrace. Seldom, if ever, should a person model the specific situation of interest but, instead, should model the family of systems to which the specific one belongs.

The model now represents a general theory of economic behavior. I say "A" general theory because any change in structure or in a parameter would be a different theory. Most such changes would not affect the fundamental behavior of the model, but where important changes in behavior did occur, one would then have to judge whether or not the alternate theory is better.

The model is an early step in the future of applying system dynamics to economic behavior. I believe we can look forward to better large models. Even more important will be many smaller system dynamics models dealing with specific issues.

The model I am working on is generic. By changing parameters, it could be tailored to represent a wide range of specific countries. The model generates the major modes of behavior that are seen in real economies and addresses many of the controversies that have arisen in the economic literature. Such a model can apply to most industrial nations, and can even be interpreted as applying to the developed world.

Historical Time Series

There is no reason that a generic model should reproduce any specific historical time series. Instead, it should generate the kind of dynamic behavior that is observed in the systems that are being represented.

If one runs the model with different noise sequences one will get simulations that have the same character, but not the same values at different points in time. Likewise, the time series from an actual economy represent only one of a multitude of detailed behaviors that might have occurred if the random effects in the real system had been different. In other words, historical data from a real economy should be interpreted as only one of a multitude of possible data histories.

I believe there is much too much attention given in economics, and in system dynamics, to reproducing a specific historical time series. The dynamic character of past behavior is very important, but the specific values at exact points in historical time are not. Different random sequences in the past in the real economy would have produced different historical data sequences all with the same general character, just as would happen in a series of model simulations using different random inputs.

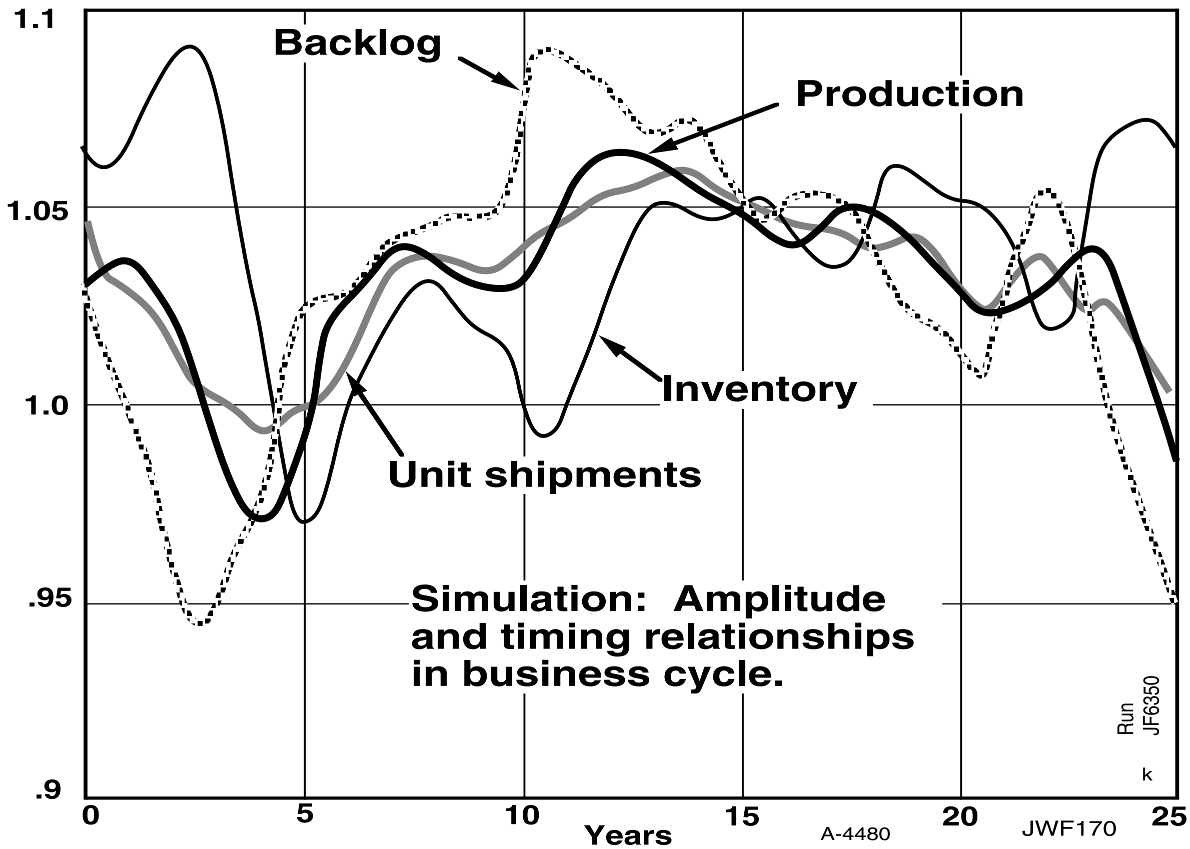

Figure 2. Lead-lag phasing during business cycles.

Figure 2 shows production, backlog, inventory, and shipments over several business cycles from a simulation without growth. The time phasing of leading and lagging variables is similar to data in the literature from several studies of business cycles.

Other comparisons can be made of amplitude and phase relationships between variables in different sectors. From the model, one can plot almost any output for which there is real life information to see how well the model generates the kinds of behavior observed in real systems.

Structure of the Model

The model uses capital plant and people to produce goods. It has money flows, internally generated prices, a monetary authority, movement of labor among sectors, and a household sector that buys, saves, and consumes the output of production.

In this model the monetary authority is endogenous, responding to liquidity, inflation, unemployment and other conditions in the economy. One only has to read the newspapers to realize how fully responsive the monetary authority is to changes in the economy. Real monetary authorities are not exogenous to the economies within which they operate. They respond to economic conditions, take actions, and respond to new economic situations that they may or may not have influenced.

The model has conserved flows of money, people, capital plant, and goods.

Growth expectations are included in several places because people extrapolate the past beyond the point justified by more objective physical and financial conditions of the system.

There are various structures that are not explicit in the model such as a Social Security System and foreign trade. Also the model does not contain limits from land, pollution, and resources that would slow and stop growth. I believe the absent structures are not necessary to the issues that the model does address and can be added in the future or, perhaps better, be handled in smaller specific models.

Unifying Microstructure and Macrobehavior

In academic economics there are two fields, microeconomics and macroeconomics. Microeconomics deals with firms and households, macroeconomics with behavior of the overall economy. There is little connection between the two; microeconomics does not explain how the parts of the system interact to create the combined behavior. But one must believe that the interacting parts of the real system are producing its observed behavior. In the system dynamics model that we are discussing, the microstructure creates the macrobehavior.[4] The microstructure of a production sector is essentially a model of a corporation that stands for the aggregate of all businesses in that particular sector. Labor, government, households, monetary authority, and banking likewise appear as structures that represent observable activities in the real economy.

Generic Models as Theories of Behavior

This system dynamics economic model is a generic model of how an economy operates. I want to stress the importance in all modeling endeavors of starting from the generic or common class of systems to which the special case belongs. If one were modeling a corporate problem, one should want to understand why the particular corporation differs from other members of the class that may be more or less successful. A corporate model structure should apply to all members of the class when appropriate distinguishing parameter changes are inserted. The production-distribution system in *Industrial Dynamics*,[5] which is the basis for the widely played "Beer Game," is a generic structure that applies throughout business and an economy. The model in *Urban Dynamic*[6] illustrates behavior in a wide range of cities. Generic models are the key to successful education. If a person understands a dynamic structure in one field, that understanding transfers to all other fields where the same structure may reappear.

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[4] Forrester, Jay W. 1979. An Alternative Approach to Economic Policy: Macrobehavior from Microstructure. In Nake M. Kamrany and Richard H. Day (ed.), *Economic Issues of the Eighties*, pp. 80-108. Baltimore: Johns Hopkins University Press.

[5] Forrester, Jay W., 1961. *Industrial Dynamics*. Waltham, MA: Pegasus Communications. 464 pp.

[6] Forrester, Jay W., 1969. *Urban Dynamics*. Waltham, MA: Pegasus Communications. 285 pp.

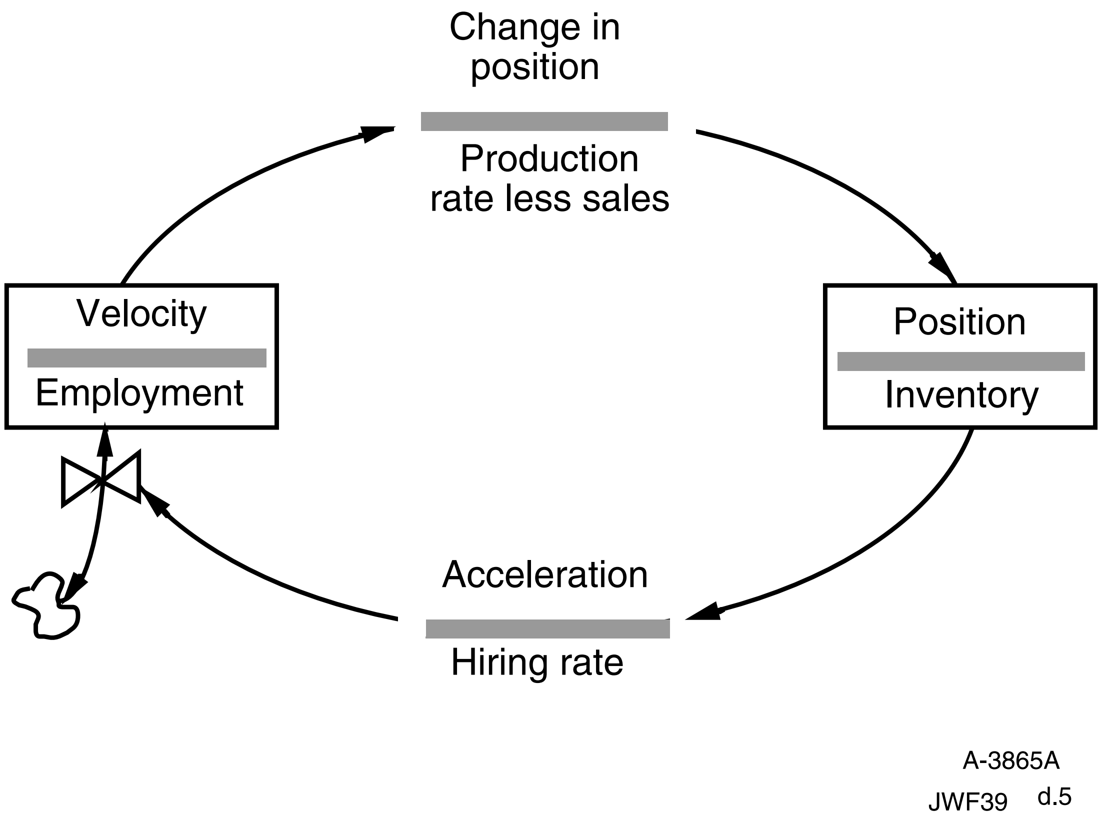

Figure 3. Generic two-level negative loop.

Figure 3 gives a simple example. As soon as one sees two levels in a single negative loop, one knows that the structure will exhibit continuous undamped oscillation. The two sets of nomenclature identify different oscillating systems, one a simple clock pendulum, the other a central part of economic business cycles. In this generic structure, the proper parameters for acceleration will yield a one-second swinging clock pendulum, whereas reasonable parameters for the hiring rate produce a several-year cycle that is a component of business cycles. Additional structure must be included to produce damped behavior in either system.

Generic structures give a student powerful insights that are transferable from one setting to another.

A generic model is a theory of how the class of member systems behaves. The theory arises from observation of the real system and from information that is almost always sufficiently available.

The economic model is not only a generic model of economic behavior but also uses generic substructures in which two production sectors are represented by the same equations with distinguishing array designators and different parameters. Much of the production sector structure is carried over to the household and the government sectors.

Modeling Philosophy

The approach in this system dynamics model differs in many fundamental ways from common practices in economics. It is interesting to observe that some departures from mainstream economics, which a system dynamics viewpoint suggests, have already appeared in lectures by award winning economists. Those senior people in the field look at the practices of the discipline, observe its shortcomings, and suggest new directions, but those lectures have had almost no effect.

Information Sources

An example of a lecture that recommends an approach that we would favor in system dynamics relates to use of observational information. It is from a Presidential Address to the Royal Economic Society in England:

> "For our knowledge of the behavior of economic agents we must rely mainly on the patient accumulation of direct observations... The findings of those... who have been at pains to ask businessmen what they actually do, have been smiled at as impressionistic, as somehow unprofessional. In the present stage of our science, at least, I believe that this relative valuation should be inverted: we ought to value powers of observation more highly than powers of abstraction." [7]

In the social sciences, and especially in economics, modeling is based primarily on historical numerical data. Restriction to numerical data excludes the overwhelming body of information on which the real world operates. Families, companies, and countries function because of the information and attitudes in people's heads. To use only numerical data and to exclude information from the mental and written data bases means that one loses most of the available information about structure and governing policies.[8]

Forecasting

The attempt to forecast future economic behavior is often taken as the proper and maybe the only important test of an economic model. The ability of a model to forecast future conditions is sometimes described as the gold standard for model evaluation. But seldom in the economic literature is there any claim that a model forecast is better than a naïve forecast of simply extrapolating from the recent past. Actually, I believe that attempts to forecast future conditions is a losing game and has been a diversion that has carried economists away from far more productive work. Some issues surrounding forecasting are treated in Appendices K, L, M, and N of *Industrial Dynamics.* But there are considerations, other than the failure of forecasting efforts, to believe that such attempts are inherently doomed.

Figure 4 illustrates forecasting in the context of system behavior. A past path of some variable is known up to the decision time. Because stocks in the system change slowly, we can expect the near future to be an extrapolation of the past because nothing can quickly divert the path. But the likely range for the future value of the path diverges with time due to randomness and the dynamics inherent in the system structure.

The time horizon for an effective forecast is that interval during which little deviation is possible from future disturbances. Action taken at the decision time will have little effect in the forecast time horizon because, like the slow response to randomness, there will be a significant

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[7] Brown, E. H. Phelps, 1972. The Underdevelopment of Economics. *The Economic Journal* 82 (325), 1-10.

[8] Forrester, Jay W., 1980. Information Sources for Modeling the National Economy. *J. Am. Stat. Assoc.* 75 (371), 555-574.

time before the effect of a policy change will affect the system. Any action at the decision time will be effective mostly in the action region, which lies beyond the forecast region.

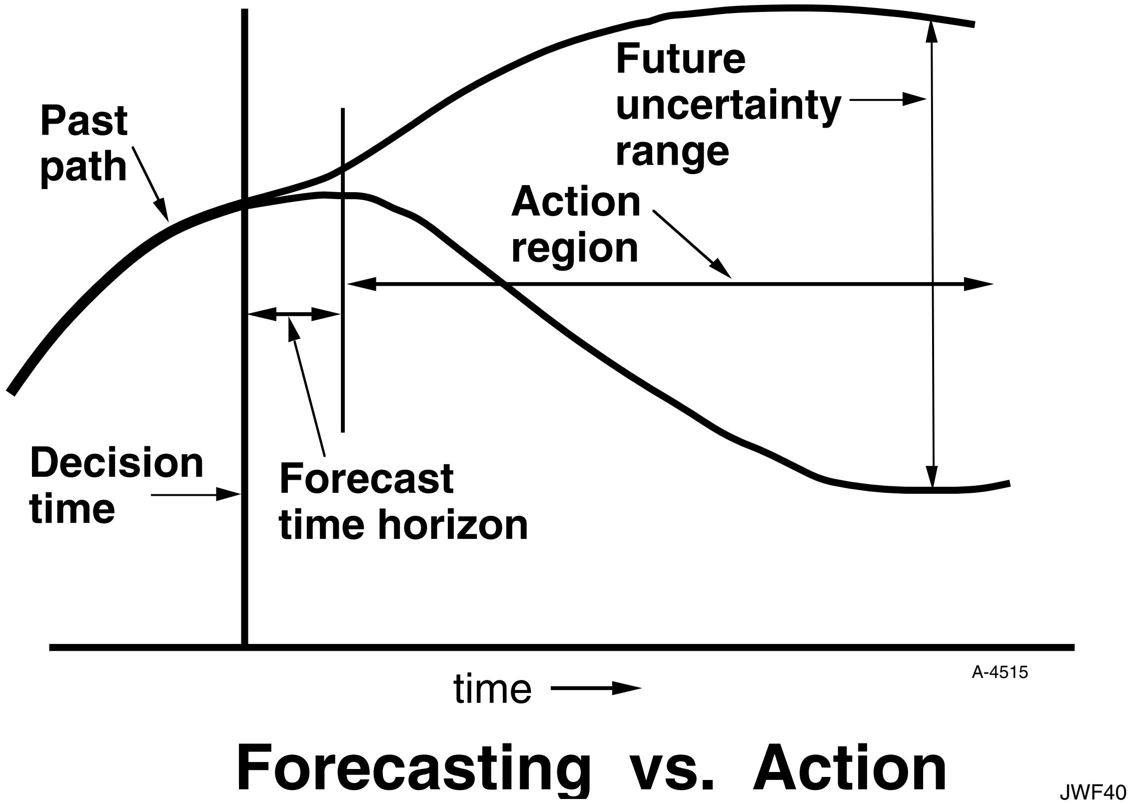

Figure 4. Limitation on forecasting.

The relationship, between the short time within which to make a reliable forecast and the long time required to affect the system, limits the usefulness of forecasting. As a result, and with only a little exaggeration, we can conclude that one can forecast in the time zone in which one cannot act, and can act in the time zone in which one cannot forecast.

The most effective use of a system dynamics model lies in a different kind of forecasting. A system dynamics model should be used to forecast how the nature of the behavior of a system would be altered by consistently following an alternative policy. Such a forecast of the ongoing effect of an enduring policy change can be done and can lead to improved systems.

Markets

In the model, supply and demand are not balanced by prices alone, as is commonly done in economic models. Inventories, backlogs, and delivery delays are the primary short-term balancing forces. Prices then change as a result of over or under supply of product.

The model does not contain any supply vs. price curves or demand vs. price curves. In economics textbooks, the supply and demand curves are used to define equilibrium conditions. However, such curves do not fit the real world in the longer run and are unsuitable for a model that is to incorporate growth and is to operate over long periods of time.

Examining Theories

I believe that an underdeveloped area in system dynamics is the use of simulation models to critique descriptive theories about behavior. Such under-evaluated descriptive theories are found in most fields. Economics, management, government, and the social sciences are especially prone to teaching and acting on the basis of asserted theories that may contain major flaws. Models derived directly from the described theories can be used to discover inconsistencies, omissions, and discrepancies between the theories and the alleged behavior.

Accelerator-Multiplier Assumed Theory of Business Cycles

An example from economics of a theory that is inconsistent with the assumed implications is shown in Figure 5.

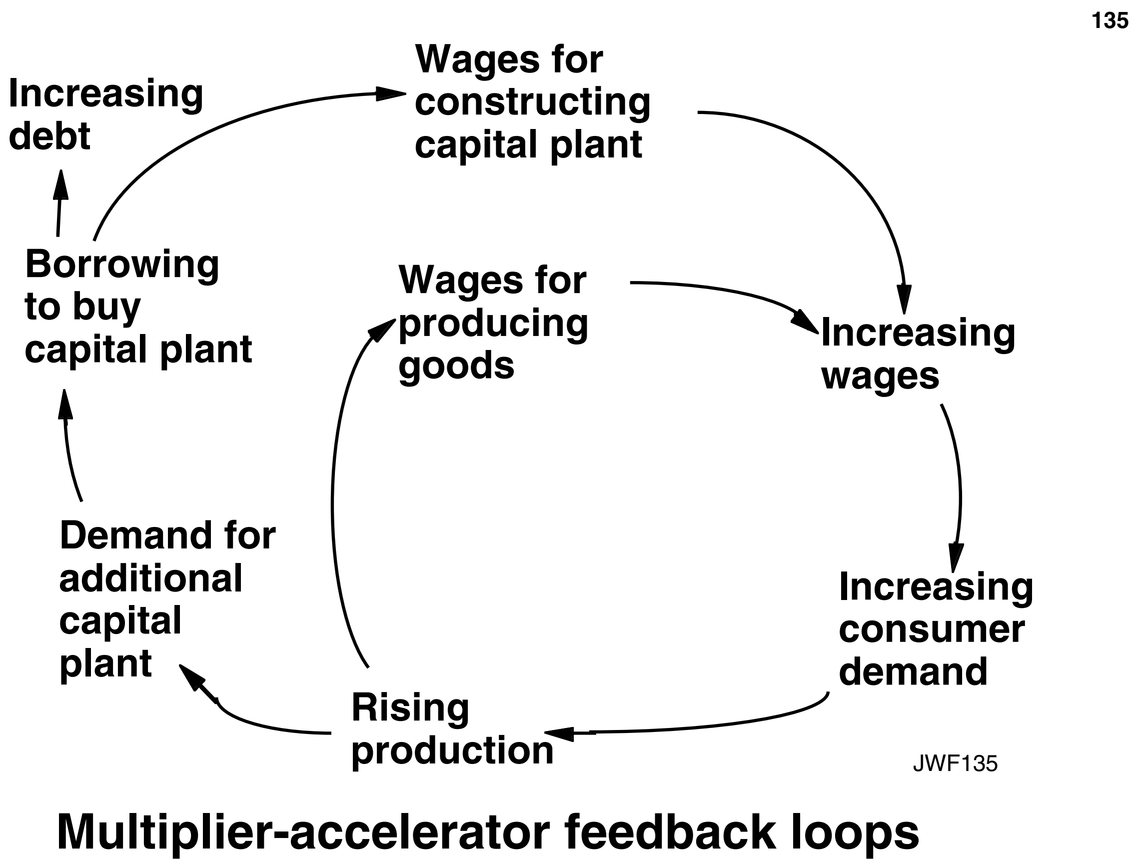

Figure 5. Multiplier-accelerator loops.

The illustrated "accelerator-multiplier theory" has been proposed as a cause of short-term business cycles. The argument asserts that rising consumer demand would lead to rising production that in turn requires hiring more people and paying more wages. At the same time, more production requires more capital plant with still more employment and wages. The increased wages flowing back to the household support a still higher consumer demand. The positive feedback is presumed to build expansion of a business cycle until shortages of labor and financial stresses reverse the direction to drive down economic activity. The model that I am developing and also other system dynamics models show that no plausible assumptions in the accelerator-multiplier theory can create business cycles.[9] [10] Instead, the structure creates a fluctuation of several decades between peaks. So, the accelerator-multiplier theory cannot create the assumed business cycles but instead is a major contributor to the economic long wave, which most economists believe cannot exist.

Other Economic Theories to be Examined

A comprehensive model that represents the structure and behavior of the real system can become a vehicle for evaluating a wide range of prior descriptive theories such as the following:

a. There has been no generally accepted theory of what causes the short-term business cycles. Those theories can be examined in the economic model and rather clearly the production-inventory theory is the most persuasive.

b. Several years ago the so-called "Phillips Curve" received wide acceptance in policy circles as a guide to monetary policy. The curve was asserted to be a relationship between unemployment and inflation with unemployment falling as inflation increased. The theory arose from plotting unemployment against inflation from business cycle data. I believe we can show that the theory was in error as a result of attributing causality to what is only a coincidental phase relationship within the complex dynamics of business cycles.

c. One debated argument asserts that the Great Depression was accentuated because wages would not fall fast enough to sustain employment and business profitability. In the comprehensive economic model, one can answer such a question by increasing the response of wage change to unemployment.

d. Another theory puts responsibility for the Great Depression on the Federal Reserve for not making credit sufficiently available during the downturn. Probably we will show that the timing of the criticism is misplaced. It is more likely that the error of the Federal Reserve was to make excessive credit available during the expansion period in the 1920s as it has again been doing the 1990s, thereby increasing the excesses that must be dissipated during the resulting downturn.

Major Depressions

There have been major depressions greatly exceeding the severity of ordinary business cycles, around the 1830s, the 1890s, and during the Great Depression of the 1930s. Economic theory has offered no convincing and generally accepted explanation for such major economic dislocations. According to one writer, "To understand the Great Depression is the Holy Grail of macroeconomics."[11]

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[9] Low, Gilbert W. 1980. The Multiplier-Accelerator Model of Business Cycles Interpreted from a System Dynamics Perspective. In Jorgen Randers (ed.), *Elements of the System Dynamics Method*, pp. 76-94. Waltham, MA: Pegasus Communications.

[10] Forrester, Nathan B., 1982. *A Dynamic Synthesis of Basic Macroeconomic Theory: Implications for Stabilization Policy Analysis*. Ph.D. thesis, Sloan School, Massachusetts Institute of Technology.

[11] Bernanke, Ben S., 1994. The Macroeconomics of the Great Depression: A Comparative Approach. *National Bureau of Economic Research* (Working Paper No. 4814), 1-53. p. 1

The Great Depression of the 1930s is usually seen as an unfortunately severe ordinary business cycle. In mainstream academic economics there is little acknowledgement that the major depressions could be a dynamic mode that is separate from business cycles. Such rejection of a long economic fluctuation probably results from there being no systemic theory that could explain depression episodes that are decades apart.

However, outside the mainstream economic theory, a substantial body of literature exists with observations and hypotheses about a behavior usually known as the Kondratieff cycle, or economic long wave. Historical data has been analyzed to show widely spaced deep economic downturns but the data analysis methods have been highly criticized and mostly ignored. Most economists deny the existence of a systemic cause for depressions. Among the few who do believe there is such a phenomenon, most adopt a unitary explanation, that is, picking a single cause such as when wars occurred, when gold was discovered, or when new inventions replaced the old technology. All such efforts to explain the major depressions have been hampered by absence of a coordinated theory of how a fluctuating economic activity with peaks spaced 50 years and more apart could be generated.

We come now to a system dynamics model that does generate economic depressions many decades apart. A model is a theory that explains the behavior created by the model. The structure of the model and the policies in it are clearly the reasons for the behavior that results from the interactions of the parts of the modeled system. Whether or not the model can be accepted as a theory describing the real world depends on the plausibility of the model. Confidence in such a model depends on whether or not the structure of the model can be identified in the real world, how similar the model behavior is to the kind of behavior that has been observed, and how well changes in model policies result in changes in behavior that are reasonable and that have been observed in actual economies. After many years of model development and comparison with numerous aspects of historical economic behavior, I believe that the model will pass an acceptable range of confidence tests.[12]

This is not the place to go into detail about the model and its simulations, but a few examples will give a glimpse of what can be done. I am starting a book that will contain a disk with the complete model and will show computer simulations of behavior and the effects of policy alternatives.

Several powerful feedback loops contribute to the economic long wave, or Kondratieff cycle by linking together:

Over investment in capital plant
Excess borrowing to build the excess equipment and buildings
Monetary policies that extend the expansion and promote the excesses
Changes in real interest rates that accentuate the rise and collapse
Increase and dissipation of growth expectations

As one of the powerful feedback loops driving an economic fluctuation of many decades between peaks, Figure 6 illustrates loops in which the monetary authority accentuates the long wave by holding down real interest rates during the expansion phase and thereby increasing the excesses of debt and overbuilding.

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[12] Sterman, John D., 1986. The Economic Long Wave: Theory and Evidence. *System Dynamics Review* 2 (2), 87-125.

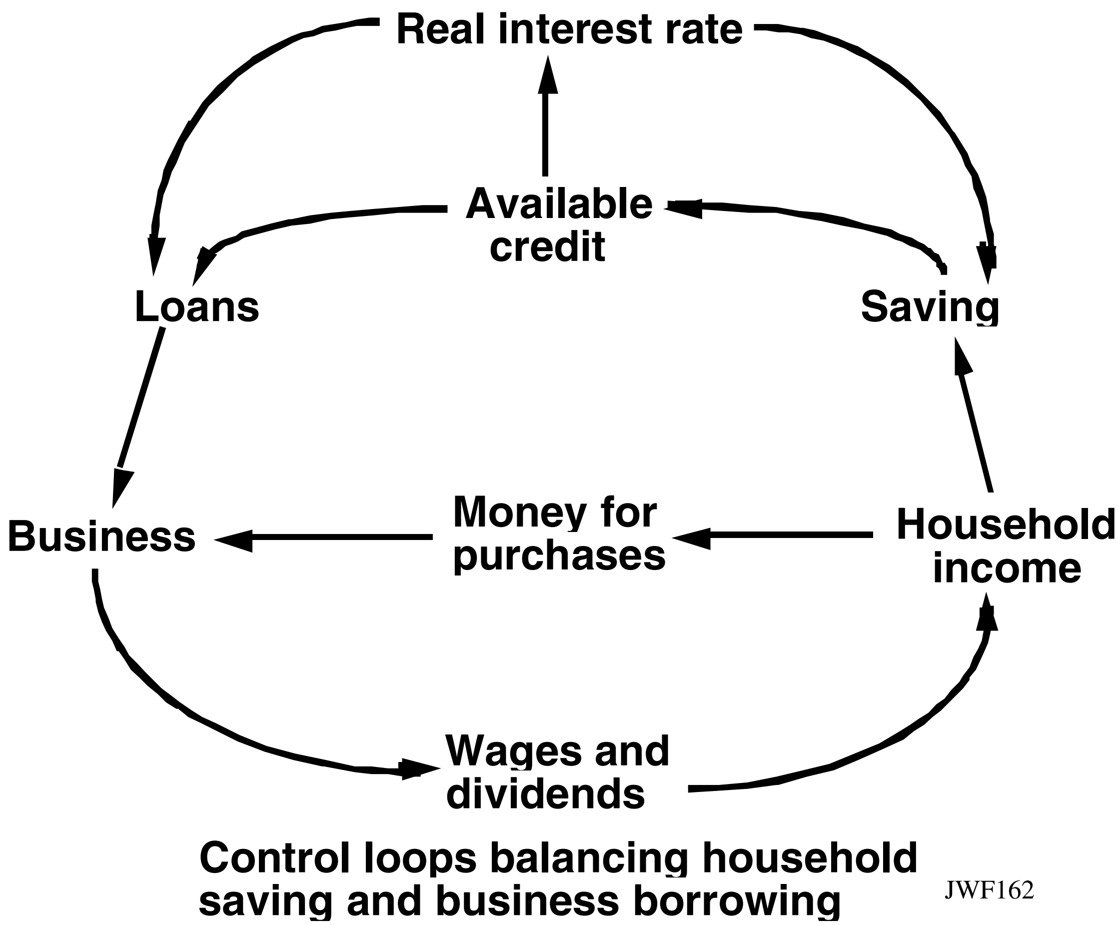

Figure 6. Real interest, business borrowing, and household saving.

Real interest equals nominal bank interest minus inflation. By holding down bank interest and allowing inflation, especially inflation in asset values such as equities and real estate, the monetary authority maintains a low real interest during the long wave expansion. Low real interest encourages business to borrow and expand, encourages increase in asset prices, but also discourages household saving. As a result of more loans and less saving, the monetary authority must make available expanding credit to hold down the bank interest rate.

Figure 7 is a computer simulation over a cycle of the long wave for a model without growth in population or technology. It shows the very low, even negative, real interest during the expansion phase of real GNP. But as the peak is approached, debt becomes burdensome, production capacity outruns demand, and competition drives down prices. Inflation becomes deflation, meaning negative inflation, causing a rise in real interest. At the peak of the long wave, capital plant is excessive and the real interest rate has risen, which together make additional investment unattractive and drive down new capital spending. In the present U.S. economy, the collapse in capital investment is especially evident in those companies that supply equipment to the telecommunications industry.

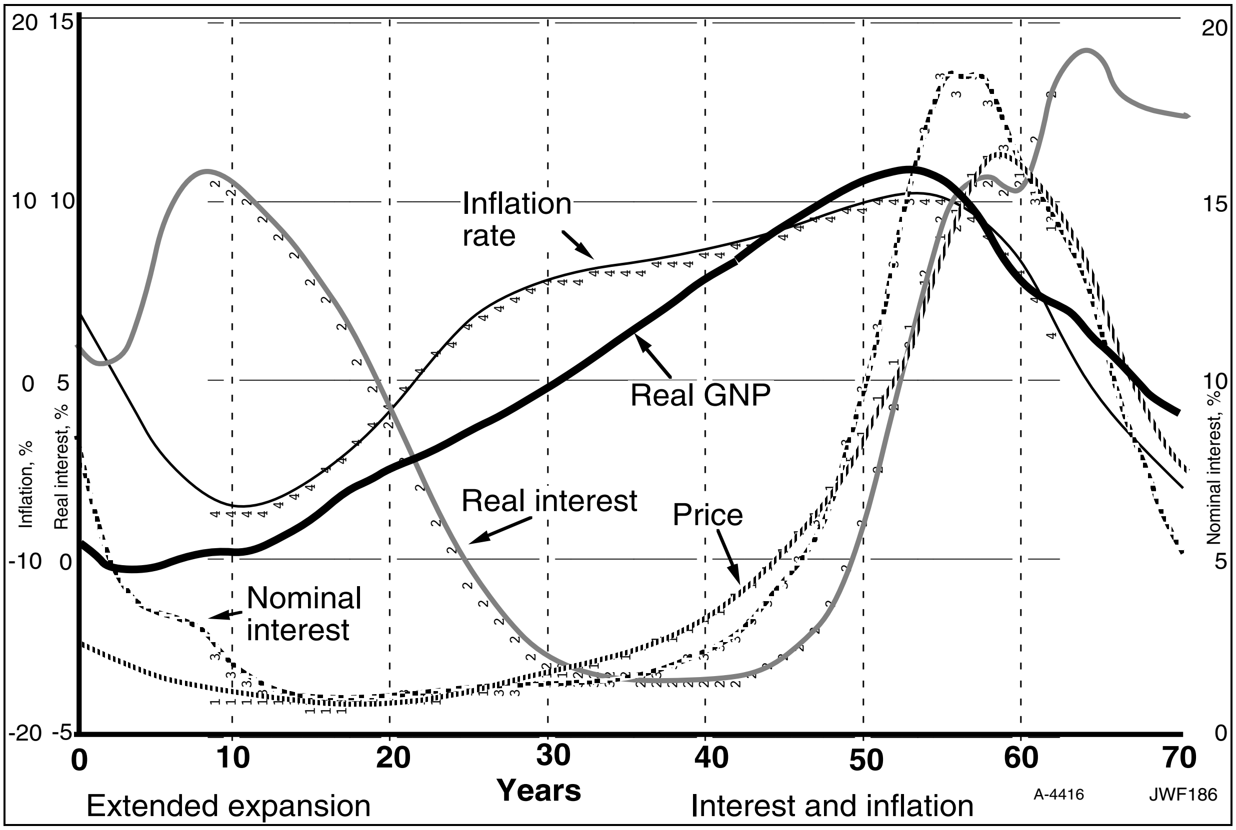

Figure 7. Interest and inflation during one long cycle.

Several years ago Japan fell into a typical long-wave depression brought about by excessive credit and an extreme bubble in real estate prices. It has yet to default on the resulting debts and awaits the eventual depreciation of buildings and capital plant.

Peaks of the long wave are often considered to be some 50 years apart. However, about 70 years have now elapsed since the Great Depression of the 1930s. An explanation appears to lie in some simulations we have made in which an aggressively liberal monetary policy was introduced a decade before the peak would have otherwise occurred. It appears that expansive credit, as we have had in the United States, can extend the peak and delay the downturn for two decades or more.

In my experience, modeling has often revealed behavior that was unexpected, and for which there was no prior reference mode, but which was then found to exist in the real system. Such was our introduction the Kondratieff cycle. I was not aware of the literature, mostly in European sources, about the possibility of a large, long-period fluctuation in economic activity. But, as soon as we coupled a capital-producing sector to a goods sector in the model, we observed a large-amplitude instability with an interval of several decades between peaks.

When such unexpected behavior occurs in a model, one should start by looking for errors in the model. However, as a model is improved, there is a rising chance that unexpected behavior is revealing something about the real system. After careful examination of the model behavior, the causes of the long-period oscillation seemed reasonable and we were led to the related literature, the controversies, and the contradictory explanations. The explanations of the long wave in the literature seem contradictory only because they lack the context of a unifying systemic theory. In light of the behavior we see in the model, the literature is a replay of the fable of the four blind men and the elephant in which each feels and identifies a different structure. Most of the economic long-wave literature contains correct fragments when one realizes that each writer is looking at a different part of a complex behavior that has multiple manifestations.

Economics Education in K-12

As we look to the future, I see a most important role for system dynamics in developing material on economic behavior for kindergarten through 12th grade education.

A multitude of small models are possible to illustrate economic issues that students encounter in their own lives and in the surrounding communities. As an example, a one-level model of credit card debt and the accumulating interest can be surprising. I have observed the shock of MIT undergraduates when they see how much their standard of living could increase if they were to forego immediate purchases and let the income stream that would otherwise go for credit card interest be available for actual purchasing.

Business people lament the poor education that pre-college students receive in economic matters. Furthermore, college economic education does not prepare students for the real outside world. So the deficiency in K-12 education would not be remedied by trying to import economic education from the universities. Students need material and ideas that are more relevant, more dynamic, easier to grasp, and more enduring.

Several people have made excursions into K-12 economic education based on system dynamics. But much thought and effort must still go into an economics education that would build cumulatively through twelve pre-college years. Of course, when 12 years of dynamic economics have been created for pre-college, then the follow-on college courses must be totally rebuilt.

Design of Economies

System dynamics modeling has a major future opportunity in developing policies and designing economic structures for better behavior. Laws and government decisions, which have resulted from lobbying, compromises, and short-term thinking, have designed present economies. Such incremental design steps often move the structure and policies in the direction of creating more vulnerable economies. Opportunities for exploring alternative designs present themselves continuously in the newspaper headlines:

> Rather than debating what the monetary authority should do at each moment in time, there should be a search for policies that can be enduring and steadily applied.
>
> Modeling will also show that feasible structural changes are desirable. As an example, to control inflation, the monetary authority should control the money supply. But structural changes, such as check writing on money market funds, has made the effective money supply very difficult to control. As a result, in the United States, the Federal Reserve has resorted to controlling short-term interest rates with undesirable and unforeseen consequences. Redesigning economies should be based on models used to examine not only policies within an existing system, but also changes in the structure of the system.
>
> The endless debate about Social Security and its future can be clarified by modeling the actual structure of the system and its relationship to the total

economy. In the United States, there is continued argument about the so-called Social Security Trust Fund, which does not exist in a meaningful way. The Trust Fund is composed simply of government bonds that have been issued while the government has spent the excess retirement taxes. To redeem those bonds the government in the future must raise taxes or borrow more, which is the same as there being no Trust Fund. All support of retirees, whether Social Security or private pensions, must come out of future current production. A relatively simple model could clarify the debate.

Many other areas invite dynamic modeling—effect of deficits, health care, foreign exchange rates, free trade, the future of economic growth, the best way to resolve excess debt in a long wave downturn, and the wisdom of loaning money to developing economies that then find themselves in a nearly impossible repayment commitment.

Laws controlling debt repayment need to be drastically altered. When loans to foreign countries are defaulted, the lender swallows the loss. But when loans to a farmer are defaulted, the farm is foreclosed and the farmer evicted. Why should the borrower be totally responsible for a debt? Indeed, the borrower should not borrow what he cannot repay. But likewise, the lender, who usually claims to be smarter, should not loan to a borrower who cannot repay. The responsibility lies on both sides. The heavy overhang of debt in a deflationary economy causes much of the hardship and extended duration of depressions in economic long wave downturns.

Wherever one looks, there are opportunities to find ways to improve economic behavior. We need to be bold and willing to look for answers to the major weakness in our societies.

Observation

Great opportunities lie ahead in establishing a new kind of systems economics and a very different kind of economics education. However, we must be aware that such a change is a major paradigm shift from that of the current economics profession. Paradigm shifts come very slowly. Holders of the existing theories and methods will probably not be converted. The future path must be through building up an alternative and more effective approach. Among present economists are many who are disappointed in the ineffectiveness of the field but only the most daring will be willing to break with their past and attempt to learn system dynamics modeling. The strategy must to be to persist, even over several decades, in surrounding and replacing the existing mainstream economic paradigm.

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