

RURAL CHANGE

The Challenge for Agricultural Economists

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*Understanding the Development of World Agriculture:
Insights from Adaptive Economics*

1 INTRODUCTION

The development of world agriculture involves among other things increasing productivity of labour and land, displacement of farm workers, a shift in the production of farm inputs to the industrial sector, a decline in the economic viability of traditional sources of livelihood, migration of rural workers to urban areas and so forth. These developments lead to a host of adjustment problems in both rural and urban areas, such as unemployment, lagging development of infrastructure in the urbanizing parts of the economy, low income including poor nutrition and in extreme cases starvation on a substantial scale. How is this massive transformation to be understood and how are the concomitant problems to be solved?

Economists often analyse such issues by using the well developed apparatus of neoclassical economics based on ideas of individual optimality, supply–demand equilibrium and social (Pareto) efficiency. In this paper an alternative approach, called adaptive or behavioural economics, is considered which looks at precisely those aspects of real world experience from which the pure economic theory abstracts, namely, limitations in human cognition, supply–demand disequilibrium and social or Pareto inefficiencies and disimprovements.

From the vantage point of this alternative approach, agriculture is seen as a dynamic process that endogenously generates irregular fluctuations and switches in techno-social regimes or phases. In extreme cases phase switches stimulate creative morphogenesis: the invention of new technologies and economic organizations that can restore viability and mediate disequilibrium transactions under newly evolving circumstances.

These ideas are used to suggest a new perspective on the emerging world-wide agro-industrial complex. A growing crisis is seen in the current trends in population, energy utilization, and food production; a crisis whose magnitude, duration, and inception cannot be predicted but whose inevitability and significance can now, on the basis of recent experience, be safely assumed. The avoidance of extreme dislocation will require energetic technical and socio-economic innovation.

2 AGRICULTURAL DEVELOPMENT: A GLOBAL VIEW

For millenia after its emergence the connection between agriculture and population was direct. Most people dwelled on farms or in farming villages, producing food primarily for their own consumption. A crucial surplus did make possible the emergence of a few urban centres. As civilization advanced cities of considerable size emerged. Technology gradually improved and agriculture expanded so that the surplus could continue to support the increasing non-agricultural population. Still, it is only in the last few centuries that development has accelerated to such an extent that some parts of the world are now primarily urban and industrial. In our own time, indeed during the last two decades, those parts of the world that are still dominated by agriculture have commenced this great transformation. As a result cities team with hundreds of thousands of rural immigrants where only backward villages stood a few years ago.

All of this means that much of what is produced by the people who remain in agriculture is sent away from the countryside. The connection between food production, processing and consumption is no longer direct.

The improvements in agriculture that underlie the urban transformation have, in part, been indigenous. Improved plant and animal breeds, and more effective rotations provide examples of such indigenous technological change. Many improvements, however, have required investments in capital that can only come from the industrial sector. The use of internal combustion engines to replace humans, bullocks, and horses provide one prime example. This substitution releases land for human food production on the one hand. It drastically reduced farm labour requirements on the other hand. Tractorization therefore stimulates the rural-urban flow and augments the supply of food to feed the expanding urban mass.

Another example of the substitution of industrially produced goods for farm produced inputs is the use of synthesized nutrients. This has made possible the productive use of land that is otherwise infertile and has augmented still more the productivity of already fertile land.

Such developments amount to an *indirect industrialization of agriculture*, that is, the production of inputs by the non-farm economy to be used for the production of food on farms. It contrasts sharply with the direct industrialization of the production of food, which, though already begun and growing in importance, is not yet having the impact its indirect counterpart has had or is having.

This indirect industrialization not only involves increasing farm productivity and rural-urban migration, it also involves an additional critical characteristic, namely the substitution of fossil fuel for solar energy in food production. This is partly because petroleum and its derivatives are used for the commercial production of both fuel and fertilizer. It is also because industrial production of machinery and other non-farm inputs makes heavy demands on non-solar forms of energy. As a consequence,

the Green Revolution has created an agro-industrial complex with corollary dependence of the nutritional well-being of the world's population on the supply of petroleum and other exhaustible resources.

The progress of this development, when viewed from an astronomical time scale, is explosive. Along a time axis stretching from the origin of the earth to the solar heat death trends in population, output, productivity and fossil fuel consumption appear as spikes. From an historical perspective, looking back, let us say, to the origins of civilization, the trends appear as more or less geometrically growing curves.

As we focus attention more narrowly on the contemporary scene, however, the epochal transition becomes less apparent. It tends to recede within a variegated pattern of differential response. In some countries where the process has scarcely begun, agriculture is seemingly stuck in ancient patterns. In others where it is underway, some regions proceed at a faster pace than others. Elsewhere the transformation is more or less complete.

In mature and fully modernized economies the dramatic changes seem to be like the classic "cobweb" phenomenon: rising and falling prices, falling and rising supplies, recurrent problems of income and employment. But in the underdeveloped areas widespread famines break out from time to time on such a scale as to exhaust world resources for disaster relief, thus bringing human suffering to catastrophic levels. In the former setting of classic price, income and trade policy, pundits often urge the movement of resources out of the surplus producing, unstable regions. In the latter setting the opposite position is taken in an effort to move resources into agriculture so as to expand the production of food, thereby raising nutritional levels and providing an increase in the well-being of rural dwellers.

3 THE NEOCLASSICAL INTERPRETATION

Our picture of the growing and fluctuating agro-industrial complex is a dynamic one. It is one of uneven, unbalanced growth, of rapid technological change, of the transformation of ways of life, and of periods of fluctuating fortunes for the producers and consumers of food. This is not the place to survey all the methods of economic analysis that can be brought to bear on understanding this complex picture. But to illustrate why a new perspective is needed I want to remind you briefly of the core features of economic analysis.

First of all, economic individuals are defined who have stationary preferences. Second, firms are defined that have stationary technologies. Third, individuals and firms are assumed to maximize preferences and profits respectively given prices. Fourth, economic equilibrium is defined for transactions among individuals and firms: the demand for commodities must not exceed the supply. Thus, although economic exchanges are decentralized they must be perfectly co-ordinated by the price system.

Fifth, social equilibrium is said to prevail when, at equilibrium prices, each individual and each firm maximizes its goal, and no individual or firm can improve its situation without diminishing the situation of at least one other. Two problems are then analysed within this framework: (1) the existence of equilibria and (2) the way such equilibria change when parameters of the system change. The latter type of comparative statics lies at the heart of much, if not most of what passes for policy analysis by economists.

To have a useful correspondence with the real world such an approach to policy evaluation must rest on two critical assumptions. First, the *real* disequilibrium system must work in such a way as to bring equilibrium about. Second, the transition period of disequilibrium must not be so long and so full of problems as to matter in any significant way. If these two assumptions are fulfilled then it is not necessary to understand the nature of disequilibrium nor is it necessary to design policies specifically to cope with its implications.

Now are the basic assumptions of neoclassical economics a good approximation of economic reality? I take it as an implication of scientific reason and of common sense that they are not. If I am right, they therefore provide an inadequate basis on which to understand actual development and from which to derive workable policy. Additional perspectives are needed and that brings me to the next topic, adaptive economics.

4 ADAPTIVE ECONOMICS AND ECONOMIC DEVELOPMENT

It is to belabour the obvious to observe that human decision-makers possess cognitive limitations, that they are imperfectly co-ordinated, and that they vary absolutely and relatively in the rewards and punishments they receive as a result of action. In contrast to orthodox economic theory adaptive economics explicitly incorporates these basic facts of life. Let us discuss them briefly in turn.

Cognitive limitations include imperfections in perception, memory, reasoning and computational power. We may also include in this category difficulties in formulating consistent preferences on the basis of which rational decisions can be based. These facts mean that rationality is "bounded", to use Herbert Simon's apt phrase, and that it involves learning. One exercises the best judgement one can, given what one knows at the time, observes the results, attempts with more or less energy and skill to acquire more knowledge, plans anew, and carries out the implied actions in response to circumstances as they unfold. In conducting these cognition-behaving sequences resort is made to imitation, rules of thumb, habit, inertia and even thoughtless impulse as well as to rational planning.

Economic models that incorporate these aspects of economizing activity include the rule of thumb behavioural economic models of Cyert and

March (1963); the goal adaptive, adjustment behaviour of March and Simon (1958) and Forrester (1964); the recursive programming approach of Day (1962), Day and Singh (1977), and Day and Cigno (1978); the X-efficiency concepts of Leibenstein (1966), (1976); and the satisficing, selection analyses of Winter (1964), (1971), and Nelson and Winter (1978).

Within complex, interactive settings individuals must reach decisions and behave without the benefit of a complete knowledge of what other participants in the process are doing. Therefore they cannot know in advance whether or not effective co-ordination can occur and whether or not supplies and demands for commodities will equate. Evidently, behaviour must be possible and viability must be maintained through the existence of special *disequilibrium mechanisms*. For example, firms may maintain inventories. In addition specialized institutions whose function is to regulate exchange may exist. Such institutions, which include stores and banks, constitute the marketing and financial systems. These systems must be viewed as instruments for mediating economic transactions among individual decision-makers and economic organizations which function out of equilibrium.

A proliferation of such mechanisms cannot always guarantee existence, however. Bankruptcies of farms, industrial firms and banks in the United States run in the thousands every month. Such events signal the demise of individual enterprises, and the transfer of their resources to other enterprises in the system. During periods of economic breakdown that occur in hyperinflations or depressions, human life itself may be in jeopardy, even in wealthy countries.

It should be noted in passing that socialist economies are not immune from the problems of disequilibrium that we are observing. They are in fact archtypical examples of the larger, hierarchically managed economic organization whose constituent members have all the characteristics of adaptive man and which must therefore display lack of perfect co-ordination. Therefore, they too must possess mechanisms much like those in capitalist countries, for mediating disequilibrium transactions within and among individual enterprises.

How do such disequilibrium systems evolve and what is the character of their historical trajectories? Careful computer simulation and theoretical analysis all point to the possibility that model systems of the character we are discussing need not and often will not converge to economic equilibria even when the latter can be shown to exist. Two striking characteristics of system behaviour emerge instead. First, many variables display irregular oscillations of more or less unpredictable complexity. This suggests that policies of control based on observed system performance may be exceedingly unreliable. Second, the system as a whole is characterized by multiple phases and corollary shifts in structure. Each phase represents a given configuration of economic activity, scarcity and surplus, and associated values. Within this configuration some activities grow more or less explosively, as economic advantage is successfully exploited by some organiza-

tions within the system. These growing activities replace uneconomic, obsolescent, or otherwise unsuccessful pursuits which are seen to diminish in importance. A counterpoint of economic growth and decay occurs. Eventually, the prevailing structure gives way as certain components are eliminated altogether or certain activities are abandoned in favour of new ones designed to cope more effectively with current opportunities and scarcities. A characteristic feature of this point-counterpoint of development is that economic activity takes place in overlapping waves involving commodities, technologies and corollary ways of life.

A more extreme feature is the occasional breakdown of the system altogether. These disruptive times provide a focus for the synthetic faculty of mind. New organizations and activities are created that temporarily resolve the internal contradictions that have emerged and that set the system off on a new trajectory of evolution.

5 THE DISEQUILIBRIUM DYNAMICS OF AGRICULTURE

To summarize the adaptive economics perspective in a nutshell, economic change involved unpredictable fluctuations, overlapping waves of growth and demise, periodic breakdowns and organizational morphogenesis. This brings us back to a reconsideration of agriculture. For in what other sector of the economy are these characteristics more evident?

The exasperating unpredictability of farm production is so well known and so universally experienced as not to require comment, except to mention that such unpredictability can now be shown to emerge under some conditions from the internal working of the system without assuming the imposition of random shocks. This would mean that many of agriculture's problems might remain, even if the weather were much more uniform and predictable than it is.

Overlapping waves of development are apparent everywhere we look at the farm scene. New practices, new machines, new cropping patterns, new consumption activities replace the old with astonishing speed in the modern world. One or two decades is enough to bring about a transition in an entire way of life.

In the developed world, where this counterpoint has already been repeated several times, it has come to be expected so that its disruptive effects are no longer so directly experienced. In newly developed areas, however, the changes are disrupting ancient patterns and forcing changes so fundamental as to involve the demise of basic cultural ways of life, and to force the mass relocation of whole peoples. Indeed, in some parts of the world we are seeing the final destruction of paleolithic and neolithic life as the last vestiges of pre-agricultural technology are literally ploughed under by the agricultural-industrial frontier.

Somewhat less cataclysmic, but of fundamental significance, is the growing network of linkages between the industrial and agricultural sectors, and, because of the uneven distribution of resources and peoples

around the world, the growing web of interdependencies between the world's various regions, nations and cultures.

Indeed everyone now knows of the petroleum crisis that has emerged as new constraints have been reached and new interactions evolved. The potential and actual instabilities are already apparent and a new generation of policy making is just getting underway that may be expected to lead to new national and international institutions for managing resource scarcity and for distributing world food supplies.

The information, decision and production delays that induce instabilities and fluctuations are lengthened and elaborated as the structure of intrafirm, intersectoral, interregional and international linkages grows more intricate. Ironically, the elaboration of new institutions, new marketing and monetary mechanisms to overcome system constraints and to provide for enhanced viability, adds to the complexity of the system. New decision variables and new decision-makers are added along with corollary information, decision and production delays. The dynamic "order" of the system increases and with it the potential complexity of the patterns of historical behaviour. Thus, the "solution" of each emerging policy problem in terms of elaborated institutional structure contains at its inception the seeds of a new order of socio-economic difficulty that will come in its turn to demand a solution in terms of new technical, social or economic organization.

In the rapidly developing African continent we see this interplay unwinding with alarming speed. Savannahs that once teemed with all manner of primeval life are giving way to modern agricultural technology. The result is an urbanization that rivals in speed the expansion of Los Angeles and other such urban explosions that, on an historical time scale, seems to have emerged suddenly as it were "out of nowhere". Its result has additionally meant the transformation of pre-agricultural peoples into urban dwellers, skipping the agricultural revolution itself; a jump from paleolithic to the agro-industrial age. And it is occurring just at the time as exhaustible resources such as petroleum are no longer growing in supply – the irresistible force of economic development seemingly running head-on against the immovable constraints of land and fossil fuels.

6 A POLICY PERSPECTIVE

Agricultural economists have long been interested in what they have rightly regarded as "adjustment problems". Their goals have often been couched in terms of helping farmers adjust, by which they have meant helping them deal effectively with changing economic opportunities, either by more quickly modifying their mix of agricultural activities, or by pursuing opportunities outside of farming altogether. In so doing, they have in part been pushing for policies of change in the face of the most rapid development in the world's history, when migrations from one way of life to another are taking place all over the world at speeds unpre-

cedented in the annals of human history.

Moreover, they have advocated such changes under the assumption (sometimes implicitly made) that the purpose of policy was to speed up the generation of the new equilibrium that would inevitably follow if the irrational barriers to economic change could be brought down.

If, however, the forces for change are disrupting what are merely temporary accommodations to fundamental disequilibrium conditions; if those forces will lead eventually to new instabilities and threats of breakdown; then the role of centralized economic policy may better lie in new directions. First, policies for *moderating* ongoing adjustments should always be considered. Second, policies focused on *preserving* exhaustible resources should receive greater attention. Third, policies for *augmenting* renewable resources should be emphasized at all times. Fourth, *emergency supplies* for meeting inevitable but unpredictable economic and natural disasters with appropriate distribution mechanisms should be put in place on a wider scale than is now done. Fifth, resources devoted to the *free play of the intellect* should be enhanced, for it is out of such free play that creative morphogenesis emerges, which as I have argued in this paper is what overcomes the unpredictable but inevitable crisis that threatens stability and survival even though in the process the seeds of the next challenge to human ingenuity are planted.

Now this last policy presents us with a paradox. For I have advocated a conservative and conservationist approach, while at the same time arguing for fostering the intellectual climate in which new ideas for changing socio-economic structure may flourish. That paradox can never be wholly resolved. It will surely continue to involve an increasing struggle between those forces that wish to preserve and those that wish to create. But, if as I think to be the case, the forces of preservation, however important as moderating influences, cannot overcome inherent instabilities and inevitable crises, then society must have within itself at all times – for its time of need can only poorly be foreseen – a dedicated cadre of socio-economic inventors, innovators and engineers. For it is from this cadre that must come the new organizations and mechanisms that will overcome the crises that would lead to cultural and possibly demographic destruction.

That such destruction is a real possibility must be a fear taken seriously by any student of history and prehistory. The artifacts of wondrous past civilizations warn us of this truth. Thus, while a call for greater resources for the intellectual community is self-serving, it is also a call to social service. For if I am correct, then every scientific paper we write, every thoughtful speech we utter, every discussion, debate or argument intelligently pursued plays its role in the dialectical process by which the human mind seeks to understand and to enhance its own evolution.

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DISCUSSION OPENING – W.H. FURTAN AND S. KULSHRESHTHA

Professor Day has provided this afternoon a very lucid yet highly thought-provoking discussion of an alternative avenue for looking at world agriculture. The purpose of his paper is to present a view of the agricultural adjustment problems based upon the notion of "adaptive behavioural" economics.

Day has correctly identified two parameters of adjustment. The first, which is mainly indigenous, has caused a substitution of capital for labour. The second, the agri-industrial complex, is based largely on non-solar sources of energy. Finally, Day suggests reasons why the neoclassical model does not facilitate an understanding of the adjustment process. In its place he suggests "adaptive economics".

Professor Day has provided us with "what" to look for in the area of disequilibrium economics; but in my opinion he has not led us as to "how to get there". A lack of discussion on how the learning process takes place in the context of world agriculture leaves us in a somewhat confused state. The assumptions regarding the rules under which the adaptation occurs are not clearly specified and thus, after reading the paper, one is left bewildered. Many adaptive models require imposition of rules of learning and constraints within which an individual (or the system) can behave.

From the standpoint of policy making using adaptive economic models one further faces issues such as the optimal degree of aggregation (or disaggregation) of world agriculture and the resulting data requirements. Furthermore, the institutional framework that surrounds the individual system greatly affects the likely behaviour of the individuals over time.

Yet another issue that emerges in the study of any economic system is how to deal with changes in the environment in an *ex ante* framework. Each shock (as an unanticipated change is called) leads to some departure in the behaviour.

The discussion should focus on two things: (1) the ability of the adaptive model to analyse the disequilibrium process of farm adjustment; and (2) what assumptions are implied by the adaptive model. Such discussion might provide some further insights into the usefulness of such an approach in the study of world agriculture.

GENERAL DISCUSSION – RAPPORTEUR: KENNETH H. BAUM

The discussion of Professor Day's paper raised many questions concerning the possible conceptual and application possibilities for testing economic hypotheses and performing quantitative policy analyses. A primary concern of those present was the utilization of adaptive economics as a behavioural approach for rural development and agricultural change research and teaching activities. The assertion that neoclassical modelling approaches may be inadequate theoretical tools for investigating economic disequilibria relative to adaptive economics stimulated many participants' comments in three general areas. First, specification of real world behavioural or resource constraints needs to be more adequately detailed. Second, the particular type and aggregation level of economic problems needed for optimal use of the conceptual framework may vary a great extent and also needs to be explained further. Third, explicit knowledge of the operating processes may be necessary to explain the effect of exogenous shocks on the stability and activity level of the economic system. In addition, both quantitative and qualitative changes may affect the disequilibrium processes of dynamic adjustment. Finally, a question was raised regarding the explanatory relationships among economic disequilibrium processes and class conflicts in terms of adaptive economics.

Professor Day responded to these thoughts by first commenting that the broad economic issues mentioned by the participants are at the core of our economic thinking and simple answers are not readily available. Nevertheless, adaptive economics should be viewed as a cohesive family of concepts, while only a particular set might be utilized in an applied study. The primary goal of the agricultural economist should be to ask how the system in question works, while drawing generously on observations of real world behaviour for derivation of the modelling processes. These processes should not be viewed as *ad hoc* behavioural rules, but rather seen as developed from inductive reasoning utilized to investigate economic theory more fully.

Day explained that the process of economic change and class conflict should be analysed as a natural result of disequilibrium processes. Economic models that "break down" reflect world phenomena where the

market process does not work well. Also conflict seems to be endemic where an economic system is successful. Day's final comments expressed an awareness of the difficulty of teaching adaptive economics. But this difficulty is partially a problem of lack of theoretical work to refine the theory into a more rigorous economic theory, which he hoped would be remedied in the future.

Participants in the discussion included N. Meyer, D. Feinup, M.L. Lerohl, George T. Jones and Indra Jit Singh.