Chapter 3

DISEQUILIBRIUM ECONOMIC DYNAMICS

A Post-Schumpeterian Contribution*

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Adaptive economizing in a decentralized economy with alternative technologies and scarce resources leads to various kinds of locally unstable behavior. Economic disequilibrium is the rule in such a world and requires the presence of market mechanisms that make possible continued viability. If in addition to local instability economies are also globally unstable, as considerable evidence suggests, then the discovery and application of new structure is essential. A complete dynamic theory of economic change must therefore be based not only on conventional rationality and routinely adapting behavior but on a superior faculty which may perhaps best be called creative intelligence.

1. Introduction

Schumpeter began his *Theory of Economic Development* with a description of the circular flow. In it each producer and consumer acts according to a best plan, the former maximizing profits (which must of necessity be zero) and the latter maximizing utilities. All actions are compatible with no room for any one to gain except at the expense of others. In short, he described the circular flow as a competitive, Pareto efficient, general equilibrium or steady state.[1]

Schumpeter's dynamic analysis concerns those forces that break the circular flow and that internally generate and perpetuate fundamental change

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[1]In this chapter 'a competitive equilibrium' is defined in the usual way as a state in which individual optimality and interagent consistency prevail; I define 'economic disequilibrium' to be a state in which one or both of these properties do not hold. A 'stationary state' is a state of rest in which the state variables describing the economic system do not change; a 'steady state' is one in which all variables are changing in the same proportion ('balanced growth'). Stationary or steady states can only be defined for a complete dynamic model that describes the laws of change for the system. The concept of a competitive equilibrium as defined above can (and typically is) used to describe a static model where the laws of change are not specified. For Schumpeter, who was explicitly concerned with dynamics, the 'circular flow' was a stationary or steady state that was also a competitive equilibrium.

in the conditions and activities of economic life. The entrepreneur perceives the possibility of new combinations; banks create credit and place it in the control of entrepreneurs who then command the means of production from their current occupations by bidding up their prices. The temporary monopoly power of the entrepreneur enables profit to exist from which interest can be paid (which provides the source of livelihood for bankers) and which provides an incentive for additional entrepreneurial effort. The latter occurs in swarms, which leads to business cycles that are perpetuated in a more or less irregular fashion. The latter characteristic complicates economizing calculations which encourages error. Such planning errors are inherent in the uncertain trial of new combinations that begin an economic boom.

These familiar elements are still of sufficient interest by themselves to command attention. Indeed, one would hope that this and other similar celebrations of Schumpeter's birth might stimulate a resurgence of interest in his work. In line with this hope I intend in the immediate pages that follow, to consider two ingredients of Schumpeter's system. The first is the behavioral content of economizing and equilibrium. The second is the assumption that economizing and equilibrium are stable in the absence of entrepreneurial activity.

On considering the first ingredient, which would now be referred to as 'bounded rationality' after Simon, one is led, I think, to reject the second, that of the stability of equilibrium. In its place may be introduced components that allow for instability and disequilibrium. Although the Schumpeterian framework is substantially modified in the process we arrive at what I hope might be an improved understanding not only of how but why economies evolve and, indeed, why entrepreneurs exist.

The subtitle 'A Post-Schumpeterian Contribution', indicates that in addition to Schumpeter the discussion draws on subsequent literature on business cycles (including contributors of the Swedish School),[2] behavioral[3] and post-Keynesian[4] economics (including a good share of the colleagues present at this occasion) and on my own work on adaptive economics[5] and

[2]Much of the business cycle literature of the 30's through 50's has a distinct behavioral character. As examples I think of Kalecki (1935), Metzler (1941) and Goodwin (1955), just to mention a few. The 'Stockholm School' focussed on the essence of the problem. The seminal works include Myrdal (1939), Lundberg (1937) and Lindahl (1939). For a review see Bjorn A. Hansson (1982).

[3]The behavioral literature is surprisingly large (if scattered). Seminal contributions include Simon (1948, 1955), March and Simon (1958), Cyert and March (1963), Forrester (1961, 1966), Kornai (1971), Winter (1964), Nelson and Winter (1975, 1982) and Eliasson (1976). Space does not permit more than these few samples. A brief survey of the field will be found in Day (1982).

[4]Examples included Clower (1965), Clower and Howitt (1978) and Leijonhufvud (1968).

[5]I first attempted to develop my ideas in the context of the agricultural sector (1963), then for industry, Day, Morley and Smith (1974), Abe, Day, Nelson and Tabb (1978). Ideas building toward a general approach are contained in Day (1971, 1975), Day and Kennedy (1970), and Day and Cigno (1978).

'complicated' dynamics.[6] In the confines of this chapter it will not be possible to trace the intellectual genealogy of all the ideas presented. I hope readers will allow me to deal with issues of lineage and association in a later work and that they will find sufficient novelty to justify inclusion of some familiar material to which they may themselves have contributed.

The central question at issue is: are economies — or human systems generally — best understood as equilibrium or as disequilibrium processes? My answer is an attempt to provide 'a coherent account of the manner in which ... activities of individual economic agents are coordinated in theoretical systems that bear a family resemblance to economies of actual record'. [Clower and Leijonhufvud (1975, p. 183).]

2. Behavior in and out of the circular flow

Schumpeter described the circular flow as an intricate balancing of production and consumption activities. In it no one would have an incentive to change and agents would not need '... to find their way towards the goal of greatest possible economic welfare by conscious and rational effort' [Schumpeter (1934, p. 10)]. The formidable logical requirements of individual optimality and interagent consistency would not tax the limited cognitive abilities of ordinary people or the imperfect co-ordinative functioning of markets. Tradition, mere habit or inertia would be enough to keep economic actors in line with their own best interests.

Schumpeter elaborates this behavioral theme repeatedly and at some length. I think he did so because it was essential to his assumption of stability. First of all there is the question, if agents cannot calculate the steady state from scratch how do they contrive to stay in such a state once there? Why don't they jump or wander away? Second, there is the even more important question, if the conditions for a general equilibrium have *not* been attained, how can agents who are unable to calculate their optimal equilibrium states conspire to bring about an equilibrium position with the passage of time?[7]

To Schumpeter the answer to both questions was that practical behavior had a stabilizing character. He cited several reasons. (i) Agents inherit an inventory of means and methods of production that are the basis of current activity (*op. cit.* p. 6). (ii) The past influences the activity of the individual because it has 'taught him what to do' (*ibid.*). (iii) One will cling tightly to habitual economic methods and only submit to the pressure of circumstances

[6]A summary of ideas on complicated dynamics in Day (1981, 1982).

[7]In the parlance of dynamical systems theory Schumpeter was asking first, does the dynamic system of behavior possess a stationary or steady state; and second, (if so) is it stable? Roughly speaking 'local stability' means the ability of a system to approach a stationary or steady state arbitrarily closely if the initial conditions are sufficiently close to begin with. A locally unstable system will move away from such states no matter how close they may initially be.

as it becomes necessary (*op. cit.* p. 8). (iv) The individual is never equally conscious of all parts of the value system ... also he does not pay attention to all the facts but only to certain indexes 'ready at hand'. (v) He acts in 'the ordinary daily round according to general custom or experience' (*op. cit.* p. 40).

Evidently, to Schumpeter, it is the tendency to cling to the familiar, to resist change, to adapt only slowly under pressure that keeps adaptive agents at equilibrium within the circular flow (*op. cit.* p. 235). Moreover, this presumed 'stability' is indispensable for the economic conduct of individuals. Without it the limited economizing of which they are capable is rendered extremely difficult. He continues:

> 'This empirical way of acting has a rational basis. There is one kind of economic conduct which, under given conditions, establishes the equilibrium between means on hand and wants to be satisfied in the best way possible. The value system ... cannot be altered ... without the individual's having the experience that he is worse off than before ... therefore ... one and only one way of acting commends itself to the individual, and the results of action remain the same as long as the given conditions remain the same.' (*Op. cit.* p. 40.)

Schumpeter argued that all this applies to steady growth as well for it does not involve essential change or difficult choice but only stable repetition of established activity. Thus, Schumpeter is precise: General Equilibrium Theory characterizes the rational content of an equilibrium or steady state; *the adaptive nature of people explains its perpetuation once entered.*[8]

He also thought that this adaptive nature adequately described the 'economic system's tendency towards an equilibrium position' (*op. cit.* p. 62). This tendency 'may be described as an adaptation to data existing at any time' (*ibid.*). The data of course may change, either gradually, in which case no change in the equilibrium story is necessary, or drastically, in which case stable adjustment will occur bringing about a 'new equilibrium position' (*op. cit.* p. 62–63). But, in contrast to the quite elaborate defense of the various other points of his argument, here he merely postulates a 'noteworthy stability' in the absence of any creative agent. As long as agents in their roles as consumers, workers and managers have only given 'data' to which to adapt, the circular flow emerges.

Given this *assumption* of stability, new forces must be introduced to disrupt equilibrium once it is attained, ones that *do not function in the*

[8]In this chapter 'adaptive behavior' is defined to be behavior that responds to states of the system (effectively or not). Thus, farsighted economic behavior is adaptive if the data anticipated for the future upon which current behavior is based depend only on current and past information about the economic system.

circular flow. These disequilibrating forces are mediated by two new agents who augment the pre-existing population of consumers and firms. These agents are entrepreneurs and banks. The former perceives (or creates) new combinations of the materials and forces of production while the latter creates purchasing power and places it in the hands of the former, thus enabling entrepreneurs to effect the pursuit of expected profit which without credit would be impossible.

The introduction of these 'new' agents raises two further questions whose answers are essential for a complete theory of development. First, why, if we begin within a circular flow, should entrepreneurs and banks exist? And second, if entrepreneurial activity exhibits swarms and perpetuates a business cycle so that the circular flow is never attained, then how is the economy able to function in disequilibrium when agents make mistakes and when supply does not equal demand?

In order to answer these questions we have, I think, to re-examine Schumpeter's case for the stability of the circular flow. As a prerequisite we have, however, first to take a close look at the actions and interactions of agents.

3. Actions

An economy consists of a population of individuals who are organized into a variety of groups, such as firms and households. Following well established convention I will refer to such groups as well as individual persons as agents. Production and consumption activities pursued by agents are coordinated in a variety of ways, within centralized organizations by systems of budget, valuation and allocation messages and rules, and between individuals and organizations by means of price adjustments and exchange.

Organizations must construct plans through a series of exchanges up and down a hierarchy in an essentially dynamic process that includes data collection, storing and processing activities. Current and past performance indexes are prepared. Current external conditions are estimated and forecasted. Plans of a more or less elaborate nature are drawn up. While all this is going on actions must take place in fact; resources must be allocated in fact; food must be produced and consumed in fact. Therefore, while actions may be influenced by existing plans, they have to be controlled by various mechanisms which are also determined by current operating conditions and which themselves may not be accurately or correctly anticipated in existing plans or in the new plans being formed. This control system must operate in *real* time and *must be distinct from planning itself*. An organization's behavior is therefore determined by an Information–Planning–Control (IPC) system. Individual behavior may be thought of appropriately

also as determined by an IPC system but with a mental-physiological structure of specialized functions rather than a socioeconomic one.[9]

All coordination among agents must take place through the operation and interaction of these IPC systems. Ostensibly, in equilibrium, plans will be realized, estimates will not change; the control system need only keep behavior from wandering or jumping. Ostensibly, also, information will correctly determine not only where data and performance indexes are but where they will be in the future. If one wants to characterize the *rationale* for the equilibrium no harm is done by ignoring or suppressing the distinct information and control subsystems and substituting for them an assumption of perfect forecasting ability, as is done by some of the more extreme members of the neoclassical school.

In disequilibrium, however, expectations are not fulfilled. Individuals and groups do not and cannot know what everyone is doing or what they will do in the future. They must observe, construct a record or image of the past which is of necessity simplified and imperfect. They must base plans on data that may prove biased, wrong or misleading. They must construct controls that enable economic activity to continue when even the most carefully constructed and elaborated plans must be modified in the light of accumulating information or because they simply can't be carried out. If one wants to explain how and under what conditions an equilibrium circular flow emerges or fails to emerge one must take account of these *fundamental* facts.

4. Transactions

Transactions among agents are mutually interrelated actions involving the exchange of information and goods and the establishment or modification of constraints on further action. How do transactions occur? According to the classical/neoclassical economic theory upon which Schumpeter builds, they occur — in the circular flow — according to competitive equilibrium prices. These constitute the 'partial' information indexes upon which equilibrium plans can be based by practical agents.

But the equilibrium prices are determined implicitly on markets that are not fully described by Schumpeter or subsequent contributions to the theory

[9]The distinction between planning and control is not unrelated to Kornai's distinction between 'real' and 'control' spheres of an economic system. Here, however, information, planning and control are separate functions within Kornai's 'control sphere' required by disequilibrium in the real sphere. See Kornai (1971, pp. 39–42). I draw directly on Day (1975) who distinguishes between 'transitor' and 'adaptor' which would appear to be the same as Kornai's breakdown. This idea seems to underly the flexible accelerator and goal adaptive adjustment processes of Simon and Simon and March and of Forrester's distinction between 'absolute management goal' and 'negative feedback' adjustment rule.

of exchange.[10] To the extent that markets are dealt with at all they are represented as auctions or bidding games, or as bargaining procedures such as those that govern real estate or the formulation of wage contracts. Markets governed by Bidding–Negotiation–Bargaining processes of these first two types are reflected in the abstract idea of the 'auctioneer' or 'helmsman' and constitute the Hicksian 'flex-price' mechanisms that are modelled in stability analyses of general equilibrium. For our purposes here it is important to recognize that the stability of flex-price adjustments rests on highly restrictive assumptions and even the most prominent contributors to the theory have never been satisfied with it.[11]

A glance at the real world reveals two widely used market mechanisms in addition to auction and bargaining procedures. Most evident on the retail scene are stores. Stores are essentially inventories on display with Information–Processing–Control procedures that focus on inventory adjustment and price determination.

Almost as evident and perhaps even more important are order–delivery information systems that govern most wholesale, construction and heavy investment transactions. Individuals and organizations order goods. Producers, warehouses and stores receive orders and either fill them or delay delivery, adjusting their order backlog accordingly. Even the stock market, which is often thought of as an example of a competitive market, works in part on the basis of order–delivery information systems with special broker-specialist agents.

From a physical point of view these second two market types are stock–flow mechanisms that mediate transactions among agents using periodic price-adjustment rules. They are the prototypes of Hicks' fix-price markets. To emphasize the role of inventories and orders in such markets I will refer to them as Inventory–Order–Price Adjustment processes.

No doubt the specific character of the commodities involved, such as their storability, their time period of production or their relative cost, influence or determine what type of market mechanism is used in transactions involving them. But a noteworthy fact is that Bargaining–Negotiation–Bidding processes are not pervasive in the real world. Moreover, one could imagine an economy that uses Inventory–Order–Price Adjustment procedures exclusively. Their basic virtue is that they facilitate exchange when supply and demand are not equated at prevailing prices. Or to put it into the terms of the Information–Planning–Control framework, they enable production

[10]In both Debreu (1959), and Arrow and Hahn (1971) the term 'market' does appear but markets are not described. Debreu does devote a chapter to a careful description of commodities and prices. Thus, while the theory of competitive general equilibrium may rationalize an equilibrium system of transactions and constitutes an equilibrium theory of price, it is *not* a theory of markets.

[11]That individual bargaining need not lead to supply–demand equilibria was a possibility illustrated by Chamberlain (1957) in what was probably the first experimental market.

and consumption *actions* to occur when consumption and production *plans* are inconsistent.

5. Disequilibrium

All of the transaction types outlined can be and sometimes are carried out within a single organization, usually by means of a decentralized subunit (agent) that specializes in that function. Importantly, however, independent agents also exist who mediate transactions. Stores mediate transactions through inventories on display. Catalog orders and sales agents and brokers mediate order/delivery exchange mechanisms. Banks and other financial intermediaries govern the exchange of money and credit while negotiators, arbitrators, lawyers and courts mediate the bargaining processes. These must be added to the 'auctioneer' and to firms and households as the fundamental economic agents of economy. The questions we now need to consider are (1) Would these agents exist in equilibrium? (2) If not, why do they exist?

As we noted above, Schumpeter gave what has become the standard answer [Debreu (1959), Arrow–Hahn (1971)] to the first of these questions. It is, 'No'. In equilibrium, plans become actions that are optimal given prevailing equilibrium prices. No distinction between plans and actions need be made. Moreover, as a best action is taken on the basis of current data no agent will modify his behavior if similar data are repeated. The commodity flows implied by action are perfectly coordinated. Stocks remain constant or change at a constant rate and play no fundamental role.[12] A greatly simplified structure results, one that has only producers and consumers. But in reality marketing agents exist and so do entrepreneurs. Why? This is the question begged by Schumpeter's dependence on an equilibrium description of the circular flow. An answer to it can be contemplated if we agree that if practical agents cannot compute optimal actions and equilibrium transactions, then it is appropriate to consider an initial condition in disequilibrium.

Consider the process leading to action. Its information and planning elements take time, are costly and subject to error. The more 'rational' in terms of careful observation, elaborate data processing and sophisticated analysis, the more time and resources it takes. But actions must occur more or less continuously. These must be feasible for the economy to work. Out of equilibrium they need not and very often will not correspond to plans. Changing action will lead to changing data to which agents will adapt their plans, but these can only be formulated imperfectly and with a lag. By what means can such agents be sure to converge to equilibrium? Even if they did,

[12]The point is made especially clearly in Arrow and Hahn who assert that '... the distinction between stock and flow equilibrium (is) relevant only in the analysis of what, in our definition, are disequilibrium situations'. Arrow and Hahn (1971, p. 50).

as long as they did not — which could be a very long time — mechanisms that allowed the agents to function in the meantime would have to exist.

Or consider the nature of transactions. Bargaining especially takes time, lots of time. Try to imagine a real world where *all* transactions are directly negotiated. Is it possible that such a world would *not* break down? To reduce transaction costs to manageable levels market mechanisms would have to be introduced that do not explicitly require negotiation and bargaining. They would have to allow production, consumption and exchange to occur when plans are immediately impracticable and while excruciatingly slow Negotiating–Bargaining processes are at work.

To summarize: *economies work only because actions are governed by principles in addition to rationality and the theoretical existence of equilibrium prices.* These principles include (1) the separation of information, planning and control activities in economizing behavior and (2) the existence of explicit Inventory–Order–Price Adjustment mechanisms that mediate transactions in disequilibrium.[13] Each agent controls a stock of resources that is required by his information processing, planning, and controlling activities. These activities involve consumption, production and exchange that diminish some and augment other stocks. Agents must determine actions and transactions compatible with feasible stock–flow relationships. They are aided in this task by the existence of exchange mechanisms based on Inventory–Order–Price Adjustment procedures. Since equilibrium prices cannot govern behavior out of equilibrium, explicit price adjustment rules must emerge. They must be constructed in such a way that actions can take place more or less continuously even though current prices transmit more or less erroneous information and must themselves be adjusted according to unfolding information.

If transactions between agents at a given time can not be perfectly co-ordinated except perhaps by the miraculous direction of some unseen hand, then how much less plausible is the possible co-ordination of transactions involving future, anticipated actions? Banks' abilities to create credit introduced an extremely flexible medium allowing the supply and demand for purchasing power to differ and for its excess demand or supply to fluctuate indefinitely. Historically, as economies become more and more complicated, the gradual evolution of credit instruments became a primary means — not of bringing about equilibrium — but for allowing economies to work at all.

[13]Of course the business cycle literature, for example Metzler (1941), encompassed the role of inventories in the economy and in particular dealt with why inventory replacement demand tended to keep the economy away from equilibrium. I do not know that the point made here, however, has been recognized unless it would be in the industrial dynamics approach of Forrester (1961). Kalecki might have had the principle in mind in his dynamic model of capitalism. Certainly he recognized the role of order-backlogs but like most Marxians he was so interested in the instability of markets that he overlooked their more fundamental role in mediating disequilibria!

An economy that has evolved banks *in order to sustain disequilibria is of course preadapted for the Schumpeterian entrepreneurical/credit expansion process!* Nonetheless, the origin of banks must be bound up with the need to provide for intertemporal exchanges out of equilibrium.[14]

6. Economizing

The neoclassical theory of economic rationality and of general equilibrium was invested with a behavioral content by Marshall who recognized that economic calculation was an incremental process that took place 'at the margin' in response to utility, profit or quasi-rent differentials, and by Walras whose tâtonnement was supposed to represent in an abstract way price–quantity 'groping'. As is well known, however, this behavioral content was not sufficient to define a theory of behavior out of equilibrium. Instead it was interpreted as a prerequisite to exchange which took place after the assumed emergence of equilibrium prices. Hence it did not require the definition of action–transaction mechanisms of the kinds elaborated above. Schumpeter fully accepted this interpretation in basing the stability of economizing and equilibrium on behavioral principles.

This behavioral rationale for the Walrasian equilibrium paradigm contrasts in an interesting way with another well-known contemporary point of view based on continuous market clearing and 'rational expectations' in which information is optimally utilized, the economy is driven by external stochastic shocks — which do not prevent continuous equilibration — and in which agents know the relevant probability distributions.[15] In this theory rationality, supply–demand consistency, and social efficiency are used not only to characterize steady states but also to explain irregular business fluctuations. Although wisely motivated and ingeniously developed I do not think it provides a sufficient understanding of how economies work — for the reasons that have concerned us up to this point and that are to be further developed below. I shall therefore return to a consideration of economizing from a behavioral point of view in the context of economic disequilibrium.

In practice, economizing must proceed by intuitable or computable steps. These are usually extremely simple relative to the overall problem of choice under consideration. The mathematical analog of economizing behavior is the optimizing algorithm that decomposes the choice problem into a sequence of simple calculations and binary comparisons that are applied

[14]Contrast this view with the 'monetarist position' that it is the existence of money which allows equilibrium to exist. If we define economic equilibrium conventionally (see footnote 1) money would not be necessary in it. One can hardly imagine disequilibrium without it. Borrowing (waiting to pay) must have accompanied the emergence of exchange even in the most primitive economies of early man.

[15]See Lucas (1979) for the classic statement and appropriate collateral references.

iteratively. These iterative steps are usually nested within a sequence of approximations to the 'true' optimizing problem at hand.

These optimizing algorithms converge to a 'true' optimum only for a relatively small class of problems that have very strong but not very realistic regularity conditions. It is fundamentally for this reason that in real life economizing activity is focused on relatively simple, relatively stable choice situations that usually solve only a part of the problem of deciding what to do. Other behavioral rules must fill in the huge gap that is left between what is to be explained and what is well explained by explicit economizing calculations.

Economizing behavior is, therefore, conditioned in two ways. First, it applies to only a part of the variables over which individuals and organizations have control. Second, it proceeds according to forms that are approximate, relatively simple and iteratively applied. Because of these two characteristics, models of economizing behavior are distinctly different than the definition of an optimizing problem or than the specification of the sufficient conditions for optimality upon which orthodox theory builds.

A specific model of economizing behavior reflecting this point of view can be based on a frequently encountered principle of algorithm construction which is the incorporation of more or less *ad hoc* rules that limit the distance succeeding steps take in a sequence of trial choices. This is the analog of the principle of local search that forms a part of the core of adaptive or behavioral economics. When explicitly represented in a mathematical model of economizing behavior it leads to a sequence of recursively connected mathematical programs, each of whose constraints depend on solutions of programs earlier in the sequence and which define what I have called elsewhere 'zones of flexible response' (ZFR's) within which local rationality is exercised. This representation of behavior might be called 'local optimizing' or 'suboptimizing with feedback'.[16]

In one particular form of this approach the zone of flexible response is defined to be a region centered on past experience which allows departures from the preceding choice to a greater or lesser extent that also depends on experience. In illustrating the idea I have used fixed maximal and minimal percentage changes from preceding actions ('flexibility coefficients') to govern current choices. While such a model may not capture all the characteristics of real world economizing, I think it is a plausible if not compelling candidate for a first approximation. It has a property in some experimental

[16]The idea of such behavioral constraints in an explicit optimizing framework was introduced by Wood (1951) and was the basis of an ingenious behavioral programming model actually used to forecast U.S. Agricultural production on a regional basis by James M. Henderson (1959). I explored the dynamic implications of Henderson's model and incorporated similar relationships in a more general recursive programming model in 1963, and early exposition of which relating it to Schumpeterian ideas was published in 1959. Attempts to develop the idea more generally followed in 1970 and 1977.

model economy settings that illustrates a broader principle crucial to the subsequent discussion. Such economizing simulated in a competitive market environment on the computer does not converge to a stationary state but rather to a bounded set containing the stationary state and within which oscillations are perpetuated [Day (1979)]. Using a principle of increasing caution in response to failure, convergence to a stationary state within this framework could, however, be achieved.

Suppose all agents did in fact behave in *this* way and so behavior *did* converge. Such stationary states might only be local optima with better candidates at some remove. Moreover, if data changed from time to time due to 'external' forces, such 'optimal' equilibria could be less effective than would be suboptimal behavior that failed to converge to a stationary state. Indeed, because no one understands completely how the world works, no one fully comprehends the problems whose optimal solutions we want to find. Therefore, one cannot be sure that when an algorithm for solving a *perceived* problem converges one has converged to the solution of the *real* problem at hand. This suggests that optimum seeking behavior should not allow a succession of market punishments gradually to discourage search to the point where it disappears entirely. Rather there should be continuing *unmotivated search* in an environment that may be 'irregular' or subject to drift or perturbation, or when local search in response to feedback can get 'stuck' in locally good, but globally suboptimal decisions. Such search can be driven by curiosity, eccentricity or 'playfulness', but not economic calculation of the usual kind. *Evidently, the whole idea of an equilibrium is fundamentally incompatible with wise behavior in an unfathomable world.*

Another class of procedures for irregular (non-linear, non-convex) optimization problems has been developed in which at each step a local *random* search is made; then an approximate choice-response function is estimated and optimized. An early example was Box's evolutionary operations procedure (EVOP) for minimizing production costs for highly non-linear (and not completely understood) chemical processes. An important point is that a rational solution is attained through local search in which random behavior plays an essential role. Ironically, it is in the constructed 'rational' solution process that randomness is introduced.

7. Local dynamics

So we have found in models of bounded rationality a reason why an economy might continue to wander, never settling down to an equilibrium. And we have found in constructive models of rational choice a reason for randomized behavior. Such 'irregularities' would provide a source of continuing perturbation that would bring about an escape from any economic equilibrium accidentally entered. The implication is that even in an

economy where a hypothetical equilibrium existed the behavioral mechanisms that govern it might not possess a corresponding stationary state. And even if such a state did exist it might not be locally stable so that the slightest perturbation might disrupt it. In either case appropriate disequilibrium mediating mechanisms would have to be present for the economy to work.

Now set aside these sources of local instability. Set aside also any exogenous source of stochastic shock to the economy. There are at least two additional reasons for considering the local instability of economic equilibria.

New theoretical research suggests that purely deterministic economies need not converge but may wander in a completely non-periodic, random like fashion because of non-linear relationships in technical structure or behavioral rules. This 'chaotic' phenomenon has been shown to arise naturally in economic models, even within widely known and accepted or standard economic theories. The possible sources of non-linear feedback in economic processes are many, and include, among others, a sufficient intertemporal substitutability condition in overlapping generation models, non-linear experience dependence of preferences, sufficiently strong induced investment demand in the standard Keynes IS-LM model and the existence of financial (working capital) constraints in models of the firm.[17]

In a chaotic world *no* amount of time series information about the past could enable one to forecast with any accuracy the future course of economic data essential for long-run rational planning. Moreover, the tiniest error in the estimate of any parameter or initial condition leads to rapidly growing prediction error — even if all functional forms are perfectly known!

It is noteworthy that in the first of the above examples chaotic intertemporal, competitive equilibrium trajectories are shown to exist. Consequently, it should be clear that we are not dealing with artifacts of adaptive economizing or disequilibrium processes. Of course, the possibility of deterministically generated pseudo-randomness for some parameter values of a mathematical model does not establish the existence of the phenomenon in the real world. It *does* show, however, that economies contain relationships that can provide an endogenous explanation of the observed irregularity of economic variables. Such endogenously generated irregularity does involve instability including the possibility of local instability of conventional economic stationary or steady states.

Still another important source of instability in the economy is that of *endogenous phase switching*. The technical processes of production provide alternative means for transforming materials and energy into commodities, these in turn are constrained by resource availabilities. In an essentially linear world such as envisioned by Von Neumann a steady-state growth path

[17]The work I refer to includes Benhabib and Day (1981, 1982) and Day (1982, 1984).

may exist that involves an unchanging menu of production/consumption processes. However, if constraints from unproducible and exhaustible resources are introduced then the course of development must lead to a change in the relative supplies of resources and produced capital. These changes in the relative limitativeness of constraints will also bring about a change in imputed values similar to those that occur when technological change introduces new production processes into the choice set, with the result that the economy as a whole and individuals or organizations in particular are 'triggered' on to different paths characterized by essentially different equation structures.

This process of *multiple phase dynamics*, which is a characteristic property of recursive programming models of economic change, provides an endogenous explanation of structural change that does not rest on the existence of entrepreneurs but merely on conventional economizing in the presence of unbalanced development. It says that given techno-economic *regimes* may be unstable; that such regimes may switch with the passage of time. Irreversible switching may be called *structural development*. Experience with models incorporating multiple technologies suggests that oscillations among regimes in a periodic or even in a more or less random fashion can occur but that under some conditions of resource availability or of preference or demand irreversible switching of a kind mimicking technological evolution characterizes model behavior.[18]

8. Global dynamics

We now have a basis intrinsic to the structure of economic action and transaction for rejecting the idea that stationary equilibria exist — or even if they exist that they are locally stable. *This means that disequilibrium mechanisms are necessary for the existence of an economy.* That is, if an economy is to work at all and keep on working at least for a while it must possess specific structures that allow actions to occur when the conditions of economic equilibrium do not prevail. It also means that entrepreneurs are *not* needed to explain the disruption of equilibrium or even the progression among technological–behavioral regimes where the latter resemble certain of the stages of development that characterize part of what are observed in the evolving real economy.

Does this also mean that disequilibrium mechanisms, properly specified, are also sufficient for continuous economic viability without the presence of entrepreneurs?

If the answer were 'yes', then we would have shown that economies were *globally stable*, which means that they would neither expand in some kind of boundless explosion or contract until they break their bounds of definition.

[18]See Day and Cigno (1978) for examples. For a summary of the implications see Day (1982).

They would continue to work without innovation even if, due to changing resource availabilities, ordinary economizing led to a kind of progressive structural change.

If the answer is 'no', there is a reason intrinsic to the economy itself for entrepreneurs to exist, a fundamental reason why there should be a source of wholly new combinations of material and activity that ultimately replace the system already in place.

I began to consider the possibility that global instability of economies had to be considered after years of accumulating experience with simulating models that were designed to represent adaptive economizing behavior in hypothetical, representative firms, empirical agricultural regions and industrial sectors.[19] Sometimes these models would exhibit growth with bounded but eventually expanding oscillations with an eventual but quite sudden transition to inviability. Very often the source of breakdown was in the financial feedback relationships linking sales, revenue, production costs, credit/debt transactions, and the supply of working capital. Eventually, after considerable experimentation, stabilizing parameter changes could be found, but these did not always have a compelling basis in the empirical data.

A common reaction to such simulation experiences is to reject the models as unrealistic, to keep tampering with them until they behave in a more stable manner. I now believe this kind of reaction is based on an unwarranted presumption that real economies are approximately stable, a view which is based on the observation that economic variables often exhibit proximate stability for extended periods of time. Such 'finite span viability' is not ultimately reassuring to those who find themselves close to the end of the span.

Possibly the presumption of stability is also based on the mistaken belief that only for stable processes can meaningful, analytical theory be developed. However, one can imagine analytical proofs in our field analogous to those in some others, of finite 'escape', i.e., that trajectories of economic variables must escape, after a definite period of time, some bounded set that defines viability. I do not have such proofs for any of the models whose simulations suggest their relevance. This is a task for future theoretical work that will be neccessary to buttress inference based on computational example.

Here I want to stress other sources of evidence: direct experience and the historical and archeological record.

There is, of course, no question that great civilizations disappear, that once flourishing technologies decline and cease to be used, that important institutions give way to others based on new forms of organization and different rules of conduct, that once common strategies are abandoned in favor of new ways of planning what to do and new rules for controlling what is done.

[19]See footnote 17.

We know that in the course of such developments parts of an economy stop working not merely because they are voluntarily abandoned but because they break down. While the grand forces that led to the decline and fall of past empires can only be conjectured on the basis of incomplete historical data or scanty prehistoric artifacts, the more common breakdowns of contemporary economic life are sometimes chronicled in considerable detail in the daily press and in the transcripts of court and regulatory agency proceedings. In the midst of the present recession, for example, we read of financial crises in firms and banks on the brink of insolvency and of bankruptcy proceedings for institutions that have already gone under. In a dynamic microeconomic model the state variables representing the character of such organizations would have passed outside the limits consistent with the definition of viable behavior. If such a model were simulated the computer would usually be instructed to print, 'no feasible solution'.

Even at the macro level comparable breakdowns occur. Think of the U.S. banking system in 1933 when the 'bank holiday' was declared. In this case not just a single bank but the entire system stopped working. In the process the old system was destroyed and a new one set in motion. Are we to think of this merely as a switch between two pre-existing regimes? Are we to think in general of the switch between a given population of agents and their rules of behavior and the successor population where an old agent as such has disappeared or a new one has emerged — are we to think of this transition *in general* either as an analytical switch in regime or as a change in population?

No doubt as theorists dedicated to the development of analytical models of understanding we will want to pursue these possibilities as far as we can. But it seems to me that in doing so we are unlikely to explain those features of economic change which we experience as its most human quality, namely, the ability of individuals to conceive new combinations and of groups to form unanticipated solutions to temporarily unresolved conflicts.

9. Entrepreneurship

... And so we come to entrepreneurs, for they are the ones in the arena of human getting and spending that create new combinations from which the forms of economic activity and organization evolve. In a globally unstable economic world *their* specific existence is a necessary condition for economic existence in general. Out of the population of ideas they create are selected ones that lead to forms that prevent collapse, or that reshape a system so that it takes off on a new spiral of development.

The existence of entrepreneurs must no doubt be explained by the forces of biological and social evolution that explain human development generally. Certainly it is related to the emergence of creative intelligence — I

distinguish this from rationality — that has led to the origin, proliferation and growing sophistication of human culture. Once creative intelligence exists the possibility of inventing economic structure exists.

Schumpeter taught us much of what we need to know about the nature of entrepreneurs but he did not explain why they intruded themselves on the circular flow. One possible explanation is now clear. They do *not* intrude on the circular flow; they emerge in a disequilibrium, globally unstable economy with the fundamental function of *creating* the mechanisms that allow an economy to work when its agents are boundedly rational, its transactions imperfectly coordinated, and its long-run behavior intrinsically and globally unstable.

Thus, they are both the result of and the mediator of evolution both in its narrow biological sense and in its broader cultural sense. Once a part of human culture their activity does not switch on and off according to well-defined accounting messages or in response to carefully anticipated need. It functions more or less continuously thereby providing a continuous source of perturbation to the analytical structures that define routine production, consumption and managerial activity. The implication is that economies will evolve whether they need to or not. Schumpeter's theory of cycles tells us something about how that evolution can occur.

10. Evolution

Economies, like other aspects of nature and human existence, evolve. They have histories that are described, not just in terms of the trajectories of their states, but also in terms of the genesis of structures that define their flows. To some extent, as we have seen, the genesis of structure can be represented as a progressive switching of phases in a world where multiple potential regimes exist. Adaptive economizing in disequilibrium leads to such endogenous structural change and would be a sufficient theoretical construct to explain evolution if real economic systems were globally stable.

If it is supposed that they are not globally stable then models that can be globally unstable are relevant candidates for analyzing economic change. But they force us to augment our inventory of theoretical concepts because a given globally unstable system can describe a historical process for only a finite period of time.

One approach is to develop an evolutionary theory of variation and selection for a population of economic organizations or rules, as is done by Nelson and Winter in their several contributions and by Eliasson in his micro-to-macro model of the Swedish National Economy. Such a theoretical construct describes the transition of a population with a given set of characteristics to a new population with different characteristics. If in such a theory individual agents or behavioral structures are allowed to break down,

go bankrupt, die, or otherwise disappear, then we have a theory that provides an analytical characterization of what is from the individual agent's point of view an inviable system but one in which the population of agents may exist indefinitely. If the state variables of the theory characterize the relevant population — as opposed to the constituent individual agents or rules — then it is possible for the analytical, evolutionary model to constitute a dynamical description of a population with viable behavior.

In the transition from the dynamics of individual behavior to the dynamics of population characteristics, however, the boundaries separating the living from the dead and yet unborn is passed over. Do we know any analytical representation of what happens in these shaded domains where things that once were no longer are, where somehow something new emerges which was not there before? It was Schumpeter's special contribution to have seen, and seeing to have insisted that another force, beyond economic rationality and beyond routine adaptive behavior, was responsible for the surge of economic development from form to form.

He did not really describe that force, which I think is best described as creative intelligence, but rather its mediator in the economic realm, the entrepreneur.

We know that the states which characterize essential properties for individual living organisms eventually escape their realms of definition. Nature has been able to extend life, not by creating eternally viable organisms, but by the forces of reproduction so that populations of individuals have a much extended history. The growing record of the past, however, assures us that most species that have ever existed have perished and that many of those now in existence are also rapidly perishing as well. Again we see the dynamics of *inviable* systems working even at this higher level of organization.

In human affairs the story seems to be the same at every level. As Schumpeter perceived, it is the entrepreneur who is partly responsible for he is the one who introduces the new combinations that lead to the eventual abandonment of existing activity. More fundamentally, however, if the theory presented here is correct, the entrepreneur, even in his most extreme achievements, exists not as an agent who disrupts a system that without him would settle down to a repetitive existence of indefinite duration. Instead he spans the dialectical penumbra between a system that without him would self destruct and a new system that can grow and flourish, if not forever, then for some span of time. Thus, his destruction is creative, and to the intelligence he exercises is owed the continuing existence of a mundane realm within which rational choice and economic exchange can function.

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