MARK SETTERFIELD

Expectations, endogenous money, and the business cycle: an exercise in open systems modeling

> Capitalism is almost always to be found in non-steady state, the explanation being that it is a game played simultaneously by millions of players who cannot possibly have the information necessary to play it well, let alone optimally. The result is a system that bifurcates back and forth. (Goodwin, 1987, p. 158)

> Many empirical phenomena are not covered well by either the theoretical or the empirical analyses based on linear stochastic systems, sometimes not by either. The presence and persistence of cyclical fluctuations in the economy as a whole of irregular timing and amplitude are not consistent with a view that an economy returns to equilibrium states after any disturbance. Instead of stochastic steady states, we observe that volatility tends to vary greatly over time, quiescent periods . . . alternating with eras of rapid fluctuation. . . . These empirical results have given impetus to the closer study of dynamic models and . . . have also given rise to criticisms of the models themselves, and this tradition goes far back; it suffices to mention the alternative theories of J.M. Keynes. (Arrow, 1989, p. 278)

Expectations are now so common a feature of macroeconomic models as to be almost ubiquitous. Moreover, one particular method of modeling expectations—the rational expectations hypothesis (REH)—is, itself, near ubiquitous. The consistency of the REH with mainstream neoclassical methodology is such that introducing expectations into a macroeconomic model is seldom, nowadays, considered to be a methodological as well as a modeling issue. One of the aims of this paper is to reopen the methodological aspect of the debate about expectations in

The author is an Associate Professor in the Department of Economics, Trinity College, Hartford, CT. This paper was written while the author held a visiting position at CEPREMAP, Paris, France.

0160–3477 / 2000 $9.50 + 0.00.

macroeconomic models, in the context of a formal Keynesian model of the business cycle.

The point of departure for this discussion is Keynes's principle of effective demand, or rather, the variant of this principle that Kregel (1976, p. 215) describes as "Keynes's complete dynamic model"—the model of shifting equilibrium. It will be argued, following Kregel (1976), that this model represents a methodological as well as a theoretical challenge to mainstream macroeconomic thinking—including variants of Keynesianism, such as the neoclassical synthesis and New Keynesian economics, that have developed from mechanistic (mis)interpretations of Keynes's static and stationary models of effective demand. This methodological challenge requires that both the modeling of expectations and monetary relations differ markedly from their presentation in mainstream macroeconomic models. The paper will show how these elements of an alternative (non-neoclassical) macroeconomic vision can be combined into a model of aggregate fluctuations in output and employment that produces aperiodic cycles of variable amplitude. In the following section, the essence of Keynes's methodological challenge to neoclassical thinking is outlined, and its implications for the treatment of expectations and money are spelled out. Next, a nonlinear model of aggregate fluctuations that is consistent with this non-neoclassical methodology vision is constructed. The model is then compared to and contrasted with existing business cycle models. Finally, some concluding remarks are offered.

Openness versus foreclosure in social systems and its implications for macroeconomic methodology

Central to the claims of this paper is the idea that the notion of society as an open system—or what Davidson (1996) describes as a transmutable reality—is at the core of Keynes's economic vision. It follows that in order to do Keynesian economics, we must proceed in terms of this vision,[1] accepting in the process that its implications are antithetical to current mainstream neoclassical methodology, which is based on a vision of social systems as being foreclosed and determinate.

[1] Note that implicit in this claim is the notion that a theory is Keynesian if and only if it reflects critical aspects of the vision and methodology that can be recovered from Keynes's work. A theory does not qualify as Keynesian simply because it generates "Keynesian results." This view is compatible with a realist conception of economic science, which attaches importance to the descriptive content of economic theories—the way they describe decision-making procedures, transmission

Mainstream neoclassical economics perceives social systems as being foreclosed and (therefore) determinate. A system is foreclosed when it can be described in terms of a structure that contains all of the information necessary to uniquely determine the outcomes associated with the system. Such systems can be described in terms of a series of structural equations that can, in turn, be solved for closed-form solutions that describe the level or evolution of a system's endogenous variables in terms of the exogenous givens or "data" that comprise its structural equations.[2] As remarked by Lawson (1997), models of such systems can be extended by "endogenizing" what was previously regarded as data, but only insofar as these newly endogenized variables are themselves described in terms of exogenous data, thus maintaining system closure. The hallmark of this conception of reality is that social systems—including, of course, the economy—are characterized by event regularities of the form "whenever *x* then *y*" (Lawson, 1997). Conditions *x* yield outcomes *y* always and everywhere, since outcomes *y* are uniquely associated with conditions *x* through the foreclosure and determinacy of the system.

An open system, in contrast, is one in which behavior and hence outcomes are afforded a "degree of freedom," by virtue of the absence of foreclosure and hence any determinate relationship between given conditions and the specific outcomes to which these conditions give rise. Information about the structure of an open system can be obtained (and presumably will be obtained by decision-makers interested in the system's outcomes), but this information does not suffice to allow the computation of a closed-form solution to the system, which instead remains open by virtue of the impossibility of obtaining such a solution. An open system cannot, therefore, be reduced to description in terms of the mechanical, universal recurrence of event regularities of the form "whenever *x* then *y*." Instead, in an open system, behavior and hence outcomes can be different even in the hypothetical situation of repeated trials under like circumstances. The irreducibility of the outcomes of an open system to foreclosed, determinate explanation in terms of the more "primitive" factors that are purported to have brought them about can be

---

mechanisms, and so forth—rather than an instrumentalist vision, which attaches importance only to a theory's results (see also Davidson, 1992).

[2] And, in some cases, such as vulgar interpretations of cumulative causation (see, for example, Grossman and Helpman, 1991, ch. 8), the "data of the initial situation" (i.e., initial conditions; see Kaldor, 1934, pp. 131–132).

labeled the property of *emergence*. Emergence so defined is not a denial of the existence of cause and effect relationships—nor even does it deny that *conditional* event regularities may be observed during historically specific eras due to the introduction of "synthetic" or conditional forms of closure into an otherwise open social system.[3] It does, however, imply that enshrined within the conception of society as an open system is the principle of effective choice—the ability, in any given set of circumstances, to have acted differently. This is necessarily absent from neoclassical economics, which, by combining a foreclosed vision of reality with the notion of substantive rationality, makes individuals, their choices, and so their behavior, captives of the data in terms of which the closed-form solution of a system is expressed. To deviate from the "optimal" behavior so prescribed is impossible by hypothesis, as it would violate the assumption that agents are guided by substantive rationality.[4]

The notion of an open system as described above has important implications for the way that expectations should be thought about in macroeconomic models. The principle of emergence posits a nonmechanical relationship between causes and their effects when this relationship is mediated by behavior based on effective choice. In consequence, forecasts of the outcomes generated by an open system will be subject to fundamental uncertainty. Openness creates an ontology in which decision-makers cannot know the "true" model that will determine future

[3] The conditionality of these forms of synthetic closure—and hence ultimately the conditional event regularities to which they give rise—stems from the fact that the institutions with which they are associated are not given, but must instead be socially reproduced over time. A conditional closure may, despite protracted stability, ultimately decay/change in a manner that, in keeping with the openness of social systems, itself displays the property of emergence (see Setterfield, 1997).

[4] This critical distinction between openness and foreclosure in social systems has long been recognized, and has been discussed before in different terms. Hence Samuelson (1969, pp. 184–185) draws attention to the centrality of the "ergodic hypothesis" in classical (and neoclassical) thinking, according to which the arrival of the economy at a particular long-run equilibrium position is predestined. Economic outcomes are understood to be determinate solutions to structurally immutable, closed systems. In the hypothetical situation of repeated trials under like circumstances, the same long-run outcomes will always be observed. In contrast, Hicks (1979, p. 38) argues that "all economic data are dated, so that inductive evidence can never do more than establish a relation which appears to hold within the period to which the data refer." In other words, economic outcomes are the product of a structurally transmutable or *non*-ergodic reality. This is, of course, consistent with the view that social systems are open, and that the hypothetical situation of repeated trials under like circumstances will give rise to different outcomes. Davidson (1984, pp. 571–572) identifies Samuelson's ergodic hypothesis as the *sine qua non* of mainstream theory, and non-ergodicity as the *sine qua non* of Keynes's and Post Keynesian thought.

macroeconomic outcomes, elements of which have yet to be determined by the effective choices of decision-makers themselves—choices which, by hypothesis, are not predetermined by the data of the current situation, but which may be creative/innovative, and thus contribute to the very constitution of a future reality that is different, in novel ways, from that of the present and past.[5] In sum:

> knowledge of social systems is uncertain, because they can only be understood as open systems. Logical certainty is limited because in open systems the full range of relevant variables is not known; empirical certainty is limited because in open systems evolutionary processes and discontinuities limit the incidence of replicable events. Belief under uncertainty is grounded in such evidence as is available and recognised as relevant given theoretical understanding; beyond that, recourse is made to conventional knowledge. This understanding applies to economic agents and also to theorists. (Dow, 1997, p. 87)

As these latter comments suggest, fundamental uncertainty does not prevent agents from forming expectations and then acting upon them. The point, rather, is that in an open system, the same "degree of freedom" exists in the formation of what Keynes called the state of long-run expectations as exists in the determination of other outcomes. The state of long-run expectations is, itself, an emergent property. It is relatively autonomous from current macroeconomic reality, because although it will be influenced by information about the structure of the economy collected in the present and the past, the assumption that the future will simply be a structural reflection of the past is untenable in open systems, and decision-makers know this. At the same time, the state of long-run expectations will influence behavior, which, as intimated above, is constitutive—that is, it will contribute to the realized structure of the future "true" model of the economy, either through the purposive reproduction of conditions that existed in the past, or, *via* the medium of creative/innovative behaviors, through the production of new conditions (in which case the system will experience structural change). This, of course, means that expectational factors will influence the structural determinants of macroeconomic outcomes and hence

[5] Note that the source of uncertainty in an open system is thus ontological rather than epistemological. The point is that agents *cannot* know the "true" model that will determine future macroeconomic outcomes, not that they simply *do not* know this model because of some learning or informational constraints that prevent an (otherwise achievable) correspondence between their subjective model of the economy and the "true" data-generating process that will produce future macroeconomic outcomes.

the realized values of these outcomes in a non-transitory manner. In other words, expectations matter, in the precise sense that they are instrumental in the determination of long-run or final (however defined) system outcomes.

The obvious contrast here is with the REH. Far from completing Keynes's mission of accounting for the effects of expectations in macroeconomics, the REH as it is conventionally applied is designed not to take expectations seriously (i.e., make them matter in the sense defined above) but to expunge macroeconomic systems of (long-run) expectational influences. The REH is, in essence, a traditional model closure device, which is compatible with the vision of social systems as being foreclosed and determinate and incompatible with the notion of effective choice and its corollary—that expectations matter.[6] The REH permits the introduction of expectational variables into foreclosed and determinate macroeconomic models, in a manner that restores model closure by describing the formation of "model-consistent" expectations. These make a model work (in the long run) in the same fashion as it did *before* the formation of expectations was considered. Of course, the REH allows expectations to affect a model's outcomes in the short run, this transitory impact resulting from the possibility of random expectational errors. However, assumptions about the distribution of these errors, coupled with the crucial assumption that errors have no feedback effects onto the structure of the model, deny them a role in the determination of long-run outcomes. Ultimately, REH models fall within the general class of models in which exogenous shocks create impulses that, propagated through the dynamics of the system, create transitory departures from long-run or final outcomes that are, themselves, defined independently of these transitory events.

In addition to having implications for the formation of expectations, conceiving social systems as being open also has implications for the nature of money and monetary relations. In an open economic system,

[6] Nowhere is this better demonstrated than in Sargent's (1993, pp. 26–27) claim that "regime changes" (i.e., changes in state- and time-contingent government policy rules) are incompatible with rational expectations, *unless* it is assumed that all possible regimes are described initially and in a fashion that allows private decision-makers to incorporate them into optimal decision-making rules. (In other words, decision-makers must be aware of all possible policy regimes, and their associated probabilities of adoption.) In the REH, then, there is no such thing as state- and time-contingent behavior that cannot be both conceived as a future possibility in the present, and described in a form that permits its incorporation into a framework of constrained optimization. All choices are predetermined, and the possibility of acting outside this given choice set is ruled out by hypothesis.

decision-making does not take place "all at once," as envisaged by foreclosed models of economic processes that involve the principle of dynamic optimization. Instead, decision-making becomes a sequential, recursive process that, at any point in time, takes place in the context of a given and immutable past and an as yet unmade (and hence fundamentally uncertain) future. In this environment, as has been repeatedly emphasized by Davidson (1978; 1994), money is revealed as something other than the curious and separate commodity, explicable only in terms of its convenience as a medium of exchange, that it appears to be in neoclassical economics. Instead, it plays central roles as a unit of account, a store of value (having an internal yield or liquidity premium thanks to its conferring on the holder the ability not to commit to current or future purchases in the present period) and (importantly for our purposes) a source of finance. This latter role stems from realization of the important implications of the sequential-recursive nature of economic behavior for production. The latter is revealed as an inherently dynamic process, the purchase of inputs preceding, in calendar time, the production of outputs and the subsequent (anticipated) sale of these outputs and the associated realization of profits. It is thus an inherently *monetary* process. This observation stems from the need of firms to finance input purchases prior to their subsequent (anticipated) realization of proceeds from the sale of output (Keynes, 1973, XIV, p. 220). The conception of capitalism as a monetary-production economy is central to the circuitist conception of money as entering the economy through the process of production, and the associated notion of the stock of money in circulation as being endogenously determined by the demand for loans, as mediated by commercial banks and, through its control of the price of reserves, the central bank (see Lavoie, 1992, ch. 4).

In what follows, a model of the business cycle is developed that is broadly consistent with the conception of the economy as an open system, and the concomitant claims that expectations are subject to fundamental uncertainty and that the supply of money responds endogenously to the demands of credit-worthy firms seeking to engage in processes of production. Of course, the absence of closure in an open systems model prevents the calculation of closed-form solutions such as conventional, determinate equilibria or mechanical expansion paths based on the "laws of motion" of the system. And yet such models are not, as is commonly believed, nihilistic. It is possible, as will be demonstrated, to deduce certain generic properties of the evolution of an open system stemming from given initial conditions, even in the absence of the closure required for a closed-form solution to the system.

Expectations, endogenous money and the business cycle

The basic model

As intimated earlier, our point of departure is Keynes's model of shifting equilibrium. This model can be approximated in a manner in keeping with an emphasis on open systems by the following structural equations:[7]

$$Z(N_t) \equiv Z_t = Y_t^e \tag{1}$$

$$D(N_t) \equiv D_t = C_t + i_t \tag{2}$$

$$C_t = \gamma Z_t\,,\ 0 < \gamma < 1 \tag{3}$$

$$I_t = I(r_t, e(\alpha_t)),\ I'_r < 0,\ I'_e \cdot e' > 0 \tag{4}$$

$$i_t = \phi \cdot I_t\,,\ 0 < \phi < 1 \tag{5}$$

$$r_t = (1 + \tau)\delta_t \tag{6}$$

$$\delta_t = \overline{\delta} \tag{7}$$

$$Y_t^e \equiv D_{t-1}\ \forall\, t \geq 1, \tag{8}$$

where Z denotes aggregate supply, Y^e is the expected value of nominal income in the short run, D is aggregate demand, C is aggregate consumption, I and i denote notional and effective investment, respectively, r is the commercial rate of interest, α represents firms' animal spirits and δ is the central bank discount rate. In all cases, t subscripts denote time periods. Equations 1 and 2 represent Keynes's aggregate demand and supply functions in a closed economy with no active government sector. Equation 3 is a simple proportional consumption function, in which γ represents a conventional average (and marginal) propensity to consume out of the previous period's income.[8] Note that in an open

[7] The shifting equilibrium model is only approximated in what follows as a result of our employing the *ceteris paribus* methodology identified by Kregel (1976) as an integral feature of Keynes's own development of the principle of effective demand in *The General Theory*. In employing this methodology, we "lock up without ignoring" some aspects of the dynamics of the economic system in order to facilitate analysis of others. This is done by treating as given variables, coefficients, and/or structural relations that are actually believed to be capable of change over time (see also Vickers, 1994, and Setterfield, 1997).

[8] Combination of Equations 1, 3, and 8 reveals that the consumption function can be written as $C_t = \gamma D_{t-1}$.

economic system in which the future is subject to fundamental uncertainty, the description of consumption as a conventional rather than an optimizing behavior is entirely appropriate. The precise value of γ can be taken to reflect households' (uncertain) long-run expectations of their future income streams, although we abstract here from such considerations in favor of focusing on the play of long-run expectations elsewhere in the economic system.

Equations 4–7 describe the behavior of investment spending.[9] Beginning with firms' notional investment, the latter is described in Equation 4 as being a function of the commercial rate of interest and a shift parameter ($e(.)$), which is itself a function of what has been defined above as firms' animal spirits. Recall that we are modeling an open economic environment, and hence one in which decision-making with respect to the future is subject to fundamental uncertainty. In such an environment, in which agents cannot know the "true" data-generating process (DGP) that will ultimately create observed future economic outcomes and know that they do not possess this information, expectations, like all choices, are formed with a "degree of freedom": they are relatively autonomous from current and past observations of the functioning of the economy. Keynes dubbed the psychological component of expectations that reflects this relative autonomy agents' "animal spirits." As will be demonstrated below, animal spirits are not absolutely autonomous. However, their relative autonomy and the concomitant impossibility of reducing their evolution to a closed-form solution is an axiomatic feature of the model that is being constructed here, giving expression to the conception of an open economic environment on which the model itself is founded.

The distinction between notional and effective investment in Equation 5 draws our attention toward monetary relations in the basic model. Effective investment is that proportion of notional investment that commercial banks are willing to finance or, put differently, the proportion of loan demands that commercial banks, as gatekeepers of the credit creation system, warrant as being worthy of obliging. We are assuming, then, that firms must borrow in order to finance investment expenditures,[10] and that commercial banks create credit in response to firms' demands for loans in accordance with their assessment of the creditworthiness of would-be borrowers. Furthermore, notional investment—

[9] It will be noticed that these equations do not fully explain the behavior of investment; discussion of the behavior of α_t is necessary to complete this task. This is taken up below.

[10] We are abstracting from the existence of retained earnings and corporate stock and bond issues for the sake of simplicity.

and hence notional loan demands—are influenced by the commercial rate of interest, which is set by commercial banks as a markup over the central bank discount rate (Equation 6), the latter being assumed constant in this basic model (Equation 7).[11] This behavior is motivated by the need of commercial banks to borrow reserves from the central bank (at the discount rate δ) in amounts that they deem sufficient, for reasons of prudence, to meet self-imposed reserve requirements, the latter constituting some proportion of the liabilities that arise when households (to whom firms' investment expenditures ultimately accrue as income) make deposits at the commercial banks. We thus have a model of a simplified overdraft economy in which loans create deposits and hence the demand for reserves (see, for example, Lavoie, 1992, ch. 4).

Finally, Equation 8 describes the formation of short-run expectations. The latter are treated as being qualitatively different from long-run expectations, which, as discussed above, are formed in an acknowledged environment of fundamental uncertainty. Following Keynes (1936) and Gerrard (1994), firms are conceived as forming short-run expectations as if they were repeatedly sampling outcomes arising from a structurally stable DGP. In consequence, they form expectations by a trial and error process involving some mechanism of learning from experience—in the case of Equation 8, a simple adaptive expectations mechanism. Short-run expectations are thus immune from the relatively autonomous psychological influences that affect the state of, and hence behavior based on, long-run expectations.

It is straightforward to combine Equations 1–8 in order to derive an expression for the evolution of aggregate demand and hence nominal income (and by extension in this model, aggregate employment) over time.[12] First, given Equations 6 and 7, we can write:

$$r_t = (1 + \tau) \cdot \bar{\delta} = \bar{r}$$

[11] We thus begin with a model of "pure" accommodation, in which—given also the assumed constancy of τ and ϕ—money plays an essentially passive role in the evolution of aggregate income.

Note that both τ and ϕ are properly conceived as conventional values that may, in principle, change over time. Once again, however, we abstract from considerations of this nature in what follows, "locking up without ignoring" the behavior of commercial banks in favor of concentrating on other features of the monetary sector's dynamics.

[12] Note from Equations 1, 2, and 8 that realized nominal income is demand-led in this model, supply adjusting between periods in response to any observed discrepancy between expected income and demand (and hence actual income) in the

and hence:

$$I_t = I(\bar{r}, e(\alpha_t)). \tag{4a}$$

Substituting Equation 8 into Equation 1, Equation 4a into Equation 5 and Equations 3 and 5 into Equation 2, we arrive at:

$$Z_t = D_{t-1} \tag{9}$$

$$D_t = \gamma Z_t + \phi \cdot I(\bar{r}, e(\alpha_t)) \tag{10}$$

from which it follows that:

$$D_t = \gamma D_{t-1} + \phi \cdot I(\bar{r}, e(\alpha_t)) \tag{11}$$

or

$$D_t = \gamma^t D_0 + \phi \cdot \sum_{i=1}^{t} \gamma^{t-i} \cdot I(\bar{r}, e(\alpha_t)). \tag{12}$$

Shifting equilibrium

It is obvious at this point that it is impossible to proceed further without describing the evolution of α_t. First, note that if $\alpha_t = \alpha_{t-1} = \bar{\alpha}$, then we can rewrite Equation 12 as:

$$D_t = \gamma^t D_0 + \phi \cdot I(\bar{r}, e(\bar{\alpha})) \cdot \sum_{i=1}^{t} \gamma^{t-i} \tag{13}$$

---

previous period. These supply adjustments may involve changes in both prices and quantities, depending on the precise microfoundations of the aggregate supply relation (see Setterfield, 1999a). Note that the ruling real wage is thus treated as being determined *ex post* (i.e., after employment and output decisions have been made) by the (given) nominal wage and firms' subsequent pricing decisions, which may be sensitive to the disappointment of short-run expectations. It is also important to note that autonomous changes in either nominal wages or prices (i.e., those occurring independently of demand-led changes in nominal income) have, at best, an ambiguous effect on aggregate employment and income in this type of model—regardless of whether or not they affect the value of the real wage (Palley, 1996). Hence in what follows we abstract from such autonomous changes in wages and prices for the sake of simplicity, and *not* because the absence of such an abstraction would automatically invalidate the basic conception of demand-determined outcomes on which our model is predicated.

from which, given $0 < \gamma < 1$, it follows that:

$$\lim_{t \to \infty} D_t = \frac{1}{1-\gamma} \cdot \phi \cdot I(\bar{r}, e(\bar{\alpha})). \tag{14}$$

In the presence of constant animal spirits, or what Keynes (1936) described as a "given state of long run expectations," the model in Equations 1–8 converges to a determinate equilibrium.[13] However, our interest is in Keynes's model of shifting equilibrium—a model of the principle of effective demand in which any movement toward a point equilibrium such as that described in Equation 14 causes revisions in the state of long-run expectations and hence (as cursory examination of Equation 14 reveals) changes the conditions and position of equilibrium itself. In order for the current modeling exercise to remain in keeping with our assumption of an open economic system, however, it cannot be possible to describe this revision of animal spirits in a closed form, which would ultimately permit us to describe the evolution of nominal income in a structurally determinate (whether stochastic or not) manner. The evolution of animal spirits must, instead, remain relatively autonomous—that is, impossible to fully "endogenize" in the sense in which this latter term is conventionally used in mainstream macroeconomics.[14] It is thus described as follows:

$$\alpha_t = f(D_{t-1} - Z_{t-1}) = \begin{cases} \alpha_{t-1} + \varepsilon_t \text{ if } D_{t-1} - Z_{t-1} \geq c \\ \alpha_{t-1} \text{ if } |D_{t-1} - Z_{t-1}| < c \\ \alpha_{t-1} - \varepsilon_t \text{ if } D_{t-1} - Z_{t-1} \leq -c \end{cases} \tag{15}$$

where

$$\varepsilon_t \sim \left(\mu_{\varepsilon t}, \sigma^2_{\varepsilon t}\right), \; \varepsilon_t >> 0 \; \forall \, t$$

[13] This is what Kregel (1976) describes as Keynes's stationary equilibrium model of effective demand—one of two models of the principle of effective demand developed by Keynes that involve "locking up without ignoring" the possibility of variations in animal spirits in order to demonstrate the existence and stability of a point equilibrium value of nominal income (and by extension, employment; see also Setterfield, 1999a).

[14] The reader is referred back to the discussion of this process on p. 79.

and c is assumed constant. In this model, animal spirits are revised in a discontinuous fashion, in response to the magnitude of any prior disappointment of short-run expectations.[15] The critical or hurdle value, c, is assumed constant, although it should be thought of as a conventional value and therefore as something that may, in principle, change over time.[16] The extent to which animal spirits are revised in any period depends on ruling conventions as captured by $\mu_{\varepsilon t}$, although it is allowed that agents who make effective choices are not captives of even stable (i.e., relatively enduring) conventional forms of behavior. Hence the actual revision of α_t in any given period is described by ε_t, which may vary around the conventional value $\mu_{\varepsilon t}$ without this convention being undermined by such "defection." As long as conventions endure, and hence as long as the first moment of ε_t remain constant over time, it may be possible for decision-makers to "know" (i.e., to forecast) the likely magnitude of any revision in animal spirits following the prior disappointment of short-run expectations. However—and critically—the moments of ε_t are time-dependent; conventions are liable to change over time. Furthermore, they do so, by hypothesis, in novel ways. Hence the system remains open, because the evolution of the moments of ε_t is impossible to describe on a prior basis.[17] Equation 15 is thus the part of our model that is explicitly recognized as being subject to structural changes that are innovative or novel, and thus defy explanation (and hence prediction)—even in stochastic terms—on a prior basis.[18] It is thus the part of our model that captures the openness of the economic environment that we have taken to be axiomatic.

Self-reinforcing tendencies in the model of shifting equilibrium

According to Kregel (1976), the key features of Keynes's model of shifting equilibrium are: short-run expectations may be disappointed; the

[15] Note that $D_{t-1} - Z_{t-1} = Y_{t-1} - Y^e_{t-1}$ given Equation 8 and the fact that nominal income is demand-determined in any given period.

[16] Once again, we are abstracting from these considerations by treating c as a constant.

[17] As such, of course, even those agents who learn about the moments of ε_t during periods of conventional stability will remain fundamentally uncertain; they do not (indeed, cannot) know how and when conventions will change, and know that they do not possess this information.

[18] It is *implicitly* recognized, as has been repeatedly intimated, that other features of the model could also be presented in similar terms. These other features, modeled as constants, have, however, been "locked up without being ignored" in the interests of analyzing other aspects of what would otherwise be an extremely fluid dynamical system. This is, of course, evidence of our employment of the *ceteris paribus* methodology described earlier.

state of long-run expectations is variable; and long-run and short-run expectations are interdependent. Equation 15 clearly satisfies the last two conditions. In order to satisfy the first, we assume that in some initial Period 0:

$$Y_0 - Y_0^e = D_0 - Z_0 = k_0 \geq c.$$

Utilizing Equations 12 and 15, we can now begin to study the subsequent evolution of nominal income based on these initial conditions.

We begin by considering the events that transpire between Period 0 and Period 1, which involve adjustments on both the supply and demand sides of the model. Clearly, firms will revise their short-run expectations and hence their production plans in Period 1, in light of the prior disappointment of short-run expectations in Period 0 (Equations 1 and 8). Furthermore, consumption demand will be revised in light of these changes in production plans (Equation 3). As was demonstrated in Equations 13 and 14, with a given state of long-run expectations, these adjustments would, *ceteris paribus*, constitute "forces of convergence," pushing the economy toward a determinate point equilibrium. However, the state of long-run expectations is not given; Equation 15 insists that, given the initial conditions postulated above, animal spirits will be revised in light of the prior disappointment of short-run expectations, so that $\alpha_1 = \alpha_0 + \varepsilon_1$. This change in animal spirits will alter the conditions and hence the position of equilibrium, "shifting" the point equilibrium toward which changes in production plans and consumption expenditures would otherwise be propelling the economy. The "forces of convergence" present in the model are thus (given initial conditions) accompanied by "forces of structural change." Furthermore, the latter are not amenable to description in a closed form. As discussed in the previous section, Equation 15 describes the evolution of animal spirits as being relatively autonomous—an object of effective choice that can be creative/innovative, and thus a source of openness in the system we are modeling.

Obviously, this makes it difficult to characterize the precise state of the system in Period 1. It is not, however, impossible to characterize the motion of the system over time, as long as we content ourselves with generic descriptions of its possible trajectories as a substitute for a closed-form solution for the value of nominal income. Hence, subsequent to the initial conditions postulated above, consider now the situation in Period 1. In order to reflect further on the evolution of nominal income, we need to know whether or not:

$$D_1 - Z_1 \geq c = (D_0 - Z_0) - k_0 + c$$

(since $D_0 - Z_0 = k_0$ by hypothesis) or, in other words, whether or not:

$$\Delta D_1 - \Delta Z_1 \geq -(k_0 + c).$$

Referring back to Equation 10, it can be seen that:

$$\Delta D_1 = \gamma(Z_1 - Z_0) + \phi \cdot I'_e \cdot e' \cdot \varepsilon_1,$$

where

$$I'_e \cdot e' = \partial I / \partial \alpha$$

and

$$d\alpha_1 = \varepsilon_1$$

by hypothesis. Meanwhile, since $Z_1 = D_0$ by Equation 8, we can write:

$$\Delta Z_1 = D_0 - Z_0 = k_0.$$

Combining these last two expressions, we arrive at:

$$\Delta D_1 - \Delta Z_1 = (\gamma - 1) \cdot k_0 + \phi \cdot I'_e \cdot e' \cdot \varepsilon_1. \tag{16}$$

Suppose now that we define a variable η, such that:

$$\eta_1 = I'_e \cdot e' \cdot \varepsilon_{1\,min}, \tag{17}$$

where ε_{1min} is the smallest change in α necessary to ensure that $D_1 - Z_1 \geq c$ and where η_1 is thus the minimum change in notional investment spending required to satisfy the same condition, and hence for there to be a change in the conditions and position of equilibrium in period 1. It thus follows from the definition of η_1 that:

$$-(k_0 - c) = (\gamma - 1) \cdot k_0 + \phi\eta_1$$

$$\Rightarrow \eta_1 = -\frac{1}{\phi}[(\gamma - 1) \cdot k_0 + (k_0 - c)]$$

$$\Rightarrow \eta_1 = \frac{c - \gamma \cdot k_0}{\phi} \tag{18}$$

This allows us to solve for the value of ε_{1min} in terms of the historical and exogenous "givens" of the model by combining Equations 17 and 18 to yield:

$$\varepsilon_{1\,min} = \frac{c - \gamma \cdot k_0}{\phi \cdot I'_e \cdot e'}$$

Finally, generalizing this result for any period t (since we are interested in the general evolution of the model and not just the changes that take place between periods 0 and 1), we can write:

$$\varepsilon_{t\,\min} = \frac{c - \gamma \cdot k_{t-1}}{\phi \cdot I_e' \cdot e'}. \tag{19}$$

Suppose now that:

$$|D_0 - Z_0| \geq c$$

and that the following conditions apply:

$$\varepsilon_t \geq \frac{c - \gamma \cdot k_{t-1}}{\phi \cdot I_e' \cdot e'} = \varepsilon_{t\,\min} \ \forall\, t \geq 1. \tag{20}$$

In this scenario, each period will involve changes in production plans and consumption demand that (*ceteris paribus*) are forces of convergence within the model, accompanied by forces of structural change manifest in revisions in the state of long-run expectations that, through their impact on investment spending, change the conditions and hence the position of equilibrium. Although it is not possible to determine precisely the volume of nominal income *ex ante*, it is possible to identify on a prior basis a generic trajectory that nominal income will follow, given Equation 20. Specifically, we will observe a series of self-reinforcing increases or decreases in the value of nominal income over time, depending upon whether $D_0 - Z_0 > c$ or $D_0 - Z_0 < c$ initially.

Note that, on the basis of the foregoing description of the behavior of nominal income, the model developed above is based on neither the nonexistence nor the instability of equilibrium. On the contrary, we can identify at any given point in time, t, an equilibrium value of nominal income, which may be written as:

$$D_t^* = \frac{1}{1 - \gamma} \cdot \phi \cdot I(\bar{r}, e(\alpha_t))$$

or

$$D_t^* = \frac{1}{1 - \gamma} \cdot \phi \cdot I\left(\bar{r}, e\left(\alpha_0 + \sum_{i=1}^{t} \varepsilon_i\right)\right) \tag{21}$$

Not only does this equilibrium exist, but it also acts as a conventional point attractor; it does not repel the value of nominal income in the centrifugal fashion characteristic of a classically unstable equilibrium.

Having said all this, however, the equilibria defined in Equation 21 are not stable in the conventional sense. As a result of Equation 20, the dynamics of the system do not operate in such a way that the system "gets into" these equilibria—and as such, of course, they do not accurately describe the actual configuration of the system (and the associated value of nominal income) at any point in time.[19] Instead, the equilibria in Equation 21 are properly thought of as temporary equilibria which, although they contribute to the dynamics of the system in their capacity as point attractors or "centers of gravity," are such that their conditions and hence position are subject to ongoing redefinition as a result of the endogenous but indeterminate (i.e., relatively autonomous or open) revision of animal spirits described in Equation 15. In this way, the model being developed combines both conventional and unconventional forces in its description of the evolution of nominal income. It contains conventional "forces of convergence" that arise from the presence of temporary equilibria, which, although their precise configurations go unrealized, act as point attractors or "centers of gravity." But the model also contains unconventional "forces of structural change," which evolve in an endogenous but indeterminate fashion, giving rise to emergent (in the sense defined earlier) changes in the conditions and hence position of equilibrium. The result is that the precise value of nominal income must itself be treated as an emergent property of an open system.

[19] Of course, were the condition in Equation 20 not to hold in any period *n*, then the dynamics of the model would be dominated entirely by the convergent properties of the equilibrium defined in period *n* in all subsequent periods, and the value of nominal income would approach this (path-dependent) stationary state. This possibility is examined in detail in Setterfield (1999a). It is overlooked here because we wish to focus on the prospects for continual change and ultimately cycles in the value of nominal income. The analytical possibility of a stationary state being reached—the likelihood of which varies directly with the value of *c* in Equation 15—would seem to suggest that the self-reinforcing changes in nominal income identified above (along with the possibility of cycles discussed below) may require occasional impulses in the form of exogenous shocks, because of the potential for their dynamics to peter out. This is not necessarily the case, however. A richer view of the process of revising the state of long-run expectations formed under uncertainty might allow for the possibility of animal spirits being affected, not just by the disappointment of short-run expectations (as in Equation 15), but also by their successive realization (see, for example, Asimakopulos, 1991, pp. 156–158, and Setterfield, 1997, pp. 65–68). The possible interruption of the dynamics of the model developed here by the achievement of a path-dependent stationary state is thus a product of the precise manner in which the interdependence of short-run and long-run expectations has been modeled, and not a necessary property of Keynes's model of shifting equilibrium *per se*.

Revisiting monetary relations: turning points and cyclical behavior

We now revisit monetary relations within the model of shifting equilibrium, which to this point have been modeled in terms of "pure" accommodationism within an endogenous credit money (overdraft) economy. As will be demonstrated, the change from "pure" to "dirty" accommodationism embraced in the central bank reaction function described below introduces a source of negative feedback into the model of shifting equilibrium, following some initial disappointment of short run expectations. In the context of the cumulative dynamics of the model developed above, this allows for the possibility of turning points in the otherwise self reinforcing trajectory of nominal income, and hence the emergence of cycles.

At present, monetary relations have been presented in the form of "pure" accommodationism, as:

$$r_t = (1 + \tau) \cdot \delta_t \tag{6}$$

$$\delta_t = \bar{\delta} \tag{7}$$

$$\Rightarrow r_t = (1 + \tau) \cdot \bar{\delta} = \bar{r}.$$

Suppose that we now introduce the following central bank reaction function, which embodies "dirty" accommodationism in the sense that the central bank continues to act as supplier of reserves to commercial banks in a manner determined by the effective demand for loans, but does so at a price of its own making, and which is set—albeit in a relatively autonomous manner—with reference to underlying conditions in the economy. Hence we write:

$$\delta_t = g(D_{t-1}, Z_{t-1}) = \begin{cases} \delta_{t-1} + \nu_t \text{ if } D_{t-1} - Z_{t-1} \geq \kappa \\ \delta_{t-1} \text{ if } |D_{t-1} - Z_{t-1}| < \kappa \\ \delta_{t-1} - \nu_t \text{ if } D_{t-1} - Z_{t-1} \leq -\kappa \end{cases} \tag{22}$$

where

$$\nu_t \sim \left(\mu_{\nu t}, \sigma^2_{\nu t}\right), \; \nu_t >> 0 \; \forall \, t$$

and $\kappa > c$ is a conventional value, treated here as being constant.

It is obvious by inspection that the precise form of Equation 22 mimics that of Equation 15, and that it thus embodies the same principles of effective choice (this time on the part of the central bank in its setting of the discount rate) and systemic openness as this earlier equation. The central bank is conceived as adjusting the discount rate in response to any "excess disappointment" of short-run expectations, the absolute value of which exceeds the threshold level given by $|\kappa|$. Note that since $Z_{t-1} = D_{t-2}$ by Equation 8, the central bank is effectively responding to the actual expansion of the economy in relation to what it regards as a conventional or normal range of expansions between periods, given by $\kappa > D_{t-1} - D_{t-2} > -\kappa$. And, of course, it is doing so in a relatively autonomous manner, which may be governed for discrete periods by a convention, μ_v, that is relatively stable, but which is ultimately susceptible to revision in a creative/innovative manner that defies prior, closed-form description.

In order to demonstrate the possibility of turning points in this extended model of shifting equilibrium, we must begin by rewriting Equations 11 and 12 as:

$$D_t = \gamma D_{t-1} + \phi \cdot I(r_t, e(\alpha_t)) \tag{11a}$$

and

$$D_t = \gamma^t D_0 + \phi \cdot \sum_{i=1}^{t} \gamma^{t-i} \cdot I(r_i, e(\alpha_i)), \tag{12a}$$

and consider how the evolution of D_t that they describe is affected by the operation of both Equations 15 and 22, which determine the evolution of α and r, respectively. We have already seen the capacity for self-reinforcing change in D_t on the basis of Equation 15 alone, given $|D_{t-1} - Z_{t-1}| > c$ initially. Now suppose that we begin in the midst of a series of self-reinforcing increases in the value of D_t. Specifically, suppose that we have observed $c < D_0 - Z_0 < \kappa$, following which:

$$\varepsilon_t \geq \frac{c - \gamma \cdot k_{t-1}}{\phi \cdot I'_e \cdot e'} \quad \forall\, t = 1, \ldots, n$$

such that $D_{t-1} - Z_{t-1} < \kappa \;\forall\, t = 2, \ldots, n$.[20] A turning point, followed by a cumulative contraction of nominal income, will occur if, in period n, D_n

[20] Note that these conditions are sufficient but not necessary for a cumulative expansion of nominal income. They are not necessary because even with $D_{t-1} - Z_{t-1} > \kappa > c$ for some t, the resultant increases in the discount and commercial interest rates may not reduce investment sufficiently, given the positive impact on investment that

$-Z_n = k_n > \kappa > c$ and if, following the changes in both animal spirits and the discount rate that we observe in period $n + 1$, we are left with a situation where:

$$-\kappa < D_{n+1} - Z_{n+1} \leq -c$$

and

$$\varepsilon_t \geq \frac{c - \gamma \cdot k_{t-1}}{\phi \cdot I'_e \cdot e'} \ \forall t \geq n + 1,$$

such that $D_{t-1} - Z_{t-1} > -\kappa \ \forall \ t > n + 2$.[21] What we wish to know is what conditions—specifically, what adjustment in the discount rate in period n—will bring this situation about.

Given that $D_n - Z_n = k_n$, the condition:

$$-\kappa < D_{n+1} - Z_{n+1} \leq -c$$

can be rewritten as:

$$\begin{aligned}(D_n - Z_n) - k_n - \kappa &< D_{n+1} - Z_{n+1} \\ &\leq (D_n - Z_n) - k_n - c \\ \Rightarrow -(k_n + \kappa) &< \Delta D_{n+1} - \Delta Z_{n+1} \\ &\leq -(k_n + c) \end{aligned} \tag{23}$$

On the basis of Equation 11a, it can be seen that:

$$\Delta D_{n+1} = \gamma(Z_{n+1} - Z_n) + \phi[I'_r \cdot (1 + \tau) \cdot \nu_{n+1} + I'_e \cdot e' \cdot \varepsilon_{n+1}],$$

where

$$I'_r = \partial I / \partial r$$

will result from the revision of animal spirits, to ensure that $D_t - Z_t < c$. We overlook this latter possibility and focus on the sufficient conditions for cumulative change in nominal income for the sake of simplicity, this focus having no impact on the qualitative behavior of nominal income over time as described in what follows.

[21] Once again, we focus on the conditions that are sufficient (but not necessary) to generate a cumulative contraction in nominal income following an upper turning point in the latter. The reader is referred back to the discussion in the previous footnote.

and

$$dr = \frac{\partial r}{\partial \delta} \cdot d\delta = (1+\tau) \cdot \nu_{n+1}$$

by Equations 6 and 22, whilst given that $Z_{n+1} = D_n$ by Equation 8, we have:

$$\Delta Z_{n+1} = D_n - Z_n = k_n.$$

Combining these expressions, we arrive at

$$\Delta D_{n+1} - \Delta Z_{n+1} = (\gamma - 1)k_n + \phi[I'_r \cdot (1+\tau) \cdot \nu_{n+1} + I'_e \cdot e' \cdot \varepsilon_{n+1}],$$

which in turn allows us to express Equation 23 as

$$-(k_n + \kappa) < (\gamma - 1)k_n + \phi[I'_r \cdot (1+\tau) \cdot \nu_{n+1} + I'_e \cdot e' \cdot \varepsilon_{n+1}] \leq -(k_n + c). \quad (24)$$

The inequality in Equation 24 suggests that there are upper and lower bounds to the value of ν_{n+1} that will satisfy the conditions that have been stipulated for an upper turning point followed by a cumulative contraction of nominal income. We can solve for these boundary conditions as follows. First, we need to find the minimum value of ν_{n+1}, $\nu_{n+1\min}$, that satisfies $D_{n+1} - Z_{n+1} \leq -c$, or alternatively[22]

$$\begin{aligned}(\gamma - 1)k_n &+ \phi[I'_r \cdot (1+\tau) \cdot \nu_{n+1\min} + I'_e \cdot e' \cdot \varepsilon_{n+1}] \\ &= (k_n + c) \Rightarrow \phi \cdot I'_r \cdot (1+\tau) \cdot \nu_{n+1\min} \\ &= -[k_n + c + (\gamma - 1)k_n + \phi \cdot I'_e \cdot e' \cdot \varepsilon_{n+1}] \Rightarrow \nu_{n+1\min} \\ &= \frac{-[c + \gamma k_n + \phi \cdot I'_e \cdot e' \cdot \varepsilon_{n+1}]}{\phi \cdot I'_r \cdot (1+\tau)}.\end{aligned} \quad (25)$$

Second, we need to find the value ν^*_{n+1} that the realized value of ν_{n+1} cannot exceed if we are to satisfy the condition $-\kappa < D_{n+1} - Z_{n+1}$. This is given by[23]

[22] Note that since $I'_r < 0$ by hypothesis, the value of $\nu_{n+1\min}$ in the following expression is strictly positive.

[23] Again, note that ν^*_{n+1} is strictly positive, since $I'_r < 0$.

$$-(k_n + \kappa) = (\gamma - 1)k_n + \phi\left[I'_r \cdot (1 + \tau) \cdot \nu^*_{n+1} + I'_e \cdot e' \cdot \varepsilon_{n+1}\right]$$

$$\Rightarrow \nu^*_{n+1} = \frac{-\left[\kappa + \gamma k_n + \phi \cdot I'_e \cdot e' \cdot \varepsilon_{n+1}\right]}{\phi \cdot I'_r \cdot (1 + \tau)}. \qquad (26)$$

On the basis of Equations 25 and 26, the sufficient condition for an upper turning point followed by a cumulative contraction of nominal income in response to the initial conditions postulated earlier is that:

$$\nu^*_{n+1} > \nu_{n+1} \geq \nu_{n+1\,\min}$$

or

$$\frac{-\left[\kappa + \gamma k_n + \phi \cdot I'_e \cdot e' \cdot \varepsilon_{n+1}\right]}{\phi \cdot I'_r \cdot (1 + \tau)} > \nu_{n+1}$$

$$\geq \frac{-\left[c + \gamma k_n + \phi \cdot I'_e \cdot e' \cdot \varepsilon_{n+1}\right]}{\phi \cdot I'_r \cdot (1 + \tau)}. \qquad (27)$$

It would, of course, be straightforward to demonstrate a lower turning point in this cumulative decline in nominal income on the basis of the same method employed above if, in some period $t = n + s$, we observe $D_{n+s} - Z_{n+s} < -\kappa < -c$, followed by changes in the discount rate and animal spirits in period $n + s + 1$ that result in $\kappa > D_{n+s+1} - Z_{n+s+1} \geq c$.

Further comments

Several features of the model developed above are noteworthy. First, it is clear that the range of values of ν_{n+1} that satisfy the condition in Equation 27 cannot be deduced from the historical and exogenous "givens" of the model: Both the upper and lower bounds of this range depend on the contemporaneous value of ε. Furthermore, ε is not a variable that can be accurately forecast. Indeed, forecasts of ε are necessarily subject to fundamental uncertainty because of the time-dependent nature of the moments of its distribution, coupled with the fact that the evolution of these moments is subject to innovation/novelty (due to the hypothesized nature of choice) and is therefore inexplicable *a priori* in a traditional deterministic (including stochastic) form. Even when the conventions governing the moments of ε are relatively enduring, lending some conditional stability to the distribution of this variable, it cannot be forecast accurately within any given period. As such, the range of values of ν_{n+1} satisfying the inequality in Equation 27 will only be fully evident *ex post*. This obviously makes the pursuit of monetary policy difficult, since it suggests that policy interventions can have unintended consequences for the trajectory of nominal income. Monetary policy matters in the same way that expectations matter in this model, since it can impact in a nontransitory manner on nominal income and associated employment outcomes. However, this is not a model in which the monetary authorities can systematically "fine tune" the economy to a steady rate of expansion, having first learned the immutable "true model" governing the economy's dynamics.

Second, note that firms may become aware of the central bank's reaction function and, especially when the convention κ is relatively enduring, this may encourage them to modify the way they revise their animal spirits in response to the prior disappointment of short-run expectations (as currently modeled in Equation 15). Hence, for example, if $D_n - Z_n > \kappa > c$ in some period n, then firms that have learned about central bank behavior may be less inclined to revise their animal spirits in the same fashion they would have done in the absence of the central bank's "dirty" accommodationism. Of course, the central bank may, in turn, become aware of this revised behavior within the private sector and adjust its reaction function accordingly, triggering further learning and adjustments on the part of firms, and so on. Note, however, that these sequential adjustments to the structure of the model would not fundamentally alter the results derived above, although it would affect the magnitude of the range of values of ν_{n+1} found to satisfy the inequality 27 by affecting the size (and possibly even the sign) of the term:

$$\phi \cdot I'_e \cdot e' \cdot d\alpha_{n+1}$$

where

$$d\alpha_{n+1} = \pm \varepsilon_{n+1}.$$

Rather, the point is that while such adjustments in response to learning about the economy are both possible and even likely within the framework of analysis adopted here,[24] this same framework insists that, despite such learning, neither firms nor the central bank can ever be

[24] Indeed, they serve as a timely reminder that the structure of the economy within an open environment is never immutable, so that the precise form of the structural equations developed above can never be taken to represent "the" structure of the economy.

anything other than fundamentally uncertain about one another's behavior (and hence the behavior of the economy as a whole). This, of course, is because the behaviors of both are sources of openness in this framework, subject as they are to effective choice. Unlike the Lucas (1976) critique, then, which envisages the private economy as being foreclosed and determinate (and hence predictable) in the absence of changes in public policy, the ontology of the model developed above is such that the interaction between private and public decision-makers is only one of a general class of dynamic Keynesian "beauty contests" (Keynes, 1936), that would characterize the economy even in the absence of policy interventions.

Finally, note that in the model developed above, the behaviors of both firms and the central bank in revising α and δ are modeled as being symmetrical about $D_{t-1} - Z_{t-1} = 0$. It is quite possible, however, that revisions of α and δ are symmetrical about a positive value of $D_{t-1} - Z_{t-1}$. This would not eliminate the possibility of cyclical behavior in the model, but it would suggest that fluctuations would be more likely to occur about an *ex post* trend positive expansion path of nominal income, resulting in a model of growth and cycles.[25] In any event, it should be obvious that the trend of nominal income in this model is an *ex post*, path-dependent product of the sequence of short-run adjustments to which the model's dynamics give rise. We are thus in concurrence with the basic insight of Kalecki (1971, p. 165) that "the long-run trend is but a slowly changing component of a chain of short-period situations; it has no independent identity."

A comparison and contrast with other models of the cycle

A final task that remains is to briefly compare and contrast the model developed above with other models of the cycle. In the model developed above, sequences of self-reinforcing changes in nominal income can be "punctuated" by changes in monetary policy that, acting as negative feedbacks, can arrest and reverse both cumulative expansions and cumulative contractions of economic activity. The possibility of cycles in nominal income thus arises—although these fluctuations will be both aperiodic and of no fixed amplitude. This is because the factors chiefly responsible for the cyclical evolution of nominal income—revisions in

[25] Of course, it would be necessary to revisit the supply side of the model before such an extension to the model could be completed in a manner that would facilitate reasonable conclusions about growth.

the state of long-run expectations and changes in the discount rate—cannot be explained in the foreclosed, deterministic fashion that would give rise to a fixed period and amplitude. On the contrary, changes in both animal spirits and the discount rate can vary about their current normal (conventional) values in unpredictable ways, while these conventional values themselves are subject to innovative change over time. Although the latter has not been explored in detail in this paper, it is in keeping with the open systems method on which the foregoing analysis is based to assert that the evolution of the conventions $\mu_{\varepsilon t}$ and μ_{vt} cannot be "endogenized" in the sense of being reduced to closed-form explanation in terms of exogenous data. Their evolution may be endogenous in the sense of being influenced by past and present economic outcomes, but in the presence of effective choice, it must remain relatively autonomous. In this way, the evolution of the model developed above is subject to structural changes (in α, δ, $\mu_{\varepsilon t}$, and μ_{vt}) that cannot themselves be described in terms of a closed-form solution, even though these changes are influenced by (and hence endogenous to) past outcomes of the system they help to define. The model can thus be said to display evolutionary hysteresis (see Setterfield, 1999b).[26]

Following Jarsulic (1993), this model can be compared and contrasted with three broad classes of models of the cycle: linear-stochastic models; nonlinear endogenous models; and chaotic models. Linear-stochastic models represent the economy in a homeostatic form, in which shocks, resulting in departures from an otherwise stable equilibrium, are then propagated into a cycle by the form of the disequilibrium adjustment mechanism. Contemporary examples of this class of models are the new classical cycle theories inspired by Lucas (1975) and Kydland and Prescott (1982). The model developed above clearly has little in common with these models, because it does not conceive the economy in a traditional homeostatic fashion. Instead, out-of-equilibrium behavior is capable of redefining the conditions and hence the position of equilibrium, which is both path-dependent and generally irrelevant as a description of the system's configuration at any point in time.

Nonlinear endogenous models of the cycle eschew the homeostatic vision of the economy associated with linear-stochastic models. Instead

[26] This is not a surprising conclusion. In his discussion of the acceptance of the ergodic hypothesis described earlier in connection with closed-system analysis, Samuelson suggests that "technically speaking, we theorists hoped not to introduce *hysteresis* phenomena into our model, as the Bible does when it says 'We pass this way only once' and, in so saying, takes the subject out of the realm of science and into the realm of genuine history" (Samuelson, 1969, pp. 184–185. Emphasis in

of requiring shocks to initiate cycles in an otherwise steady-state environment, they describe the trajectory of an economy as a series of self-sustaining fluctuations. Among the classic contributions to this tradition are Kalecki (1937), Kaldor (1940), Hicks (1950), and Goodwin (1951).[27] The model developed above shares with this class of models the desire to avoid a homeostatic conception of the economy in favor of one characterized by self-perpetuating fluctuations. However, nonlinear endogenous models typically give rise to periodic cycles. As was noted above, the indeterminacy that characterizes the model developed earlier is highly unlikely to give rise to such regular behavior. Fluctuations are far more likely to be, instead, aperiodic.

Finally, chaotic dynamics have been applied to the analysis of business cycles (see, for example, Grandmont, 1985; Goodwin, 1990), resulting in a demonstration of the fact that aperiodic fluctuations may emerge from deterministic, nonlinear equations of motion that are capable of generating chaos. The potential for aperiodic cycles in these models is obviously a feature that is shared with the model developed earlier. However, the latter takes a fundamentally different view of the underlying economic process that is responsible for generating these outcomes. It is commonplace in chaotic models to emphasize that, because of the tendency for only modestly different initial conditions to produce subsequent outcomes that diverge exponentially, it is not possible to know these systems in sufficient detail to forecast accurately. Learning the "true" model governing economic outcomes is so difficult as to be practically impossible, so that agents must thus remain fundamentally uncertain of the future. Nevertheless, a "true" model—captured by the deterministic equations of motion that generate chaotic output—does exist, so that this uncertainty is a purely epistemological phenomenon. In the model developed earlier, however, uncertainty has an ontological source. The ontology of this model differs fundamentally from that of a typical chaotic model because it postulates that social systems are open: Economic outcomes do not derive from deterministic equations of motion that are knowable in principle

original). Of course, whether or not we accept the conflict between science and history that Samuelson identifies depends on our conception of science. If science is about predicting the future, then the conflict must be accepted. But if it is more to do with explaining the processes that lie behind causal relations—even if these are indeterminate and therefore unpredictable—then the conflict is less obvious.

[27] See Jarsulic (1993, pp. 351–353) for discussion of more recent theories that fit into this class of models.

(even if not in practice). Hence chaotic models and the model developed earlier rest on different theories of social ontology, so that their narrative contents (the way they describe the economy as functioning) necessarily differ. This is important from the point of view of a realist conception of science, according to which the purpose of science is not simply to use models as instruments designed to generate particular results, but to elucidate the processes by which these results are actually generated.

Conclusion

This paper echoes the claim that Keynes's revolution was as much methodological as theoretical, and that inattention to methodological issues is therefore fatal in macroeconomics—especially macroeconomics that claims to be of a Keynesian genus. A theory of social ontology in which social systems are open and transmutable rather than foreclosed and determinate has been outlined, and its implications for the treatment of expectations and money in macroeconomics have been identified. A model of the business cycle that is consistent with this ontological vision has been developed, and its structure compared and contrasted with that of other classes of business cycle models.

One of the central purposes of this paper is to demonstrate that emphasizing the openness and transmutability of social systems, together with the concomitant effectiveness of choice and emergence of behaviors and outcomes, is not nihilistic. It is possible to construct models that characterize the causal processes extant within such systems and the qualitative outcomes associated with these processes, even if the calculation of closed-form solutions and hence the prediction (with either certainty or certainty equivalence) of quantitative values is impossible in principle. The importance of this exercise is best understood in the context of a realist conception of science, which rejects the "as if" modeling practices of instrumentalism in favor of an emphasis on the descriptive content of models—the form of their abstractions, their description of transmission mechanisms, and so forth—and how well this conforms to the scientist's social ontology. If science is—or should be—broadly realist in its orientation, and if social systems are open rather than foreclosed so that agents are capable of effective choice rather than just passive selection, then an important purpose of the model developed in this paper is to suggest the way in which an analytical macroeconomics that is consistent with this conception of science and society might proceed.

REFERENCES

Arrow, K. "Workshop on the Economy as an Evolving Complex System: Summary." In P. Anderson, K. Arrow, and D. Pines (eds.), *The Economy as an Evolving Complex System.* New York: Addison-Wesley, 1989.

Asimakopulos, A. *Keynes's General Theory and Accumulation.* Cambridge: Cambridge University Press, 1991.

Davidson, P. *Money and the Real World,* 2d ed. London: Macmillan, 1978.

———. "Reviving Keynes's Revolution." *Journal of Post Keynesian Economics,* 1984, *6,* 561–575.

———. "Would Keynes be a New Keynesian?" *Eastern Economic Journal,* 1992, *18,* 449–463.

———. *Post Keynesian Macroeconomic Theory.* Cheltenham, UK: Edward Elgar, 1994.

———. "Reality and Economic Theory." *Journal of Post Keynesian Economics,* 1996, *18,* 479–508.

Dow, S. "Mainstream Economic Methodology." *Cambridge Journal of Economics,* 1997, *21,* 73–93.

Gerrard, B. "Probability, Uncertainty and Behaviour: A Keynesian Perspective." In S. Dow and J. Hillard (eds.), *Keynes, Knowledge and Uncertainty.* Cheltenham, UK: Edward Elgar, 1994.

Goodwin, R.M. "The Non-Linear Accelerator and the Persistence of Business Cycles." *Econometrica,* 1951, *19,* 1–17.

———. *Essays in Economic Dynamics.* London: Macmillan, 1987.

———. *Chaotic Economic Dynamics.* Oxford: Oxford University Press, 1990.

Grandmont, J.M. "On Endogenous Competitive Business Cycles." *Econometrica,* 1985, *53,* 995–1046.

Grossman, G.M., and Helpman, E. *Innovation and Growth in the Global Economy.* Cambridge, MA: MIT Press, 1991.

Hicks, J. *A Contribution to the Theory of the Trade Cycle.* Oxford: Oxford University Press, 1950.

———. *Causality in Economics.* New York: Basic Books, 1979.

Jarsulic, M. "Recent Developments in Business Cycle Theory." *Review of Political Economy,* 1993, *5,* 344–364.

Kaldor, N. "A Classificatory Note on the Determinateness of Equilibrium." 1934, 2, 122–136.

———. "A Model of the Trade Cycle." *Economic Journal,* 1940, *50,* 78–92.

Kalecki, M. "A Theory of the Business Cycle." *Review of Economic Studies,* 1937, *4,* 77–97.

———. "Trend and the Business Cycle." In *Selected Essays on the Dynamics of a Capitalist Economy 1933–1970.* Cambridge: Cambridge University Press, 1971.

Keynes, J.M. *The General Theory of Employment, Interest and Money.* London: Macmillan, 1936.

———. *The Collected Writings of John Maynard Keynes.* London: Macmillan, 1973.

Kregel, J. "Economic Methodology in the Face of Uncertainty: The Modeling Methods of Keynes and the Post-Keynesians." *Economic Journal,* 1976, *86,* 209–225.

Kydland, F., and Prescott, E. "Time to Build and Aggregate Fluctuations." *Econometrica,* 1982, *50,* 1345–1370.

Lavoie, M. *Foundations of Post-Keynesian Economic Analysis.* Cheltenham, UK: Edward Elgar, 1992.

Lawson, T. *Economics and Reality.* London: Routledge, 1997.

Lucas, R. "An Equilibrium Model of the Business Cycle." *Journal of Political Economy,* 1975, *83,* 1113–1144.

———. "Econometric Policy Evaluation: A Critique." In K. Brunner and A.H. Meltzer (eds.), *The Phillips Curve and the Labour Market.* Amsterdam: North-Holland, 1976.

Palley, T. *Post Keynesian Economics: Debt, Distribution and the Macroeconomy.* London: Macmillan, 1996.

Samuelson, P.A. "Classical and Neo-Classical Monetary Theory." In R.W. Clower (ed.), *Monetary Theory: Selected Readings.* London: Penguin, 1969.

Sargent, T.J. *Bounded Rationality in Economics.* Oxford: Oxford University Press, 1993.

Setterfield, M. "Should Economists Dispense with the Notion of Equilibrium?" *Journal of Post Keynesian Economics,* 1997, *20,* 47–76.

———. "Expectations, Path Dependence and Effective Demand: A Macroeconomic Model Along Keynesian Lines." *Journal of Post Keynesian Economics,* 1999a, *21,* 471–501.

———. "A Model of Kaldorian Traverse: Cumulative Causation, Structural Change and Evolutionary Hysteresis." CEPREMAP, mimeo, 1999b.

Vickers, D. *Economics and the Antagonism of Time.* Ann Arbor: University of Michigan Press, 1994.