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THE EVOLUTION OF ENDOGENOUS BUSINESS CYCLES

ROGER E.A. FARMER
University of California, Los Angeles

This paper distinguishes two kinds of endogenous business cycle models: EBC1 models, which display dynamic indeterminacy, and EBC2 models, which display steady-state indeterminacy. Both strands of the literature have their origins in the sunspot literature that developed at the University of Pennsylvania in the 1980s. I argue that EBC1 models are part of the evolution of modern macroeconomics that has classical roots dating back to the 1920s. EBC2 models provide a microfoundation for one of the most important ideas to emerge from Keynes's (1936) *General Theory of Employment, Interest and Money*: that high involuntary unemployment can persist as part of the steady-state equilibrium of a market economy.

Keywords: Unemployment, Self-Fulfilling Prophecies, Hysteresis, Keynesian Economics

1. INTRODUCTION

In a special issue of the *Journal of Economic Theory* (*JET*), Benhabib and Farmer (1994) introduced a representative-agent business cycle model in which equilibria are indeterminate. Writing in the same issue of the journal, Farmer and Guo (1994) developed a discrete time analog of the Benhabib–Farmer model and added self-fulfilling nonfundamental stochastic shocks to beliefs.

The models developed by Benhabib and Farmer and by Farmer and Guo are characterized by a propagation mechanism in which the persistence of business cycles arises endogenously, as opposed to the real business cycle (RBC) model, in which persistence is explained by an exogenous autocorrelated shock to total factor productivity (TFP). Their work signaled an important departure from the conventional RBC model by demonstrating that business cycles may not be the efficient responses of rational agents to shocks to technology; instead, they may be inefficient fluctuations in employment and GDP, caused by shocks to the

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self-fulfilling beliefs of households and firms. The 1994 *JET* volume spawned a literature on endogenous business cycles (EBC) that reconciled the Benhabib–Farmer model with a broader range of micro and macro stylized facts.

In the Benhabib–Farmer model, there are a unique steady state and a continuum of equilibrium paths that converge to it. I call the class of models that exploit dynamic indeterminacy to explain business cycles first-generation EBC models, or EBC1 models for short.[1] In a recent series of books and papers [Farmer 2006, 2008a, 2008b, 2010a, 2010b, 2010c, 2012a, 2012b, 2012c, 2013a], my students and I have introduced an EBC model in which there is not just dynamic indeterminacy, but also steady-state indeterminacy. Significantly, in Farmer (2006, 2008a, 2012b), I develop a model with a continuum of steady-state unemployment rates. I will refer to this model, and to related models that exploit steady-state indeterminacy to explain business cycles, as second-generation EBC models, or EBC2 models for short.[2]

EBC1 models were innovative, but not revolutionary. Although they reintroduced the idea that beliefs may independently influence outcomes (a concept that was present in the macroeconomic theory of the 1920s), they did not break free from the classical assumption that the labor market is always close to an efficient steady-state equilibrium.

This paper explains the evolution from EBC1 models, which display dynamic indeterminacy, to EBC2 models, which display steady-state indeterminacy. Both branches of this literature have their origins in an important idea that was developed at the University of Pennsylvania in the 1980s: *what people believe to be true can independently influence what actually happens*. By combining this revolutionary idea with recent work on labor market search, the EBC2 models developed in my recent books and papers explain how high unemployment can persist indefinitely. In so doing, they offer an explanation for the Great Depression and the Great Recession of 2008 that combines Keynesian and classical ideas in a new way.

2. THE HISTORY OF MACROECONOMIC THEORY

Modern macroeconomics traces its origins to Lucas (1972), a paper about the role of money in business cycles. Lucas's work was followed by the seminal papers of Kydland and Prescott (1982) and Long and Plosser (1983), which introduced the idea that business cycles are the efficient fluctuations of a competitive economy in response to exogenous persistent technology shocks. This idea, dubbed real business cycle theory, represents a return to the classical ideas that characterized business cycle theory in the 1920s [Pigou (1929)].

Although the real business cycle model is grounded in classical economics, it is mathematically more sophisticated. Because the mathematics was hard, the initial RBC model was simple. In place of the rich panoply of shocks that drives business cycles in Pigou's work, the RBC model is driven by a single random shock: innovations to TFP. The next twenty-five years were characterized by a research agenda in which the business cycle shocks of the 1920s were brought back, one by one, into the classical model. The models developed over this period are referred to as DSGE, or dynamic stochastic general equilibrium models. EBC1 models were an important part of this DSGE agenda.

Like the RBC model, DSGE models have a general equilibrium core. They differ from it by adding nominal frictions as in Christiano et al. (2005) or additional shocks as in Hall (1997) and Beaudry and Portier (2006), or by making small departures from the core assumptions that provide a richer propagation mechanism as in Farmer and Guo (1994). By the onset of the Great Recession in 2007, Smets and Wouters (2007) had managed to replicate the verbal theory of Pigou using the language of DSGE theory. They showed that a DSGE model, loaded up with enough frictions and multiple shocks, does a credible job of replicating the dynamics of postwar U.S. business cycles.

RBC models were developed in response to the failure of Keynesian theory to explain the economic events of the 1970s. It now appears that Keynesian economics was discarded prematurely, as the classical models that replaced Keynesian theory are themselves unable to explain either the Great Depression or its recent reincarnation on a smaller scale, the Great Recession of 2008. The Great Depression shattered the classical view, and in response to the depression, Keynes (1936) argued that the economy can get stuck in a state of involuntary unemployment and that any unemployment rate can be an equilibrium. In my work on EBC2 models, I capture this concept by adding a theory of labor market search to an otherwise standard general equilibrium model. In so doing, I reconcile the economics of involuntary unemployment with microeconomic theory in a new way.

3. INDETERMINACY, SUNSPOTS, AND SELF-FULFILLING PROPHECIES: MACRO AT PENN IN THE 1980S

EBC models of both generations are based on an idea developed at the University of Pennsylvania in the early 1980s in the work of Azariadis (1981), Cass and Shell (1983), and Farmer and Woodford (1984): that indeterminacy can be combined with self-fulfilling beliefs to create a positive model of business cycles. Indeterminacy acts as the propagation mechanism and shocks to beliefs, caused by nonfundamental uncertainty, act as the impulse.

Using the term "sunspots" to refer to nonfundamental uncertainty, Cass and Shell (1983) were the first to show that sunspots can have real effects on consumption, even in the presence of a complete set of financial markets. Using the term "self-fulfilling prophecies" to refer to nonfundamental uncertainty, Azariadis (1981) was the first to show that nonfundamental shocks could be added to a DSGE model to drive business cycles. The models of Cass and Shell and Azariadis were two-period-lived overlapping-generations models with a finite number of determinate steady states.

Indeterminacy as a positive explanation of business cycles was first introduced by Farmer and Woodford (1984) [published later as Farmer and Woodford (1997)], who combined self-fulfilling prophecies with indeterminacy to generate a model in which sunspot shocks generate endogenous autocorrelated responses of GDP and employment. Up to this point, models of indeterminacy and sunspots, or self-fulfilling prophecies, were recognized as theoretical possibilities, but because they were constructed in static models or in models where agents lived for only two periods, they remained disconnected from quantitative models of the business cycle.

That changed with the 1994 *JET* volume in which Benhabib and Farmer (1994) demonstrated that indeterminacy occurs in models that are similar to the RBC model and Farmer and Guo (1994) provided a framework where, for the first time, sunspot theory could be taken seriously as a positive explanation for the business cycle.

4. EBC1: MULTIPLE DYNAMIC EQUILIBRIA AND INCREASING RETURNS TO SCALE

The Benhabib–Farmer model alters the RBC model by adding a technology with increasing returns to scale. The key idea of this model is to exploit a production externality that reconciles increasing returns to scale with the neoclassical theory of distribution. The model has been successful because it is simple and closely related to the RBC model, which by 1994 had become the industry standard.

The canonical RBC model [King et al. (1988)] consists of five equations and three boundary conditions to explain the time paths of five variables; GDP Y_t, consumption C_t, capital K_t, labor supply L_t, and TFP S_t. These five equations are

$$Y_t = S_t K_{t-1}^{a} L_t^{1-a}, \tag{1}$$

$$K_t = K_{t-1}(1-\delta) + Y_t - C_t, \tag{2}$$

$$\frac{1}{C_t} = E_t\left\{\frac{1}{1+\rho}\frac{1}{C_{t+1}}\left(1-\delta+\frac{aY_{t+1}}{K_t}\right)\right\}, \tag{3}$$

$$C_t L_t^{\gamma} = (1-a)\frac{Y_t}{L_t}, \tag{4}$$

$$S_t = S_{t-1}^{\lambda}\exp(e_t), \tag{5}$$

and the three boundary conditions are given by

$$K_0 = \bar{K}_0, \tag{6}$$

$$S_0 = \bar{S}_0, \tag{7}$$

$$\lim_{T\to\infty} E_t\left\{\left(\frac{1}{1+\rho}\right)^T \frac{K_T}{C_T}\right\} = 0. \tag{8}$$

Equation (1) is a production function, (2) is the capital accumulation equation, (3) is the representative agent's Euler equation, (4) is the first-order condition for

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labor, and (5) describes the evolution of TFP as a geometric first-order autoregressive process hit by an iid innovation. The innovation to TFP has a distribution function $D(\cdot)$ with mean 0 and variance σ^2,

$$e_t \sim D(0, \sigma^2). \tag{9}$$

The boundary conditions are the initial conditions for capital (6) and TFP (7) and the transversality condition (8). The model has five parameters: the rate of time preference ρ, the capital elasticity a, the labor supply parameter γ, the autocorrelation parameter λ, and the standard deviation of the innovation to TFP σ.

The Benhabib–Farmer model has a structure almost identical to that of the canonical RBC model, but it differentiates between the private technology,

$$Y_t = S_t A_t K_{t-1}^{a} L_t^{1-a}, \tag{10}$$

and the social technology,

$$Y_t = S_t \bar{K}_{t-1}^{\alpha} \bar{L}_t^{\beta}, \tag{11}$$

where the two are related by the identity

$$A_t \equiv \bar{K}_{t-1}^{\alpha-a} \bar{L}_t^{\beta-1+a}. \tag{12}$$

Here, $\bar{K}_{t-1}$ and $\bar{L}_t$ refer to the economywide average use of capital and labor and A_t is a productive externality. In a symmetric equilibrium, $\bar{K} = K$ and $\bar{L} = L$ at all dates. An equilibrium of the model is a time path for the variables that satisfies the dynamic equations (1)–(5), the initial conditions (6) and (7), and the transversality condition (8).

In addition to the parameters of the RBC model, the Benhabib–Farmer model has two new parameters, α and β. When $\beta > 1+\gamma$, the social technology exhibits increasing returns to scale. In this case, Benhabib and Farmer show that the model has multiple dynamic equilibria. Each of them is represented by a different path for capital, labor, consumption, and GDP, and all of these paths converge back to the same steady state. Which of the equilibrium paths prevails is determined by the self-fulfilling beliefs of the agents in the model.

5. EBC2: MULTIPLE STEADY-STATE EQUILIBRIA AS A MICROFOUNDATION FOR KEYNESIAN ECONOMICS

My version of an EBC2 model [Farmer (2006, 2008a, 2012b)] alters the RBC model by adding a theory of labor market search. I assume that workers and firms act competitively and take prices and wages as given and I demonstrate that this assumption leads to a model that displays what I call *incomplete factor markets*.[3] The key idea of this model is to exploit the fact that, when a worker meets a firm, there are many possible ways of splitting the surplus that arises from the meeting. My reason for developing this model is that EBC1 models provide an

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inadequate description of major recessions such as the Great Depression or the Great Recession of 2008.

As with other DSGE models that enhanced the RBC framework, first-generation EBC1 models represent employment fluctuations as small deviations from a unique full-employment steady-state equilibrium. Because the economy is never far from a Pareto-optimal steady state, the welfare costs of business cycles in these models are small.[4] This characteristic is undesirable because it is inconsistent with the fact that recessions appear to be hugely costly to unemployed workers. The EBC2 model I have developed solves this problem by explaining high persistent unemployment as a socially inefficient equilibrium that arises as a consequence of incomplete factor markets. In this model, self-fulfilling beliefs trigger permanent movements in economic activity.

The defining feature of the Farmer EBC2 model is the assumption that households are not on their labor supply curves. In this sense, this model follows Keynes's *General Theory*.[5] But it goes beyond the *General Theory* by providing an explicit microfoundation that explains *why* households are not on their labor supply curves. The labor supply equation is missing because there are incomplete factor markets. By this I mean that there are no prices for the two independent inputs to a technology that describes how searching workers are matched with vacant jobs; instead, workers find jobs through random search.

My work replaces the assumption that the demand for and supply of labor are equal with an explicit model of unemployment based on the search and matching framework of Mortensen (1970), Pissarides (1976), and Diamond (1982a,b, 1984). Following Howitt and McAfee (1987), I drop the Nash bargaining equation that is typically added to search models of this kind, and I assume instead that firms produce as much as is demanded. Demand is determined by forward-looking households, which form a sequence of self-fulfilling beliefs about the value of their wealth. Beliefs are determined by an alternative independent equation that replaces the assumption that firms and workers bargain over the wage.

The EBC2 model, like its first-generation cousin, relies on the idea that DSGE models may have multiple indeterminate equilibria to explain real world phenomena. Unlike the EBC1 model, the EBC2 model displays steady-state indeterminacy. *This is a significant departure from the earlier literature.* Whereas the EBC1 model adds an additional shock, self-fulfilling beliefs, to a classical model, the EBC2 model provides a microfoundation for the Keynesian idea that there may be many equilibrium unemployment rates. This work recasts the central ideas from *The General Theory* (1936) in the language of DSGE theory.[6]

6. PLOTNIKOV'S EXAMPLE: AN EBC2 MODEL WITH INVESTMENT

In Farmer (2006, 2010a, 2012b), I embedded a search market in an asset pricing model where capital is fixed and cannot be reproduced. This model is distinct from the RBC model and does not explicitly include a theory of investment. I chose that framework because I wanted to model the connection between the value of the stock market and the value of unemployment, a connection that is strong and structurally stable in the postwar period [Farmer (2012c, 2013b)].

In the model with nonreproducible capital, the value of a capital asset varies with expectations of future dividends. Although this leads to a model where there is an obvious analog of stock market valuation, it cannot easily be compared with the RBC model because it does not allow for investment. In his Ph.D. thesis, Plotnikov (2013) estimates an incomplete-factor-markets model with reproducible capital. Because stock market wealth does not enter his model, Plotnikov assumes instead that households form beliefs about their permanent income using adaptive expectations as in Friedman's (1957) work on the consumption function. I will use Plotnikov's second-generation EBC2 model in this discussion because it explicitly models investment and therefore can more easily be compared with the RBC model.

The Plotnikov model has the following characteristics. Output is produced from labor and capital by a large number of competitive firms. Firms are owned by a representative household that allocates output between consumption and investment, and next period's capital stock is determined by a standard capital accumulation equation. These assumptions lead to a model that has five equations in common with the RBC model and with first-generation EBC1 models. It is closed by adding an explicit theory of the determination of beliefs.

In a paper written in 2002 [Farmer (2002)], I developed an EBC1 model where adaptive expectations determine beliefs. Because, in that model, there are many dynamic equilibrium paths, there are ways of forming adaptive expectations that are also consistent with the assumption that expectations are rational; it is the form of the adaptive expectations equation that selects an equilibrium. Plotnikov (2013) uses that same idea. In his model, because there are multiple steady-state equilibria, adaptive expectations are fully rational.

The RBC model does not contain prices. But when the solution of the model is decentralized with competitive markets, the household's labor allocation decision, equation (4), can be split into two parts as follows:

$$\omega_t = C_t L_t^{\gamma}, \tag{13a}$$

$$\omega_t = (1-a)\frac{Y_t}{L_t}, \tag{13b}$$

where ω_t is the real wage. Equation (13a) reflects the assumption that the representative household equates the slope of an indifference curve between leisure and consumption to the real wage. Equation (13b) is the first-order condition for the choice of labor by a competitive firm.

If we add the real wage as a variable, the RBC model explains the six variables K_t, L_t, C_t, Y_t, S_t, and ω_t as functions of the innovation to TFP with six equations: equations (1)–(3), (5), and (13a) and (13b). The EBC2 model has five equations

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in common with the EBC1 model: these are

$$Y_t = A_t S_t K_{t-1}^{a} L_t^{1-a}, \tag{1a}$$

$$K_t = K_{t-1}(1-\delta) + Y_t - C_t, \tag{2a}$$

$$\frac{1}{C_t} = E_t\left\{\frac{1}{1+\rho}\frac{1}{C_{t+1}}\left(1-\delta+\frac{aY_{t+1}}{K_t}\right)\right\}, \tag{3a}$$

$$\omega_t = (1-a)\frac{Y_t}{L_t}, \tag{4a}$$

$$S_t = S_{t-1}^{\lambda}\exp(e_t). \tag{5a}$$

The model also retains the boundary conditions, given by

$$K_0 = \bar{K}_0, \tag{6a}$$

$$S_0 = \bar{S}_0, \tag{7a}$$

$$\lim_{T\to\infty} E_t\left\{\left(\frac{1}{1+\rho}\right)^T \frac{K_T}{C_T}\right\} = 0. \tag{8a}$$

But this gives only five equations to determine the six unknowns, K_t, L_t, C_t, Y_t, S_t, and ω_t. The Plotnikov EBC2 model is missing equation (13a). Instead of the labor market being assumed to be competitive, employment is determined in a search equilibrium. Households do not vary labor supply in response to changes in wages and interest rates as in the RBC and EBC1 models; instead, each household sends a fixed fraction of its members to look for a job in every period, and variation in employment arises as a consequence of endogenous changes in the efficiency with which workers are matched with jobs.

7. UNEMPLOYMENT AND SEARCH EXTERNALITIES

The EBC1 and EBC2 model both exploit the idea that there is an externality in the production function; but they do it in fundamentally different ways. In EBC1 models, the externality leads to multiple dynamic equilibria; in the EBC2 model, it leads to multiple steady state equilibria. This section explains how that works by utilizing the concept of incomplete factor markets.

To model the frictional costs of recruiting, assume that a representative firm with L_t workers, can allocate them to the activity of recruiting or production. If we let V_t be the number of recruiters and X_t the number of production workers, V_t and X_t are related to L_t by the equation

$$L_t = X_t + V_t. \tag{14}$$

Now assume that every recruiter can hire q_t workers,

$$L_t = q_t V_t, \tag{15}$$

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where q_t is taken as given by the representative firm but is determined in aggregate by the degree of congestion in the labor market. Using the definition of X_t, we can express the output of the representative firm as

$$Y_t = S_t K_t^a X_t^{1-a}. \tag{16}$$

Substituting (14) and (15) into (16) leads to the expression

$$Y_t = A_t S_t K_t^a L_t^{1-a}, \tag{17}$$

where

$$A_t = \left(1 - \frac{1}{q_t}\right)^{1-a}. \tag{18}$$

In words, the externality, A_t, is a function of the number of workers, q_t, that can be hired by a representative worker assigned to the task of recruiting. The term q_t is taken as given by each firm, but it is determined in aggregate by the number of other firms that are trying to attract workers. The connection with aggregate recruiting activity is found by specifying a matching technology that relates aggregate hires to the aggregate number of recruiters, $\bar{V}_t$. The important idea here is that the assumption that workers and firms take prices and wages as given does not lead to enough equations to determine q_t.

Farmer (2012b) adds a Cobb–Douglas matching function to this model to determine the number of workers that are hired when firms, in aggregate, allocate $\bar{V}_t$ workers to recruiting and when a measure 1 of workers look for a job. By making the simplifying assumption that all workers are fired and rehired every period,[7] he shows that $q_t = 1/\bar{L}_t$ and hence the externality A_t is given by the expression

$$A_t = (1 - \bar{L}_t)^{1-a}. \tag{19}$$

As in the EBC1 model of Benhabib and Farmer (1994), the term A_t represents a labor market externality. In the EBC2 model, this is represented by equation (19), where $\bar{L}_t$ is average employment by all other firms.

8. CLOSING THE EBC2 MODEL WITH ADAPTIVE EXPECTATIONS

The models developed in Farmer (2006, 2012b,c, 2013a) are closed by assuming that households form self-fulfilling beliefs about the value of their wealth. In Plotnikov (2013), there is no analog of stock market wealth, but households must still form expectations of their human wealth. To capture this concept, Plotnikov adapts Friedman's concept of permanent income. As in Friedman (1957), those expectations are formed adaptively. And as in Farmer (2002), because the model has an indeterminate set of equilibria, adaptive expectations are also rational.

If we evaluate equations (1a)–(5a) in a steady state, we are able to pin down a value for $\bar{S}$ that equals 1, and values of the ratios $\bar{C}/\bar{K}$, $\bar{Y}/\bar{K}$, and $\bar{C}/\bar{Y}$ that are given by the expressions

$$\frac{\bar{C}}{\bar{K}} = \frac{\rho + \delta(1-a)}{a}, \tag{20}$$

$$\frac{\bar{Y}}{\bar{K}} = \frac{\rho + \delta}{a}, \tag{21}$$

and

$$\frac{\bar{C}}{\bar{Y}} = \frac{\rho + \delta(1-a)}{\rho + \delta}. \tag{22}$$

But the steady-state real wage $\bar{\omega}$ and steady employment $\bar{L}$ cannot be found from these equations. Instead, the model is closed by assuming, as in Friedman's work on the consumption function, that consumption, C_t, is proportional to permanent income, Y_t^P:

$$C_t = \phi Y_t^P. \tag{23}$$

Here, permanent income is defined to be the value of income that would be earned by the representative household in the absence of shocks.

Because permanent income and current income are the same in a nonstochastic steady state, the coefficient ϕ is constrained by equation (22) to be

$$\phi \equiv \frac{\rho + \delta(1-a)}{\rho + \delta}. \tag{24}$$

Under the adaptive expectations hypothesis, permanent income depends on current income and on the view of permanent income that households formed one period in the past. That assumption leads to the equation

$$Y_t^P = \left(Y_{t-1}^P\right)^{\theta} Y_t^{1-\theta} \exp\left(e_t^b\right). \tag{25}$$

The parameter θ measures the speed with which revisions to current income are incorporated into permanent income, and e_t^b is a belief shock that represents the optimism or pessimism of households. This shock has distribution $D(\cdot)$ with mean 0 and variance σ_b^2,

$$e_t^b \sim D\left(0, \sigma_b^2\right). \tag{26}$$

Finally, because Y_t^P is a state variable, the model must be closed with the initial condition

$$Y_0^P = \bar{Y}^P. \tag{27}$$

The complete EBC2 model consists of the dynamic equations (1a)–(4a), (23), and (25), the initial conditions (6a), (7a), and (27), and the transversality condition (8a).

For any set of initial conditions, equations (1a)–(4a), (23), and (25) define a unique dynamic equilibrium. But setting the shocks to zero and solving for the steady state yields one less equation than unknown. This indeterminacy of the steady state arises because although equations (23) and (25) define a unique path for any set of initial conditions, they do not add information to help pin down the steady state. The steady-state value of (25) defines $\bar{Y}^P$ to be equal to $\bar{Y}$, the steady-state value of (23) replicates the information from (22), and the complete set of equations defines a system that is path-dependent. In the absence of shocks, the economy would converge to a steady-state value of employment that depended on the initial belief about permanent income, Y_0^P.

What have we gained by adapting a DSGE model in this way? *The important feature that distinguishes EBC2 models from other DSGE models is that data generated by the model display hysteresis:* a small perturbation of the initial conditions leads to a similar perturbation of the eventual steady state. As Blanchard and Summers (1986, 1987) have argued convincingly, and as I have argued elsewhere [Farmer (2012a,c, 2013a)], *this is exactly the behavior we see in the data.*[8]

9. CONCLUSION

This paper has discussed the use of endogenous business cycle models that display indeterminate equilibria as a positive explanation of real world phenomena. This idea originated at the University of Pennsylvania during the early 1980s in the work of Azariadis (1981), Cass and Shell (1983), and Farmer and Woodford (1984), and it evolved into the EBC agenda, a research program that explains business cycles as endogenous responses to self-fulfilling shocks to beliefs.

I have identified two generations of EBC models. First-generation EBC1 models display indeterminate dynamic equilibria in which many equilibrium paths converge to the same steady state. Second-generation EBC2 models display steady-state indeterminate equilibria in which there are many steady-state equilibrium unemployment rates.

One of the most important ideas to come from Keynes's *General Theory* was that high unemployment can persist as an equilibrium phenomenon. Second-generation EBC2 models provide a microfoundation for this idea, and just as EBC1 models were part of the DSGE agenda that provided a microfoundation for the economics of Pigou (1929), EBC2 models provide a microfoundation for the economics of Keynes (1936). The idea that involuntary unemployment can persist as an equilibrium phenomenon is one that will gain more credence the longer the current recession persists.

NOTES

1. Benhabib and Farmer (1999) survey EBC1 models and discuss the issues related to dynamic indeterminacy and the mechanisms that generate it, and Farmer (1999) explains how indeterminacy can arise in general equilibrium models and provides an accessible introduction to the topic. Since the Benhabib–Farmer survey in 1999, many important papers have been published in the field. Because of space restrictions, this paper is unable to provide a comprehensive introduction to that literature.

2. Related papers that I would include in the second-generation EBC2 literature include Angeletos and La'O (2013), Benhabib et al. (2012), Brown (2010), Farmer and Plotnikov (2012), Gelain and Guerrazzi (2010), Guerrazzi (2011, 2012), Heathcote and Perri (2012), Kashiwagi (2010), Kocherlakota

(2011, 2012), Michaillat and Saez (2013, 2014), Miao et al. (2012), Plotnikov (2013), and Schmitt-Grohé and Uribe (2011, 2012).

3. Kocherlakota (2012) uses the term *incomplete labor markets* to refer to the concept that I call *incomplete factor markets* [Farmer (2006, p. 12)].

4. Lucas (1987) showed that, in an RBC model, the welfare costs of business cycles are less than one tenth of one percent of steady state consumption. In DSGE models with added frictions, the welfare costs of business cycle fluctuations are also small [Galí et al. (2007).]

5. Keynes drops what he calls "Postulate II of classical economics." By Postulate II, he means that "The utility of the wage when a given volume of labour is employed is equal to the marginal disutility of that amount of employment" [Keynes (1936, p. 5)].

6. Alternative approaches include the work of Phelps (1994) on structural slumps and that of Blanchard and Summers (1986, 1987), who use the insider–outsider model of Lindbeck and Snower (1986) to generate models of persistent unemployment. Frydman and Goldberg (2011) argue the case for nonstationarity of the fundamentals.

7. In most models of unemployment—see the survey by Rogerson et al. (2005)—the number of unemployed workers appears as a state variable. Farmer (2010a, 2012b) assume instead that labor is fired and rehired every period. I maintain that assumption here because it allows me to write a second-generation EBC2 model that is close to first-generation EBC1 models and to the canonical RBC model. Farmer (2013a) develops a model that relaxes this assumption and shows that nothing of substance hinges on the simplification.

8. Blanchard and Summers (1986, 1987) argue that unemployment is highly persistent and that persistence should be modeled by a dynamical system that displays hysteresis. Hysteresis means that a small perturbation of the initial conditions leads to a similar perturbation of the eventual steady state. In a system that displays hysteresis, the equilibrium is path-dependent.

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