Animal Spirits, Persistent Unemployment and the Belief Function

Roger E.A. Farmer[1]
Department of Economics, UCLA
8283 Bunche Hall
Box 951477
Los Angeles CA 90095-1477
rfarmer@econ.ucla.edu

First Version: July 2010
This version: October 31, 2010

[1]This paper was prepared for the "Microfoundations for Modern Macroeconomics Conference" hosted by Columbia University's Center on Capitalism and Society, November 19th - 20th, 2010 in New York City. I wish to thank Ned Phelps for inviting me to write the paper and the National Science Foundation for funding my research with grant 0720839.

Abstract

This paper presents a theory of the monetary transmission mechanism in an *old-Keynesian* model with multiple equilibrium unemployment rates. The model has two equations in common with the new-Keynesian model; the optimizing IS curve and the policy rule. It differs from the new-Keynesian model by replacing the Phillips curve with a *belief function* to determine expectations of nominal income growth. I estimate the new and old-Keynesian models using U.S. data and I show that the old-Keynesian model fits the data better than its new-Keynesian competitor.

1 Introduction

This paper provides an interpretation of persistence in the unemployment rate that draws from two central ideas in Keynes' *General Theory* (1936). The first is that any unemployment rate can persist as an *equilibrium*. The second is that the unemployment rate that prevails is determined by *animal spirits*.

Existing non-classical approaches to economic policy are grounded in new-Keynesian economics, an approach based on the idea that there are frictions that prevent prices from quickly adjusting to their Walrasian levels. In this paper I present a three equation monetary model that provides an alternative to the new-Keynesian representation of the monetary transmission mechanism that is not based on the assumption of sticky prices. This theory, *old-Keynesian economics*, drops the assumption that unemployment converges to a natural rate that is independent of demand management policies.

Old-Keynesian economics differs from the canonical new-Keynesian model by discarding the new-Keynesian Phillips curve and replacing it with a *belief function* that describes how agents form expectations of future nominal income. I have shown in previous work (Farmer, 2008a,b, 2009, 2010a) that any unemployment rate is consistent with a zero profit labor-market equilibrium by providing a microfounded theory of aggregate supply, based on costly search and recruiting.

This paper provides a monetary version of the old-Keynesian model. I fit this model to U.S. data for the period from 1952:Q1 to 2007:Q4 and I compare it to a new-Keynesian model by computing the posterior odds ratio for the two models. I find that the posterior odds overwhelmingly favor the old-Keynesian model and I discuss the implications of this finding for fiscal and monetary policy.

2 The Genesis of the Natural Rate Hypothesis

In 1970 the "Phelps Volume" (Phelps, 1970a) launched an exciting new approach to the microeconomics of employment and inflation theory that was, in the words of Edmund Phelps, "an economics of disequilibrium". That volume collected together a set of papers that provided an intellectual foundation to the *expectations augmented Phillips curve*; the idea that there is a short run trade-off between inflation and unemployment but in the long-run that trade-off disappears and the Phillips curve is vertical.

The Phelps volume helped to solidify an interpretation of Keynesian economics that began with John Hicks (1937) and Alvin Hansen (1936) and was introduced to generations of undergraduates with the third edition of Paul Samuelson's introductory textbook, (Samuelson, 1955). Under this interpretation, unemployment may fall and GDP may increase following a monetary shock because prices are 'sticky'. In the long-run, GDP returns to its trend growth path and unemployment returns to its natural rate.

The papers in the Phelps volume aimed to provide a microfoundation to these characteristics of the monetary transmission mechanism. Armen Alchian (1970) talked of information costs, Charles Holt (1970) discussed the role of unions in wage setting and Edmund Phelps (1970b) explored a model of staggered wage setting. These papers, and all of the others in this remarkable collection, provided an intellectual foundation that evolved in the 1980s into new-Keynesian economics.

The idea that demand management polices cannot influence unemployment in the long run became known as the natural rate hypothesis (NRH). The papers by Edmund Phelps (1968) and Milton Friedman (1968), which formulated that hypothesis, were bold, innovative steps that challenged the 1960s Keynesian orthodoxy of an exploitable trade-off between inflation and unemployment.

But although the natural rate hypothesis is intellectually appealing, it soon became apparent that the simple form of the NRH is inconsistent with an unemployment rate that has highly persistent long-run movements. Edmund Phelps himself has addressed this problem in his book on structural slumps (Phelps, 1994) where he argues that many of the determinants of the natural rate of unemployment can be influenced by economic policy. In this paper I present an alternative explanation of persistent unemployment based on the two central ideas from Keynes' *General Theory* that I alluded to in the introduction to this paper. Any unemployment rate can persist as an *equilibrium* and the unemployment rate that prevails is determined by *animal spirits.*

3 New-Keynesian Economics

There is a widely held view amongst economic policy makers that monetary policy can influence real economic activity in the short-run but in the long run all changes in the quantity of money are reflected in prices. This view was nicely summarized in David Hume's (1777) essay Of Money.

In a large and growing literature on new-Keynesian economics,researchers have distilled Hume's view into a theory that has become known as new-Keynesian economics.[1] In this paper I will refer frequently to the *canonical new-Keynesian model*. By this, I mean a three equation monetary model, based on dynamic stochastic general equilibrium theory, that encapsulates the main insights of David Hume's essay.

The new-Keynesian model is described by equations (1) – (3).

$$ay_t = aE_t[y_{t+1}] - i_t + E_t[\pi_{t+1}] + \rho + z_t^d, \tag{1}$$

[1] New-Keynesian economics has much more in common with the quantity theory of money than it does with the economics of Keynes' *General Theory*. Since the misnomer is by now well established I will continue to use the term new-Keynesian economics in this essay in the same way that it used elsewhere in the literature.

$$i_t = \lambda \pi_t + \mu y_t + b, \tag{2}$$

$$\pi_t = \beta E_t [\pi_{t+1}] + \phi (y_t - z_t^s). \tag{3}$$

Here, y_t is the log of GDP, π_t is inflation, i_t is the interest rate and z_t^d, and z_t^s are demand and supply shocks. $E[\cdot]$ is the expectations operator and I assume that expectations are rational and hence expectations are taken with respect to an equilibrium probability measure. a is the intertemporal elasticity of substitution, ρ is the rate of time preference, λ, μ and b are policy parameters and β and ϕ are parameters of the Phillips curve.

Equation (1) is an optimizing IS curve that is derived from a representative agent's Euler equation. Equation (2) is the Taylor rule (Taylor, 1999), a description of central bank policy that John Taylor has argued is a good description of how the Fed behaves in practice and Equation (3) is the new-Keynesian Phillips curve. Derivations of the new-Keynesian Phillips curve, based on Guillermo Calvo's (1983) elegant model of sticky prices, can be found in the books by Galí (2008) or Woodford (2003) and in the survey paper by Clarida, Galí, and Gertler (1999).

As long as policy is active in the sense that the central bank responds to inflation by raising the expected real interest rate, (Leeper, 1991), the new-Keynesian model has a unique rational expectations equilibrium given by equations (4)–(6),

$$y_t = \alpha_y + \alpha_{yd} z_t^d + \alpha_{ys} z_t^s, \tag{4}$$

$$\pi_t = \alpha_\pi + \alpha_{\pi d} z_t^d + \alpha_{\pi s} z_t^s, \tag{5}$$

$$i_t = \alpha_i + \alpha_{id} z_t^d + \alpha_{is} z_t^s, \tag{6}$$

where the coefficients $\alpha_{i,j}$ are functions of the structural parameters. These equations are derived by imposing the assumption that a rational expectations equilibrium is a stationary probability measure that describes how endogenous variables respond to the state variables and to random shocks and by using the stationarity assumption to eliminate the influence of unstable roots from equations (1) – (3).

4 Five Problems with New-Keynesian Economics

In this section I am going to raise five objections to the canonical new-Keynesian model. 1) It assumes that prices are implausibly sticky: 2) It cannot explain inflation persistence in data: 3) There is no unemployment in the model: 4) The welfare costs of business cycles are trivial: 5) The model cannot explain bubbles and crashes.

4.1 Prices are implausibly sticky

The core of new-Keynesian economics is the new-Keynesian Phillips curve, Equation (3). There are two main ways that this equation has been derived in the literature: Both involve variants of a cost of changing nominal prices. Rotemberg (1982) assumes a quadratic cost of price adjustment and Tak Yun (1996), drawing on work by Guillermo Calvo (1983), assumes that a fixed fraction of agents reset their prices in each period.

Studies of price change in large micro data sets have been used to evaluate the new-Keynesian assumption that prices are sticky. The evidence from this literature suggests that price stickiness at the micro level is not large enough to explain the degree of price stickiness needed for the new-Keynesian model to explain the aggregate data. In their Handbook survey, Klenow and Malin (2010) conclude that

> Prices change quite frequently, although much of this flexibility is associated with price movements that are temporary in nature. Even if all short-lived prices are excluded, however, the resulting nominal stickiness, by itself, appears insufficient to account for the sluggish movement of aggregate prices.

Klenow and Malin suggest that a coordination failure may cause agents to act in ways that make aggregate prices more sluggish than individual prices. That is a possible explanation of the disparity between the micro and macro evidence: but it is not an assumption of the canonical new-Keynesian model.[2]

4.2 Inflation is persistent

Macroeconomic evidence from vector autoregressions suggests that prices move less than one would expect based on the Walrasian market clearing model. In addition, *inflation* is highly persistent in U.S. data. In vector autoregressions using data from the period from 1950 through 1980, lagged inflation is the only significant predictor of current inflation. For that period, inflation is well described by a random walk. In the period after 1980 inflation is less persistent but there is still a significant role for lagged inflation in reduced form representations of the data.

The new-Keynesian model can explain sticky prices but it cannot explain persistence in the inflation rate. It is possible to modify the model by adding habit persistence to preferences and a lagged interest rate to the policy rule. These modifications imply that the lagged interest rate and lagged GDP should be included in the reduced form of the model as state variables and that they help explain persistence in GDP and the interest rate. It is much harder to find a plausible modification to the new-Keynesian model that gives a role to lagged inflation whilst maintaining the core assumption of rational agents.

Fuhrer and Moore (1995) write down a contracting model that can lead to inflation persistence. While the Fuhrer-Moore modification can produce a role for lagged inflation in the Phillips curve, it is not clear why the contracts they consider would be signed by rational agents, a point first made by

[2] Some progress has been made on models of rational inattention (Sims, 2010), and the related concept of sticky information (Mankiw and Reis, 2002), but neither of these ideas has yet been fully incorporated into new-Keynesian theory.

Robert Barro (1977) in his critique of the first generation of contracting papers (Fischer, 1977).

4.3 There is no unemployment

Since the new-Keynesian model has a classical core, the canonical model does not explain unemployment. The new-Keynesians accepted the arguments of Robert Lucas and Leonard Rapping (1970) that the labor market should be modeled as an equilibrium in the classical sense where the supply of labor is equal to the demand for labor at the observed wage.

Gertler and Trigari (2009) have added unemployment to the new-Keynesian model and Gertler, Sala, and Trigari (2008) find that the model augmented in this way can explain the data about as well as similar new-Keynesian models. The version of the new-Keynesian model that they develop is similar to the old-Keynesian theory I describe in Section 5. Their model is closed with a wage equation based on long-term contracts. Because this equation leads to a unique unemployment rate in the long run, their model preserves the natural rate hypothesis. My own work drops the wage equation and replaces it with a model of self-fulfilling beliefs.

4.4 Welfare costs of business cycles are small

According to the new-Keynesian model, business cycles are caused by demand and supply shocks that generate autocorrelated movements of output and GDP around a social planning optimum.[3] The equations of the model are derived from an equilibrium business cycle model with added frictions such as money in the utility function or the Calvo (1983) pricing rule. These

[3] This position is sometimes modified to recognize that the steady state of the model may deviate from the social planning optimum because of tax distortions or monopolistic competition. These modifications do not alter the fact that the welfare costs of business cycles in this model are trivial.

frictions prevent the equilibrium of the model from adjusting quickly to the social planning optimum.

But although frictions could potentially explain large welfare losses, calibrated models fail to deliver on this promise. When the model is calibrated to realistic parameter values, Galí, Gertler, and Salido (2007) have shown that the magnitude of the distortions caused by new-Keynesian frictions is comparable to the numbers found by Robert Lucas (1987) in his study of equilibrium business cycle models. These distortions can be responsible for at most one tenth of one percent of steady state consumption.

The fact that a model based on the equilibrium assumption cannot generate large welfare losses would not have surprised James Tobin. Around the time that Ned Phelps and Milton Friedman formulated the natural rate hypothesis, Tobin quipped that: "it takes a lot of Harberger triangles to fill an Okun gap". In other words, the distortions caused by what today we would refer to as *wedges* (Chari, Kehoe, and McGrattan, 2007) are small relative to large movements in the unemployment rate during major recessions.

4.5 The model cannot explain bubbles and crashes

In *The General Theory,* Keynes stressed the importance of animal spirits as an independent driving force in the economy. In his view, the stock market crash of 1929 *caused* the Great Depression. New-Keynesian economics does not have room for that idea. The 2008 financial crisis is widely thought to have been triggered by the bursting of a bubble; a large inflation in asset prices that was not associated with fundamentals. The new-Keynesian model cannot explain an asset price bubble because equilibria in the model are driven by fundamentals.

The fact that Keynes asserted that non-fundamental market movements caused the Great Depression is not evidence for or against that proposition. And the fact that many economists assert that the 2008 crash was caused by the collapse of a bubble does not make it so. To compare the bubble hypothesis with alternative explanations, we need a theory of bubbles that is consistent with microeconomic principles in which the bubble theory can be consistently articulated and compared with the alternatives.

What is needed to advance our understanding, is a model of markets that preserves no-arbitrage pricing but allows for independent movements in asset prices. The old-Keynesian model does this. In the model, beliefs are driven by an independent fundamental shock and asset values can take on many different values in equilibrium. In this environment, the collapse of an asset bubble is fully consistent with rational behavior on the part of forward looking agents and that collapse can have devastaing effects on unemployment and on economic welfare..

4.6 Should my objections to the new-Keynesian model be taken seriously?

A defender of the new-Keynesian approach will object that I am setting up a straw man and they will claim that all of the problems that I mention are well known and have been addressed in the literature. Although there is a sense in which that is correct, the defenses that are necessary to support the theory against my five objections are, in my view, a sign of what Imre Lakatos (1978) referred to as a degenerative research program.

In 1543, Copernicus introduced the sun centered theory of the solar system. Ptolemy's theory, which preceded Copernicus, placed the earth at the center of the universe and that theory was initially better at explaining the motion of the planets than that of Copernicus. But Ptolemy's theory was successful only through repeatedly more improbable modifications to the concentric circles that described the orbits of the planets (Kuhn, 1957).

The modifications that allow new-Keynesian economics to explain the data are similar to the addition of concentric circles used to allow Ptolemy's theory to explain new data. When new evidence contradicts a pillar of the new-Keynesian theory, a piece is tacked on to account for the anomaly . A subset of irrational agents accounts for bubbles as in Kyle (1985). A concern for relative wages accounts for inflation persistence as in Fuhrer and Moore (1995). Wage contracting accounts for persistent unemployment as in Gertler and Trigari (2009). These modifications have been relatively successful at explaining data from the 1980s and 1990s. The 2008 financial crisis presents a major new challenge.

The new-Keynesian model is not a convincing theory of major recessions. During the Great Depression unemployment remained above 10% for a decade and in the 2008 financial crisis it has remained above 8% for twenty months in a row with no sign of a return to more normal levels as of November of 2010. We need a more radical departure from classical economics that can explain persistently high unemployment. Old-Keynesian economics *can* explain why high unemployment persists and, as I will demonstrate below, it can also account for variations in output and inflation in more normal times.

5 Keynesian Economics Without Sticky Prices: (Old Keynesian Economics)

Keynes' *General Theory* (1936) argued that persistent unemployment is a pervasive feature of market economies. In modern language we would describe that idea as a possibility for the economy to display a continuum of steady state unemployment rates. That idea was replaced by post-war interpreters of Keynes who appended the Phillips curve to the IS-LM model and created a synthesis of Keynesian and classical ideas that evolved into the current mainstream new-Keynesian paradigm. In new-Keynesian economics there is a unique steady state unemployment rate: the natural rate of unemployment.

This section describes an alternative theory of aggregate employment; I call this old-Keynesian economics.[4] Old-Keynesian economics introduces the

[4] The theory is explained in more depth in Farmer (2008a,b, 2009, 2010a). The clos-

idea that high unemployment can persist as a steady state equilibrium and it selects the equilibrium by introducing beliefs as an independent driving variable. The theory of employment I will describe is based on the economics of costly search that first appeared with papers by Armen Alchian (1970) and Dale Mortensen (1970) in the Phelps Volume published forty years ago. Here I will sketch the main properties of the old-Keynesian theory of unemployment. In Section 6 I will use this theory to present an alternative to the new-Keynesian theory of the monetary transmission mechanism.

5.1 Technology in the old-Keynesian model

Old-Keynesian economics explains unemployment as an equilibrium in an economy in which there are two different technologies. A production technology for producing goods from labor and capital and a search technology for moving workers between leisure and productive activity.

Aggregate output is produced from the production technology

$$\bar{Y}_t = \bar{K}_t^{\alpha} \bar{X}_t^{1-\alpha}, \tag{7}$$

where $\bar{X}_t$ is labor used in production, $\bar{K}_t$ is capital, and a bar over a variable denotes the economy wide average.

Workers are moved from home to work using a search technology. This takes the form

$$\bar{L}_t = \bar{H}_t^{1/2} \left(\Gamma \bar{V}_t\right)^{1/2}, \tag{8}$$

where Γ is a parameter, $\bar{V}_t$ is the number of workers assigned to the task of recruiting and $\bar{H}_t$ is the measure of workers searching for a job. $\bar{V}_t$, $\bar{L}_t$ and

est precedent to what I have called old-Keynesian economics is the hysteresis theory of Blanchard and Summers (1986, 1987) in which the unemployment rate is path dependent because of insider-outsider behavior in wage bargaining.

$\bar{X}_t$ are constrained by the identity

$$\bar{L}_t \equiv \bar{V}_t + \bar{X}_t. \tag{9}$$

These assumptions are relatively standard in search theory. The main difference from more mainstream approaches is my assumption that firms take the wage and the price as given. Howitt and McAfee (1987) pointed out that this assumption leads to a continuum of unemployment rates in a model with costly search and recruiting. I will exploit this observation to construct a general equilibrium model with many steady state equilibrium unemployment rates.

5.2 Profit maximization

The production technology is operated by a large number of competitive firms, each of which solves the problem

$$\max_{Y_t, K_t, V_t, X_t, L_t} \Pi_t = P_t Y_t - w_t L_t - r_t K_t, \tag{10}$$

$$Y_t \leq K_t^{\alpha} X_t^{1-\alpha}, \tag{11}$$

$$L_t = q_t V_t, \tag{12}$$

$$L_t = X_t + V_t. \tag{13}$$

Firms take P_t, w_t, r_t and q_t as given where q_t is the number of workers that can be hired by one worker assigned to the recruiting department.

At the beginning of time, a measure one of workers look for jobs. Firms put together plans that allocate a fraction V_t/L_t workers to the recruiting department and the remaining X_t/L_t workers to production. To keep the dynamics as close as possible to those of the standard model I assume that the entire workforce is fired at the end of every period and next period, the process begins again.[5]

Substituting (11)–(13) into (10) and defining

$$\Theta_t \equiv \left(1 - \frac{1}{q_t}\right) \tag{14}$$

leads to the reduced form problem

$$\max_{K_t, L_t} \Pi_t = P_t K_t^{\alpha} \left(\Theta_t L_t\right)^{1-\alpha} - w_t L_t - r_t K_t, \tag{15}$$

which has the same first-order conditions as a standard competitive model. These are represented by (16) and (17),

$$(1-\alpha) P_t Y_t = w_t L_t, \tag{16}$$

$$\alpha P_t Y_t = r_t K_t. \tag{17}$$

5.3 Search theory without the Nash bargain

In a classical model, firms and households take prices and wages as given. In the old-Keynesian model they also take the externality Θ_t as given. For every value of Θ_t there is a profit maximizing labor demand decision in which the firm equates the marginal product of labor to the real wage. When output is produced from a Cobb-Douglas technology by competitive firms this leads to Equation (16), the first order condition for choice of labor by firms.

In a standard search model, one appends an additional equation to the model to determine the wage. Typically this is the Nash bargaining as-

[5] This implies that workers are allowed to recruit themselves. This improbable assumption is a convenient way of reducing the dynamics of the model and it considerably simplifies the exposition of the theory. More generally, employment should appear as a state variable governed by the equation

$$\bar{L}_{t+1} = (1-\delta_L) \bar{L}_t + B U_t^{\theta} V_t^{1-\theta}$$

where δ_L, B and θ are parameters and U_t is the unemployment rate.

sumption. When a firm and a worker meet, there is a surplus to be split. The firm would be willing to pay any wage up to and including the worker's marginal product. The worker would accept any wage greater than or equal to their reservation wage. Mortensen and Pissarides (1994) assume that the wage is determined by bargaining over the surplus which is split according to a bargaining weight χ. This is a free parameter which is often chosen to match employment in the search model with the level that maximizes worker utility.

In the old-Keynesian model I do not use the Nash bargaining equation. I assume instead that the externality Θ_t is a variable to be determined by the assumption that the corporate sector produces enough goods to meet aggregate demand. Once Θ_t is determined, the real wage, unemployment and GDP are determined from profit maximizing behavior by firms. In my previous work I showed how to determine Θ_t from the self-fulfilling beliefs of households about the value of wealth. The old-Keynesian model, closed in that way, provides an explanation of aggregate variables in which beliefs are a driving force of business cycles.

6 Animal Spirits and the Belief Function

The new-Keynesian model is popular because it provides a tractable explanation of the data, summarized in the three equation model described in Section (3). In this section I develop an old-Keynesian counterpart to that model. The main difference between the two approaches is that old-Keynesian economics gives a central role to the idea that 'animal spirits' matter. In the new-Keynesian approach, in contrast, expectations are determined by market fundamentals.

In the old-Keynesian model, confidence is an independent driving force that selects the long-run steady state unemployment rate. In my previous work Farmer (2009) I modeled that idea by assuming that households beliefs about asset prices are determined by market psychology. Here I model the evolution of beliefs about nominal GDP by introducing a new fundamental equation; the *belief function*.

Models of self-fulfilling beliefs are often criticized as incomplete theories because they are based on general equilibrium models in which equilibrium is indeterminate. I have argued elsewhere (Farmer, 1993) that this is a mistaken criticism. When a general equilibrium model has multiple equilibria, the theory must be supplemented by an additional equation that resolves the indeterminacy by explaining how people in the model would behave. Standard search models are closed with the Nash bargaining assumption. The old-Keynesian model is closed by a theory of beliefs.

$$ay_t = aE_t\left[y_{t+1}\right] - i_t + E_t\left[\pi_{t+1}\right] + \rho + z_t^d, \tag{18}$$

$$i_t = \lambda\pi_t + \mu y_t + b, \tag{19}$$

$$E_t\left[\pi_{t+1}\right] + \left(E_t\left[y_{t+1}\right] - y_t\right) = \pi_t + \left(y_t - y_{t-1}\right) + z_t^s. \tag{20}$$

Equations (18)–(20) represent a three equation model that is implied by the old-Keynesian theory of aggregate supply. Equations (18) and (19) are identical with equations (1) and (2) of the new-Keynesian model. Equation (20) provides a theory of how agents forecast the future. I call this equation the *belief function*.

If we let p_t be the log of the price level then

$$x_t = p_t + y_t, \tag{21}$$

is the log of nominal GDP. The belief function is equivalent to the assumption that

$$E_t\left[\Delta x_{t+1}\right] = \Delta x_t + z_t^s, \tag{22}$$

where Δ is the difference operator and z_t^s is a fundamental random variable that represents shocks to beliefs. In words, agents believe that the growth rate of nominal GDP follows a random walk.[6]

The belief function is *not* an alternative to the rational expectations assumption. It is an *addition* to it. I still assume that

$$y_t - E_{t-1}[y_t] = w_t^y, \tag{23}$$

and

$$\pi_t - E_{t-1}[\pi_t] = w_t^\pi, \tag{24}$$

where w_t^y and w_t^π are endogenously determined random variables with conditional mean zero.

Agents in the old-Keynesian model form expectations of nominal GDP growth based on their observation of current nominal GDP growth. The belief function provides an anchor to their expectations. Given the belief function, Equation (18), interacts with the policy rule, Equation (19), to determine the realization of inflation and output growth in period t.

7 Long-Run Properties of the Two Models

If one identifies the long-run with the non-stochastic steady state of a model, the steady values of inflation, the interest rate and the deviation of output from trend for the new-Keynesian model are given by the expressions

$$\bar{\pi} = \frac{\phi(\rho - b)}{\phi(\lambda - 1) + \mu(1 - \beta)}, \quad \bar{\imath} = \rho + \bar{\pi}, \quad \bar{y} = \bar{\pi}\frac{(1-\beta)}{\phi}. \tag{25}$$

When $\beta = 1$, these equations simplify to give the approximate steady state solution[7]

$$\bar{\pi} = \frac{\rho - b}{\lambda - 1}, \quad \bar{\imath} = \rho + \bar{\pi}, \quad \bar{y} = 0. \tag{26}$$

[6]Since I have defined y_t as the log deviation of GDP from trend, the drift component of the random walk has been removed in the detrending operation.

[7]This is a good approximation since β represents the discount rate which is close to 1 in practice.

These expressions demonstrate that, in the new-Keynesian model, the central bank can influence inflation through it's choice of b; but the steady state deviation of GDP from trend is equal to zero. This implies that demand management policy cannot affect real economic activity in the long-run and it is a direct corollary of the natural rate hypothesis, stated in terms of the output gap, y.

The expressions for steady state variables given in (25) are found by solving the steady state versions of equations (1) – (3). In contrast, the old-Keynesian model has only two steady state equations to determine three steady state variables since $\bar{y}$, $\bar{\pi}$ and $\bar{\imath}$ all cancel from Equation (20). This leaves the expressions

$$\bar{\imath} - \rho + \bar{\pi}, \tag{27}$$

$$\bar{\imath} = b + \lambda\bar{\pi} + \mu\bar{y}, \tag{28}$$

to determine $\bar{y}, \bar{\pi}$ and $\bar{\imath}$.

7.1 Why the Old-Keynesian model is a good description of the data

The reduced form of the old-Keynesian model is a cointegrated vector autoregression. In the three dimensional space spanned by inflation, the output gap and the interest rate, the model pins down a one dimensional manifold that the data lines up around. Fed policy can decide how movements in nominal GDP are divided between movements in real output and inflation, but it cannot stabilize all three variables at the same time. This predicted theoretical behavior describes the data well. The interest rate, inflation and the deviation of GDP from trend are all highly autocorrelated and one cannot reject the hypothesis that each series is individually non-stationary but the series are connected by two cointegrating vectors.[8]

[8] y_t represents the deviation of y_t from a linear trend and although this variable does not have a systematic drift component it is has a root close to or equal to 1. The current

7.2 Why the new-Keynesian model does not support policy activism

In the new-Keynesian model, the variable z_t^s represents the time varying value of potential output. A crude form of the natural rate hypothesis would assert that z_t^s is white noise. If this were true, the deviation of GDP from trend would be quickly mean reverting, a property that is strongly contradicted in the data. For the new-Keynesian model to fit the facts, z_t^s must be highly correlated. This implies that persistent unemployment is a consequence of permanent shifts in supply side factors such as population demographics or industrial composition. In other words, new-Keynesian economics implies that there is nothing that demand management policy can do to alleviate the very high unemployment that often follows a major recession like the 2008 financial crisis.

8 Data Used in this Study

How well do the old and new-Keynesian models explain the data? To address this question I used full information Bayesian methods to estimate both models on U.S. time series data from 1952:Q1 through 2007:Q4. I excluded data from the 2008 financial crisis since the interest rate, for that period, was constrained by the zero lower bound.[9] I used the treasury bill rate, the CPI inflation rate and a measure of the percentage deviation of real GDP from a

paper draws heavily on joint work with Andreas Beyer, (Beyer and Farmer, 2007). They show that the behavior of inflation, the interest rate and unemployment are well described by a cointegrated VAR.

[9] In 1979:Q3, Paul Volcker took over as Chairman of the Fed and for the period from 1979:Q3 through 1982:Q4, the Fed is known to have used an operating procedure in which it targeted the rate of growth of the money supply. To check for robustness of my estimates I estimated the two models over the full sample and over two separate sub-periods. The first sub-period was from 1952:Q1 through 1979:Q3 and the second from 1983:Q1 through 2007:Q4. The estimates for the sub-periods gave similar results to the full sample results reported here.

linear time trend. These data are graphed in Figure 1.

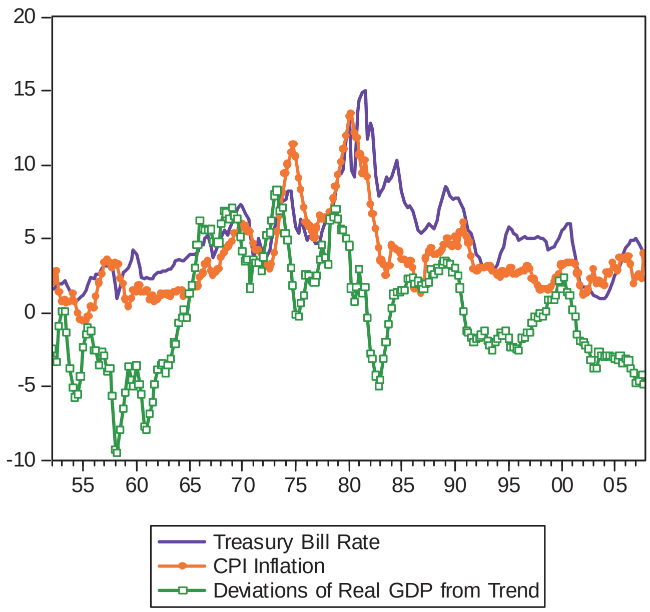


Figure 1: Data Used in the Study

For comparison with earlier studies, (Lubik and Schorfheide, 2004), I allowed for autocorrelated demand and supply shocks in the new-Keynesian model and I allowed for slow adjustment of the policy rule by including the lagged interest rate in this equation. I also added an autocorrelated policy disturbance. This specification of the new-Keynesian model leaves residuals that are approximately white-noise.[10] For each model I replaced the policy rule, Equations (2) and (19) by

$$i_t = b + (1 - \eta)(\lambda \pi_t + \mu y_t) + \eta i_{t-1} + z_t^i, \tag{29}$$

[10] I use the word 'approximately' loosely. The correlogram of each series displays little or no autocorrelation but there is fairly strong evidence of heteroskedasticity. The means of each series are zero by construction.

$$z_t^i = \lambda^i z_{t-1}^i + \varepsilon_t^i. \quad (30)$$

In practice, I found that the constant b in the policy rule was insignificantly different from zero in both specifications. For both models, I allowed z_t^d and z_t^s to follow the autocorrelated processes

$$z_t^d = \lambda^d z_{t-1}^d + \varepsilon_t^d, \quad (31)$$

$$z_t^s = \lambda^s z_{t-1}^s + \varepsilon_t^s, \quad (32)$$

and the innovations ε_t^d, ε_t^s and ε_t^i were allowed to be correlated. For the old-Keynesian model the parameter η in the policy rule and the autocorrelation parameter λ^s was insignificant and I set those parameters to zero and left them out of the results reported below.

9 Empirical Results

To estimate the two models I computed the likelihood function from the Kalman filter and used Markov-Chain Monte Carlo simulations to draw from the posterior. In Table 1 I report the log data density and the posterior odds ratio for the two models.

Table 1: Model Comparison of NK and OK Models

Sample 1952.1:2007.4	Log Data Density
New-Keynesian Model	2324.10
Old-Keynesian Model	2329.25
Posterior Odds Ratio of new versus old Keynesian Model	0.0058
	Results from 10^5 draws, MCMC

The posterior odds ratio for these models is equal to 0.0058. This is a number that can vary between 0 and ∞ where 0 means that the data overwhelmingly supports the old-Keynesian model over the new-Keynesian model and ∞ means that it overwhelmingly rejects it. The reported value of 0.0058 is strong evidence in favor of the old-Keynesian interpretation of the facts.

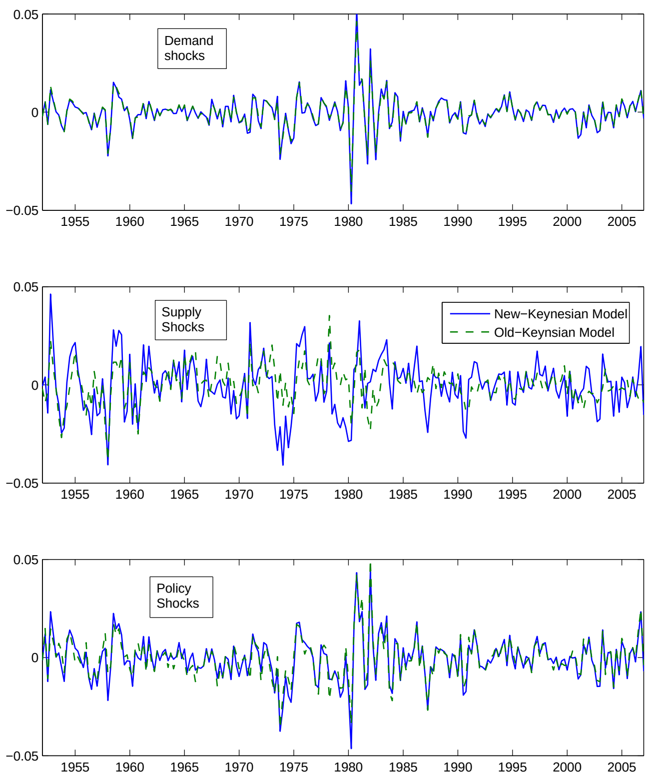


Figure 2: Estimated Residuals from the Two Models

The estimates of the smoothed residuals from the Kalman filter, $\varepsilon_t^d, \varepsilon_t^s$ and ε_t^i are graphed in Figure 2. Because z_t^s enters the old-Keyensian and new-Keynesian models with a different sign, I have graphed the negative of ε_t^s for the old-Keynesian model. The model assumes that these shocks are normal random variables with constant variance. The constant variance assumption appears to be violated for the period from 1979Q3 to 1982Q4, when the Fed is known to have followed a different operating procedure. The demand shocks and the policy shocks for this period are much larger than at the beginning and end of the sample. Histograms of the smoothed residuals are plotted in Appendix B, Figures B1 – B3.

Graphs of the prior and posterior parameter distributions are reported in Appendix A. Figure A1–A4 plot the prior and posterior parameter estimates for the two models. These figures suggest that the parameters λ, μ and λ^d are not identified in the new-Keynesian model. λ is the policy response to inflation, μ is the response to GDP and λ^d is the autocorrelation of the demand shock. Lack of identification is reflected in the fact that the posterior distributions for these parameters are equal to the priors. In contrast, the parameters of the old-Keynesian model are all strongly identified.[11]

10 The Implications of these Results for Economic Policy

What should one take away from these results? I do not want to overstate the evidence in favor of the old-Keynesian model since one should not read too much into estimates based on a single data set. As Sims (1980) pointed out, identification in rational expectations models is fragile.[12] An example of just how fragile is provided by Beyer and Farmer (2008), who show that there is an equivalence between new-Keynesian rational expectations models with

[11] I also tested the random walk assumption by modifying Equation (22) as

$$E_t[\Delta x_{t+1}] = \phi \Delta x_t + z_t^s, \qquad (33)$$

and by allowing z_t^s to be autocorrelated. The data strongly favored the restriction $\phi = 1$ and $\lambda^s = 0$ and I imposed those restrictions in the reported estimates.

[12] I am certain that a perseverant new-Keynesian would be able to find a variant of the new-Keynesian model that reverses the conclusion I have presented in this paper.

a unique determinate equilibrium and indeterminate monetary models of the kind studied by Benhabib and Farmer (2000), that are driven by self-fulfilling beliefs.[13]

10.1 How the new-Keynesian model explains persistent unemployment

Suppose the reader has a strong prior that the new-Keynesian model is correct and that the unemployment rate and the output gap really are reverting to unique fundamental values. Suppose further that the Phillips curve is the right way to close a three equation model, as opposed to the old-Keynesian belief function. How does that influence one's beliefs about the role of active policy to combat a recession?

In order to explain the data, the new-Keynesian model must attribute much of the persistence in the unemployment rate to movements in the natural rate of unemployment. In that model, the output gap is persistent because the supply disturbance z_t^s, has a root λ^s that is close to 1. The median of the posterior of λ^s is 0.985 and 95% of its probability mass is above 0.97.

The fact that z_t^s has close to a unit root is a problem for new-Keynesians who favor policy activism. z_t^s does not represent demand disturbances that cause the unemployment rate to be away from its natural rate because prices are sticky. It represents movements of the natural rate itself. A new-Keynesian can explain persistence in the unemployment rate only by arguing that the new higher unemployment rate following a financial crisis is due to a structural change. It is a short step to arguing that the natural unemployment rate is efficient and that the market should be left to recover on its

[13] One way to tell two models apart is to experiment by changing the policy rule. Beyer and Farmer (2003) suggest that evidence can be accumulated by comparing periods over which policy rules changed but, to date, there have not been good examples of conclusive policy experiments of this kind.

own. When λ_t^s is 0.985 as my estimates suggest, it would take 45 years for the natural rate of unemployment rate to return half way to its mean.

10.2 How the old-Keynesian model explains persistent unemployment

In contrast, if the old Keynesian model is true, the output gap, inflation and the interest rate are random walks with drift. The unit root in the data arises from drift in the money value of GDP caused by self-fulfilling shifts in expectations of future aggregate demand. The Fed can decide how much of the drift in nominal GDP causes an increase in inflation and how much causes an increase in the output gap. But it cannot independently stabilize both variables. But although the old-Keynesian world does not leave room for the Fed to permanently lower unemployment; it does not imply that the unemployment rate that prevails is efficient.

The old-Keynesian model is eclectic in its implications for fiscal policy. In the three-equation version of the old-Keynesian model that I presented here, fiscal policy appears as a component of the demand shock z_t^d. It is consistent with the results presented here for z_t^d to be independent of fiscal policy. It is also possible that z_t^d has a non-zero mean that is influenced by tax and expenditure policies. I did not allow for that possibility in this study since the mean of z_t^d and the rate of time preference ρ cannot be separately identified. What is certain is that, if fiscal policy *is* effective then, the old-Keynesian model provides support for its use in times of high unemployment to increase aggregate demand.

But although fiscal policy *might* be effective, I am skeptical that it is the best solution to the current crisis. In Farmer (2010b), I showed that the old-Keynesian model can be a correct description of what goes wrong in a financial crisis, but that need not lead one to support fiscal policy as a remedy for inefficiently high unemployment. That depends on the determinants of aggregate demand. If one believes, as I do, that consumption depends on wealth and not on income then fiscal policy may not be the panacea that its proponents claim. Instead, a variant of monetary policy in which the Fed directly stabilizes a stock market index could provide a more effective way of restoring confidence in the markets and moving the economy back towards a full employment equilibrium.

11 Conclusion

Forty years ago the Phelps volume gave us a new way of thinking about the relationship between inflation and unemployment. That collection contained the seeds of several important research programs that followed. Lucas and Rapping (1970) provided the genesis of new-classical economics by showing how to model employment as an equilibrium phenomenon. Armen Alchian (1970) and Dale Mortensen (1970) laid the foundation for a search theory of unemployment that was rewarded with Nobel prizes for search theory in 2010 to Peter Diamond, Dale Mortensen and Chris Pissarides. In the same volume Edmund Phelps (1970b) gave us the natural rate hypothesis.

In this paper I hope to have stirred some new thinking about unemployment and inflation. The relationship we have observed in data between inflation and unemployment does not arise from sticky prices adjusting to disequilibrium. It arises from the interaction of demand and supply shocks in a world where the forecasts made by households and firms have real consequences for what happens in the marketplace. Confidence matters and the role of confidence is captured by the belief function; the old-Keynesian replacement for the Phillips curve.

My ideas were hugely influenced by the papers in the Phelps volume. But they have also been hugely influenced by current national and global events. The dominant empirical fact of the 1970s was the emergence of stagflation. Arguably, it was that fact that led Milton Friedman and Edmund Phelps to argue that there is no long-run trade-off between inflation and unemployment. The theory sketched here preserves the idea that there is no long-run trade-off between inflation and unemployment. But the absence of a Phillips curve does not imply that unemployment is efficient; nor does it imply that we must accept persistently high unemployment as the cost of living in a market economy.

Appendix A: Parameter Estimates

Figures A1–A4 present prior and posterior distributions for the two models. In each case I used Markov-Chain Monte-Carlo methods to draw 200,000 times from the posterior and I discarded the first 100,000 draws. The dashed line in each case is the maximum likelihood estimate. The dark curve is the posterior parameter estimate and the light curve is the prior.

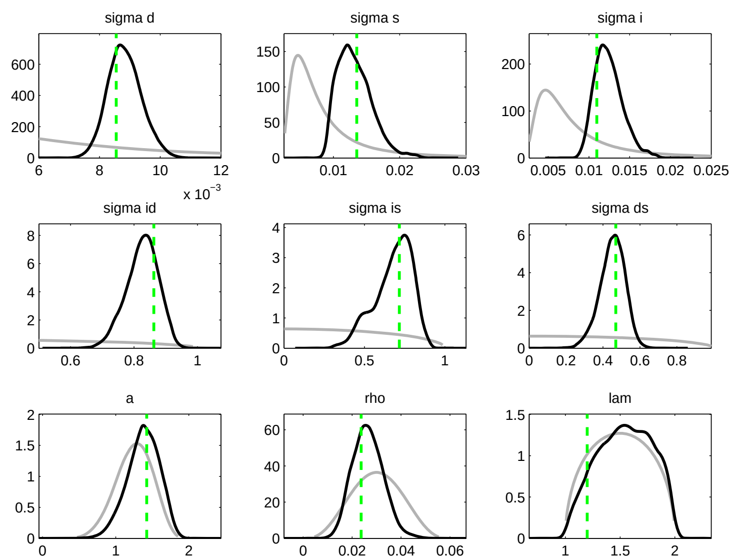


Figure A1: Parameter Estimates from the New-Keynesian Model

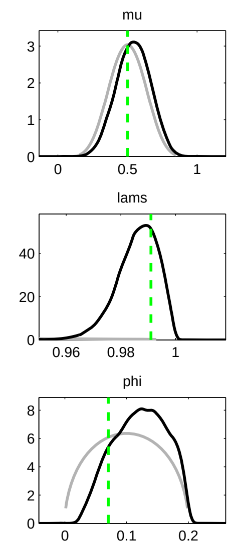


Figure A2: Parameter Estimates from the New-Keynesian Model

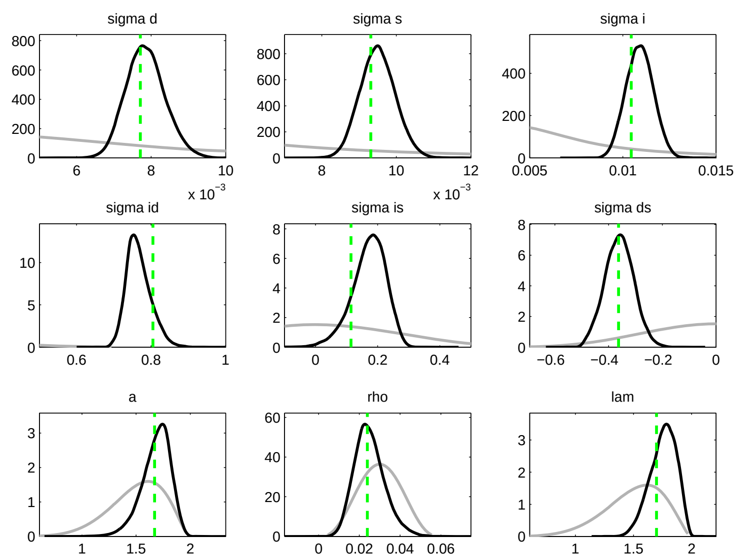


Figure A3: Parameter Estimates from the Old-Keynesian Model

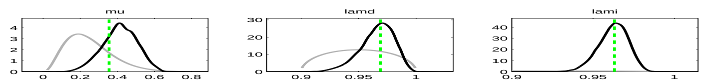
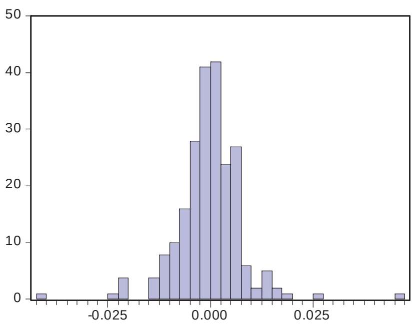


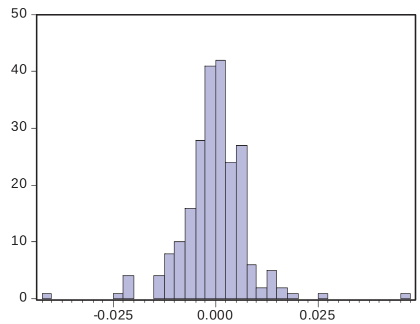
Figure A4: Parameter Estimates from the Old-Keynesian Model

A Appendix B: Properties of the Estimated Residuals



New Keynesian Demand Shock

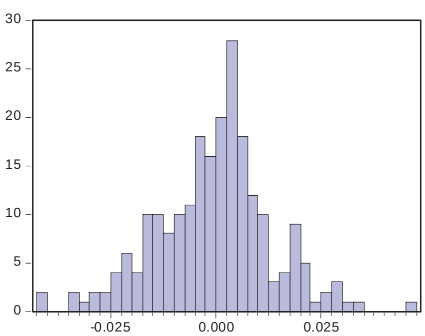
Std. Dev.	0.008007
Skewness	0.165033
Kurtosis	10.68725
Jarque-Bera	552.5592
Probability	0.000000



Old Keynesian Demand Shock

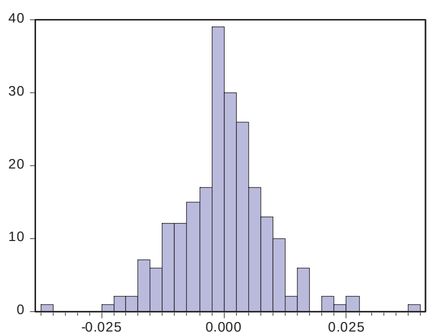
Std. Dev.	0.008007
Skewness	0.165033
Kurtosis	10.68725
Jarque-Bera	552.5592
Probability	0.000000

Figure B1: Distribution of Demand Residuals



New Keynesian Supply Shock

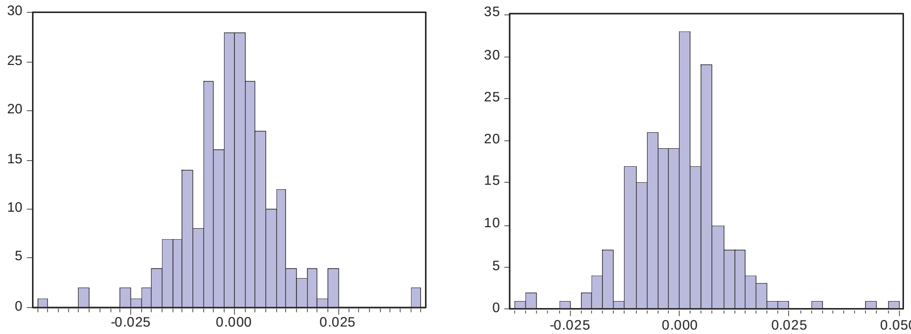
Std. Dev.	0.013754
Skewness	-0.084461
Kurtosis	3.579771
Jarque-Bera	3.403576
Probability	0.182357



Old Keynesian Supply Shock

Std. Dev.	0.009292
Skewness	0.186125
Kurtosis	4.823697
Jarque-Bera	32.33476
Probability	0.000000

Figure B2: Distribution of Supply Residuals



New Keynesian Policy Shock

Std. Dev.	0.011307
Skewness	-0.050715
Kurtosis	5.844722
Jarque-Bera	75.62549
Probability	0.000000

Old Keynesian Policy Shock

Std. Dev.	0.010731
Skewness	0.369629
Kurtosis	6.376663
Jarque-Bera	111.5180
Probability	0.000000

Figure B3: Distribution of Policy Residuals

References

ALCHIAN, A. A. (1970): "Information Costs, Pricing, and Resource Unemployment," in *Microeconomic Foundations of Employment and Inflation Theory*, ed. by E. S. Phelps. Norton, New York.

BARRO, R. J. (1977): "Long-Term Contracting, Sticky Prices and Monetary Policy," *Journal of Monetary Economics*, 3, 5–31.

BENHABIB, J., AND R. E. A. FARMER (2000): "The Monetary Transmission Mechanism," *Review of Economic Dynamics*, 3(3), 523–550.

BEYER, A., AND R. E. A. FARMER (2003): "Identifying the Monetary Transmission Mechanism Using Structural Breaks," *European Central Bank Working Paper Series, No. 275*.

——— (2007): "Natural Rate Doubts," *Journal of Economic Dynamics and Control*, 31(121), 797–825.

——— (2008): "What We Don't Know About the Monetary Transmission Mechanism and Why We Don't Know It," *Macroeconomic Dynamics*, 12(S1), 60–74.

BLANCHARD, O. J., AND L. H. SUMMERS (1986): "Hysterisis and the European Unemployment Problem," in *NBER Macroeconomics Annual*, vol. 1, pp. 15–90. National Bureau of Economic Research.

——— (1987): "Hysterisis in Unemployment," *European Economic Review*, 31, 288–295.

CALVO, G. A. (1983): "Staggered Prices in a Utility Maxmimizing Model," *Journal of Monetary Economics*, 12(November), 383–398.

CHARI, V. V., P. KEHOE, AND E. MCGRATTAN (2007): "Business Cycle Accounting," *Econometrica*, 75(3), 781–836.

Clarida, R., J. Galí, and M. Gertler (1999): "The Science of Monetary Policy: A New Keynesian Perspective," *Journal of Economic Literature*, 37(December), 1661–1707.

Farmer, R. E. A. (1993): *The Macroeconomics of Self-Fulfilling Prophecies*. (1999) MIT Press, Cambridge, MA, second edn.

——— (2008a): "Aggregate Demand and Supply," *International Journal of Economic Theory*, 4(1), 77–94.

——— (2008b): "Old Keynesian Economics," in *Macroeconomics in the Small and the Large*, ed. by R. E. A. Farmer, chap. 2. Edward Elgar, Cheltenham, UK.

——— (2009): "Confidence, Crashes and Animal Spirits," *NBER WP no. 14846*.

——— (2010a): *Expectations, Employment and Prices*. Oxford University Press, New York.

——— (2010b): "How to Reduce Unemployment: A New Policy Proposal,," *Journal of Monetary Economics: Carnegie Rochester Conference Issue*, 57(5), 557–572.

Fischer, Stanley, S. (1977): "Long-term contracts, rational expectations and the optimal money supply rule," *Journal of Political Economy*, 85, 191–205.

Friedman, M. (1968): "The Role of Monetary Policy," *American Economic Review*, 58(March), 1–17.

Fuhrer, J. C., and G. R. Moore (1995): "Inflation Persistence," *Quarterly Journal of Economics*, 440, 127–159.

Galí, J. (2008): *Monetary Policy, Inflation and the Business Cycle*. Princeton University Press, New Jersey.

Galí, J., M. Gertler, and D. L. Salido (2007): "Markups, Gaps and the Welfare Costs of Business Cycle Fluctuations," *The Review of Economics and Statistics*, 89(1), 44–59.

Gertler, M., L. Sala, and A. Trigari (2008): "An Estimated DSGE Model with Unemployment and Staggered Wage Bargaining," *Journal of Money Credit and Banking*, 40(8), 1713–1764.

Gertler, M., and A. Trigari (2009): "Unemployent Fluctuations with Staggered Nash Wage Bargaining," *Journal of Political Economy*, 117(1), 38–86.

Hansen, A. (1936): "Mr. Keynes on Underemployment Equilibrium," *Journal of Political Economy*, 44(5), 667–686.

Hicks, J. R. (1937): "Mr. Keynes and the Classics: A Suggested Interpretation," *Econometrica*, 5(2), 147–159.

Holt, C. (1970): "Job Search, Phillips' Wage Relation, and Union Influence: Theory and Evidence," in *Microeconomic Foundations of Employment and Inflation Theory*, ed. by E. S. Phelps. W. W. Norton, New York.

Howitt, P., and R. P. McAfee (1987): "Costly Search and Recruiting," *International Economic Review*, 28(1), 89–107.

Hume, D. (1777): "Of Money," in *Essays, Moral, Political and Literary, based on the 1777 edition originally published as vol 1. of Essays and treatisies on several subjects*. Liberty Fund, Indianapolis.

Keynes, J. M. (1936): *The General Theory of Employment, Interest and Money*. MacMillan and Co.

Klenow, P. J., and B. A. Malin (2010): "Microeconomic Evidence on Price Setting," Prepared for the Handbook of Monetary Economics.

Kuhn, T. S. (1957): *The Copernican Revolution*. Harvard University Press, Harvard, Mass.

Kyle, A. S. (1985): "Contnuous Auctions and Insider Trading," *Econometrica*, 53, 1315–1335.

Lakatos, I. (1978): *The Methodology of Scientific Research Programmes:*. Cambridge University Press.

Leeper, E. M. (1991): "Equilibria under 'Active' and 'Passive' Monetary and Fiscal Policies," *Journal of Monetary Economics*, 27, 129–147.

Lubik, T. A., and F. Schorfheide (2004): "Testing for Indeterminacy: An Application to U.S. Monetary Policy," *The American Economic Review*, 94(1), 190–219.

Lucas Jr., R. E. (1987): *Models of Business Cycles*. Basil Blackwell, Oxford, UK.

Lucas Jr., R. E., and L. Rapping (1970): "Real Wages, Employment and Inflation," in *Microeconomic Foundations of Employmsnt and Inflation Theory*, ed. by E. S. Phelps. W. W. Norton, New York.

Mankiw, N. G., and R. Reis (2002): "Sticky Information Versus Sticky Prices: A Proposal to Replace the New Keynesian Phillips Curve," *QJE*, 117(4), 1295–1328.

Mortensen, D. T. (1970): "A Theory of Wage and Employment Dynamics," in *Microeconomic Foundations of Employment and Inflation Theory*, ed. by E. S. Phelps. W. W. Norton, New York.

Mortensen, D. T., and C. Pissarides (1994): "Job Creation and Job Destruction in the Theory of Unemployment," *Review of Economic Studies*, 61, 397–415.

PHELPS, E. S. (1968): "Money Wage Dynamics and Labor Market Equilibrium," *Journal of Political Economy*, 76, 678–711.

——— (1970a): *Microeconomic Foundations of Employment and Inflation Theory*. Norton, New York.

——— (1970b): "Money Wage Dynamics and Labor Market Equilibrium," in *Microeconomics of Employment and Inflation Theory*, ed. by E. S. Phelps. W. W. Norton, New York.

——— (1994): *Structural Slumps*. Harvard University Press, Cambridge, Mass.

ROTEMBERG, J. J. (1982): "Sticky Prices in the United States," *Journal of Political Economy*, 90(December), 1187–1211.

SAMUELSON, P. A. (1955): *Economics: An Introductory Analysis (3rd Ed.)*. McGraw Hill.

SIMS, C. A. (1980): "Macroeconomics and Reality," *Econometrica*, 48(January), 1–48.

——— (2010): "Rational Inattention and Monetary Economics," Forthcoming in the Handbook of Monetary Economics.

TAYLOR, J. B. (1999): *Monetary Policy Rules*. University of Chicago Press, Chicago.

WOODFORD, M. (2003): *Interest and Prices: Foundations of a Theory of Monetary Policy*. Princeton University Press, Princeton, N.J.

YUN, T. (1996): "Nominal Price Rigidity, Money Supply Endogeneity, and Business Cycles," *Journal of Monetary Economics*, 37(April), 345–370.