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Search Theories and Aggregate Demand[1]

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Abstract: This paper analyzes search models within a framework of aggregate demand shocks and dominated by uncertainty. In this context, agents are bounded rational while wages are determined by some markup mechanism. Differently from the canonical search theories, unemployment is not only frictional but it can be dynamically determined by an unexpected fall in aggregate demand. Furthermore, by introducing stochastic productivity heterogeneity, a "systemic unemployment", due to both demand and supply aspects, can be generated. The model is cast in dynamic terms, while the main results are obtained by means of simulations.

Keywords: Search theories, Different types of unemployment, Nonlinearity, Bounded rationality, Simulations

JEL Classifications: D83, C15, E24, E32, J63, J64, C15

1. Introduction

There is no doubt that the so called search models àla Mortensen-Pissarides (1994) have made at least two important contributions to economic theory. First of all, they have introduced a quantity mechanism of adjustment in the labor market, along with the dominant price mechanism (see also Farmer, 2010). In fact, the equilibrium in this kind of labor market is actually reached through posting of vacancies. As stressed by Michaillat (2012b, p.18): "If labor demand is above labor supply at the current tightness, the number of vacancies posted by firms is not sufficient to hire the desired number of workers. Consequently firms post more vacancies, which increases tightness". Secondly, they explicitly take into consideration unemployment, which is usually absent in general equilib-

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rium models. Matching frictions can be a very important mechanism driving unemployment and for this reason they can enrich all those models that assume full employment.

Unemployment, although taken into consideration, is bound to remain frictional. In a recent contribution, Michaillat (2012a) has tried to extend the search models beyond the realm of frictional unemployment dealing with a more structural phenomenon called rationing unemployment, i.e. the unemployment that remains in the absence of matching frictions.

If one compares this contribution to the classical work of Malinvaud (1977) on the nature of unemployment, one discovers that this rationing unemployment corresponds to what used to be called "classical unemployment", a kind of unemployment due to excessive wages. However, there is no room for the so called Keynesian unemployment, i.e. unemployment driven by lack of aggregate demand.

The objective of the present paper is to include this possibility and generate unemployment driven by aggregate demand within a search model context. A preliminary step in this direction consists in shifting the attention away from supply shocks while emphasising the role of aggregate demand. In addition, we move away from the symmetry hypothesis by accounting for firms' heterogeneity that contributes to a "systemic" unemployment, due to both aggregate demand and supply aspects.

Specifically, the model considers bounded rational agents that have a medium-run horizon; firms act in an uncertain environment and try to adjust to unforeseen change in demand by changing quantities; wages are sticky and determined by a markup mechanism. The results, mainly illustrated by means of stochastic simulations, show that the model is capable of producing both aggregate demand unemployment and systemic unemployment.

The structure of the paper is the following. In Section 2, the standard labor market rooted in the search model is presented, stressing aspects relating to the presence of uncertainty and wages-income distribution. Demand constraints and a dynamic version of the Beveridge curve, are also formalized in this part. Section 3 discusses the nature of the results obtained. Section 4 extends the model facing the issues of heterogeneity and dynamics, giving rise to the possibility of systemic unemployment. Section 5 concludes and gives some perspectives for future research.

2. Unemployment in a Search Model

Let us suppose that that there is a unit mass of workers in the labor market, (a hypothesis to be abandoned later on) either employed or unemployed and searching for a job. In this context, the following equations are to be considered.

Let us start from unemployment. At the end of period t-1, a fraction *s* of the existing worker-job matches is exogenously destroyed. Workers who lose their jobs can apply immediately for a new one. At the beginning of period t, unemployment is given by:

$$u_t = 1-(1-s)l_{t-1} \quad (1)$$

while the dynamics of employment are given by:

$$l_t = (1-s)l_{t-1} + h_t \quad (2)$$

h_t represents the number of hiring made in period t and generated by a constant-returns matching function relating unemployment and vacancies (v).

$$h_t = \mu u_t^{\eta} v_t^{1-\eta} \quad (3)$$

where μ represents matching efficiency and η the strategic variable in the matching function.

Tightness in the labor market is measured by the ratio between u and v, (θ), while the probability of finding a job is given by:

$$f(\theta_t) = \frac{h_t}{u_t} \tag{4}$$

On the contrary, the vacancy filling probability is given by

$$q(\theta_t) = \frac{h_t}{v_t} \tag{4a}$$

In steady state, inflows to unemployment (l_0) equals outflow (h_0) so that:

$$l_0 = \frac{1}{(1-s) + s/f(\theta_0)} \tag{5}$$

where the subscript 0 indicates steady state values.

If firms post more vacancies v, labor market tightness θ increases and this raises the probability $f(\theta)$ to find a job and therefore increases l.

Equation (5) is also called the steady state Beveridge curve. The steady state frictional unemployment is simply given by:

$$u_0 = 1 - l_0 \tag{6}$$

which clearly depends on frictions (θ_0) and on the exogenous separation rate (s). The challenge consists in finding other kinds of unemployment outside steady state.

2.1 Firms' Behavior and Expectations

Let us assume that the production function is of the type:

$$Y_t = a_t l_t \tag{7}$$

where a_t is productivity.[2] Since firms take prices as given, (real) profits are given by:

$$\pi_t = a_t l_t - W_t l_t - \frac{c a_t}{q(\theta_t)} h_t \tag{8}$$

where the last component represents the cost of hiring, adjusted for the probability of filling a vacancy.

In an inter-temporal maximization framework, firms choose employment by maximizing (8) subject to (7) and (2). One obtains the following optimality condition:

$$a_t = W_t + \frac{c_t a_t}{q(\theta_t)} + N_t \frac{\partial W_t}{\partial_t l_t} - \delta(1-s) E_t\left(\frac{c_t a_{t+1}}{q(\theta_{t+1})}\right) \tag{9}$$

[2] This hypothesis is symmetric to what is usually done in so called new growth models, where l is incorporated in a. See Aghion and Howitt (1998).

where δ is the discount rate. This condition implies that firms hire labor until the marginal product of labor (l.h.s.) equals the marginal cost of labor (r.h.s.). In an intertemporal environment, the marginal cost of labor is given by four elements: i) wages, ii) hiring costs, iii) the change in the wage bill and iv) the discounted cost of hiring next period, which is subtracted from the first three elements.

Usually, this equation is solved by referring to the rational expectation hypothesis (REH). Instead, we assume that agents operate in an uncertain environment and act as boundedly rational.[3] Specifically, we assume that firms have a medium-run horizon where future values are approximated by the steady state values.[4]

2.2 Wages and Income Distribution

Given an uncertain environment, wages are assumed to depend on both productivity, as in Michaillat (2012), Blanchard and Gali (2012) and Hall (2005), and on a markup, as in Basu and Bundick (2012). Wages are therefore defined as follows:

$$W_t = \frac{a_t}{m_t} \tag{10}$$

where the markup m varies pro-cyclically and depends on macro conditions.

By focusing on the firms' medium-run horizon and defining wages according to equation (10), the optimizing condition (9) changes into the following expression:

$$\theta_{t\,t} = [(\frac{\mu}{ca_t})(a_{t\,t} + \delta(1-s)\frac{ca_0}{\mu}\theta_0^{\eta} - W_t]^{\frac{1}{\eta}} \tag{11}$$

where equations (3) and (4) are used to express (9) in terms of labor market tightness.

2.3 Aggregate Demand and the Process of Labor Adjustment

Search models, likewise the real business cycle approach, analyze recessions by assuming a fall in technology. On the contrary, we focus on the role of aggregate demand and consider that firms, in the presence of negative shocks, face a series of adjustments with respect to their plans, which take the form of lay-offs (alongside voluntary separations) (Barnichon, 2012).

The model assumes a sequence of events that can be described as follows. Based upon a medium-run forecast, vacancies v_t are obtained on the basis of a lagged level of unemployment (equation 11); this allows to determine labor market tightness θ, hence, through the matching process, hiring h_t. At this stage, firms discover the true value of aggregate demand and definitely fix employment; the dynamics of the latter drives labor supply l_s, which allows one to obtain unemployment. Finally, by means of labor lay-offs, the planned level of employment is adjusted to the actual one, l_a, where subscript 'a' stands for 'adjusted'. Notice that this flow component of the labor market has normally a negligible empirical impact, which explains why it is usually not considered in search models. However, though it may hold true in the canonical business cycle, it need not to be so during severe downturns, as the Great Recession and its aftermath.

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[3] This aspect has been revitalized by the Great Recession. See Bloom (2009) and Christiano et al. (2014); see also Hommes and Sorger (1998) for the hypothesis of consistent expectations.

[4] This hypothesis can be further refined in order to generate a steady state learning; see Evans and Honkapohja (2001) and Ferri, Cristini and Variato (2014a).

2.4 The Dynamic Beveridge Curve

As any search model must be able to reproduce a negative relationship between vacancies and unemployment, the so-called Beveridge curve, we test the model just described on this same ground and simulate it in a dynamic environment. The following recursive system of 11 equations is therefore put forward:

$$\theta_{t\,t} = [(\frac{\mu}{ca_t})(a_{t\,t} + \delta(1-s)\frac{ca_0}{\mu}\theta_0^{\eta} - W_t]^{\frac{1}{\eta}} \tag{11}$$

$$v_t = \theta_t u_{t-1} \tag{12}$$

$$Y_t = Y_0^{1-\rho} Y_{t-1}^{\rho} e^{\sigma_{ad,t}} \tag{13}$$

$$m_t = m_0 \left(\frac{Y_t}{Y_0}\right)^{\nu} \tag{14}$$

$$W_t = \frac{a_t}{m_t} \tag{10}$$

$$a_t = a_{t-1} \tag{15}$$

$$l_t = \frac{Y_t}{a_t} \tag{7}$$

$$l_{s,t} = l_{s,0}\left(\frac{l_t}{l_0}\right)^{\psi} \tag{16}$$

$$h_t = [\mu u_{t-1}^{\eta} v_t^{1-\eta}] l^{\eta}{}_{s,t-1} \tag{17}$$

$$u_t = 1 - \frac{(1-s)l_{t-1} + h_t - l_{a,t-1}}{l_{s,t}} \tag{18}$$

$$l_{a,t} = (1-s)l_{t-1} + h_t - l_t \tag{19}$$

The 11 unknowns of this recursive system are: $\theta_t, v_t, Y_t, m_t, W_t, a_t, l_t, l_{s,t}, h_t, u_t, l_{a,t}$.

Some points are worth stressing. First of all, the equations present nonlinearities so that the dynamics need not be confined around the steady state. Secondly, since a symmetric equilibrium is assumed, no distinction is made between variables pertaining to the single unit or to the total. Third, the recursive system is keeping with the timing discussed before. In particular, equation (11) has been reproduced for sake of completeness; equation (12) determines vacancies (v_t), given last period rate of unemployment; equation (13) represents the nonlinear dynamics of aggregate demand, which is disturbed by a normal shock; equation (14) implies a pro-cyclical behaviour of the markup, while equation (10) fixes real wages. Productivity is assumed to be stationary in this version of the model, so that a_t is determined by its initial given value. Equation (7) determines employment l_t, while labor supply l_s, by exploiting a widely observed fact according to which more people enter the labour force as demand rises, depends on the evolution of employment (see equation 16).[5] Hiring, in equation (17), is determined by the usual matching function, corrected by $l_{s,t}$ (the unit mass hypothesis

[5] This relationship is well documented, for example, in the various issues of the "World Economic Outlook" of the IMF.

having being corrected). It follows that unemployment defined in equation (18) is different from that illustrated in equation (1). Finally, equation (19) determines the amount of job adjustment necessary to bring the ex-ante expectations in line with the actual performance.

The system has been simulated and, given its stochastic nature, a Monte Carlo experiment has been carried out. The quarters considered are 100, while simulations have been repeated 100 times. The average behavior of the resulting Beveridge curve is illustrated in Figure 1.

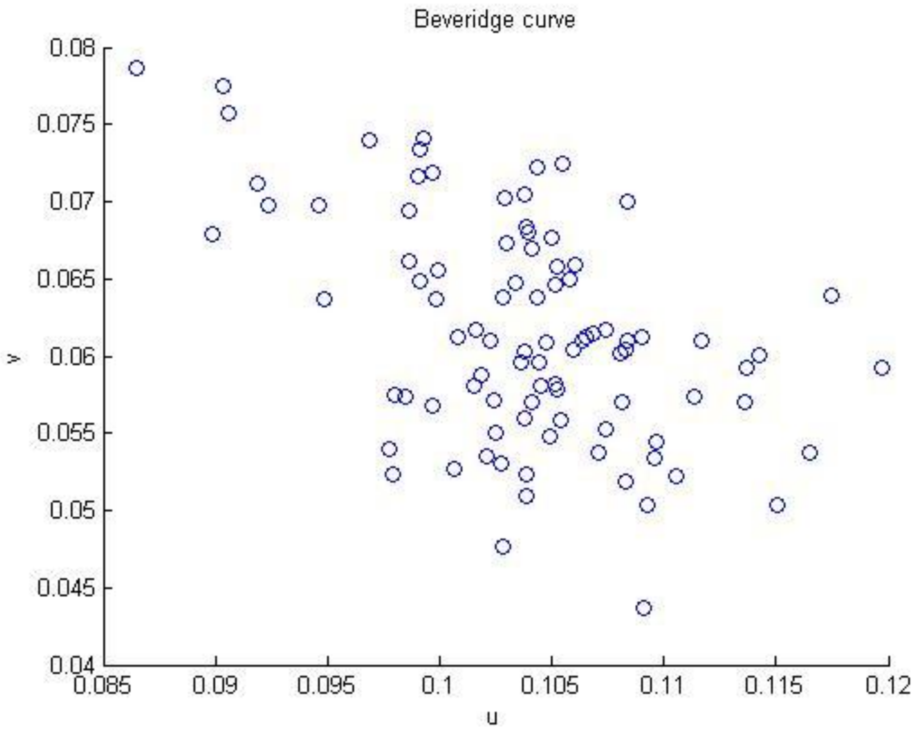

Figure 1. The Beveridge curve in a search model with aggregate demand shocks

The parameters are the same as those used by Michaiilat (2012), possibly referred to a quarterly interval, and are illustrated in Table 1, while the steady state value of the level of unemployment is 10.3%.[6]

Table 1. The parameters of the simulations

ρ=0.995	σ_{ad}=0.055	δ=0.99	σ=0.03	η=0.5	υ=0.8	ψ=0.85

In spite of the different environment, the model is capable of generating a negative correlation between vacancies and unemployment, which is the fundamental stylized fact to be reproduced. Furthermore, the result is robust as it applies to the average value of the simulations as well as to the mean of the correlations of the single drawings.

[6] The remaining steady state values are: θ_0=0.8,W_0=0.87 and m_0=1.59. Finally c=0.20 and μ =0.30.

3. The Nature of the Results

The economic explanation of the results obtained is facilitated by the recursive nature of the model. In fact, firms adopt some medium-run forecasts on the future and plan vacancies and hiring. Successively, aggregate demand is revealed and actual employment is determined. Given labor supply, the rate of unemployment is then obtained. Finally, a job adjusting mechanism intervenes in order to set the effective amount of labor in line with the ex-post situation. Given v_t, a negative shock to aggregate demand impacts negatively on employment and, although an adjustment in the labor supply does take place, unemployment increases: this creates a Beveridge curve.

Given the definition of unemployment, and supposing the presence of a normalized labor supply, one obtains the relationship illustrated in Figure 2.

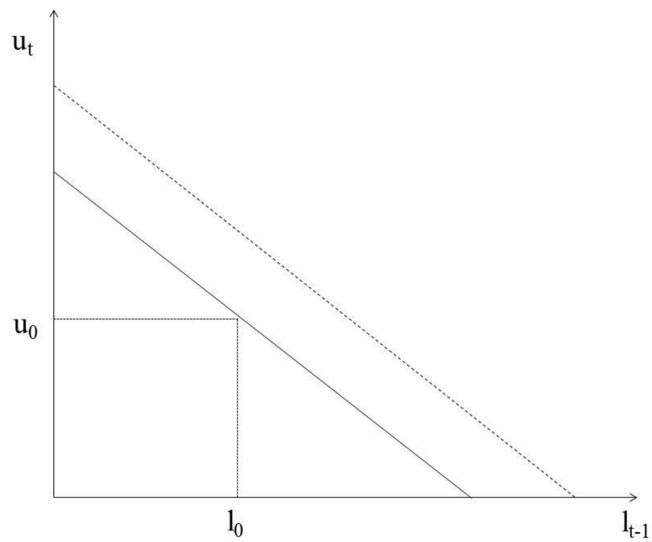

Figure 2. Employment and unemployment

Notice that the curve shifts upward according to the amount of lay-offs that takes place in the system, thus impacting on the amount of unemployment.

It follows that unemployment is partly demand driven; however, we refrain from calling it "Keynesian unemployment", for two main reasons: (i) it arises only in a dynamic context and (ii) in the absence of a monetary and credit conditions.

The same results can be obtained with a linearized version of the model, where the production function can be generalized and productivity shocks can be introduced. In this case, the type of unemployment discussed by Michaillat (2012) and defined "rationed unemployment" can also be generated.

4. Model Extension

4.1 Heterogeneity

Some forms of heterogeneity can enrich the model; in particular, the intensive phenomena just discussed can be supplemented by considering the extensive margin. To this purpose, let us consider an economy where there are n plants working out of a mass equal to 1. The total employment can then be represented in the following way:

$$L_t = n_t l_t \qquad (20)$$

where L is the extensive measure of employment on the assumption that in equilibrium all plants have the same amount of (intensive) labor.

Let us suppose that actual productivity (a_t) is determined by the stationary value (a_0), increased by an idiosyncratic shock z_t that is independent and identically distributed across time (and across locations).

In particular, it is assumed that z_t is uniformly distributed on the interval[7]

$$z_t = [-\sigma_s, \sigma_s]$$

and is drawn from a time invariant distribution (see Cooley et al., 1995 and Ferri, Cristini and Variato, 2014b). In order to obtain a new equation for productivity, some intermediate steps are necessary.

In fact, not all plants are operative, but only those with sufficiently large realized values of z_t. Since z_t is uniformly distributed, the fraction of plants that operate is equal to:

$$n_t = \frac{\sigma_s - z_{th,t-1}}{2\sigma_s} \qquad (21)$$

where z_{th} is a threshold value to be endogenously determined.

Integrating over all operative plants, one obtains the total production:

$$Y_t = \frac{n_t l}{2\sigma_s} \int_{sth,t-1}^{\sigma_s} (z + a_t) dz \qquad (22)$$

which can also be written as follows:

$$Y_t = L_t (a_t + \sigma_s (1 - n_{)t})) \qquad (23)$$

This equation is characterized by two margins of adjustment: the intensive margin l_t, and the extensive one, n_t. Productivity can then be redefined as:

$$A_t = a_t + \sigma_s (1 - n_t)_t \qquad (24)$$

If $n_t=1$, i.e. if all plants were operative and capacity were full, A_t would reach the maximum efficiency, i.e. its long-run level. If $n_t < 1$, the efficiency level would be lower. The threshold level is determined on the assumption that for a plant to be operative, the idiosyncratic shock in productivity must cover the marginal costs; hence:

$$z_{th,t} = w_t - a_t \qquad (25)$$

that is, the idiosyncratic shock in productivity must cover the marginal costs; this also implies that total productivity per man ($z_{th,t} + a_t$) has to cover real wages.

[7] One can use other distributions. For instance, Gilchrist and Willimans(2005), refer to a (log) normal distribution.

4.2The Dynamics and Systemic Unemployment

In order to simulate this version of the model, the previous model is extended by adding equations (21) and (25) that determine, respectively, the percentage of operating plants, n_t, and the threshold $z_{th,t}$. Moreover, by taking into account the new production function (23) and equation (20), equation (7) now becomes:

$$l_t = \frac{Y_t}{n_t A_t} \tag{7a}$$

In addition, equation (15) becomes (15a) and unemployment is determined by the following relationship that takes the extensive margin into account:

$$u_t = 1 - \frac{n_t[(1-\sigma_s)l_{t-1} + h_t - l_{a,t-1}}{l_{s,t}} \tag{15a}$$

This new system of equations has been simulated under the same conditions of the previous one. The parameters are those of Table 1; however, since the steady state value of wages is determined by the threshold equation, the steady state values of the other variables undergo small changes.[8] Results are illustrated in Figure 3.

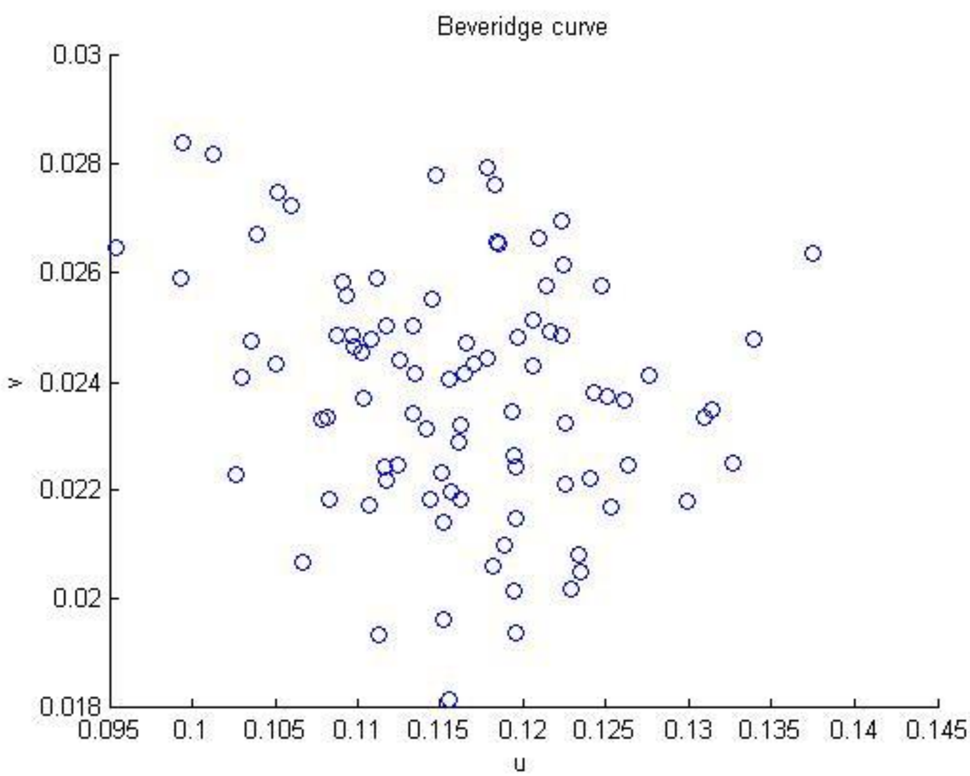

Figure 3. The Beveridge Curve in a model with heterogeneity

As before, the Beveridge curve has the expected sign. The correlation of the average relationship is negative, and the same happens to the mean of the correlation of the single shots.

[8] The parameters are the same, except μ=0.4. As far as the steady states are concerned, the threshold is equal to $z_{th,0=}$-σ_s=0.45, real wages=0.55. m_0=1.81, θ_0=0.31, u_0=0.0837.

Two further remarks are worth stressing. The results are robust to parameter change; in particular, the parameters absent in the literature (such as υ, ψ and $z_{th,0}$) can be changed by 50% without changing the main results. Furthermore, in the dynamic setting, the presence of unemployment depends on systemic forces, as illustrated by Figure 4, which confronts the results of the two versions of the model.

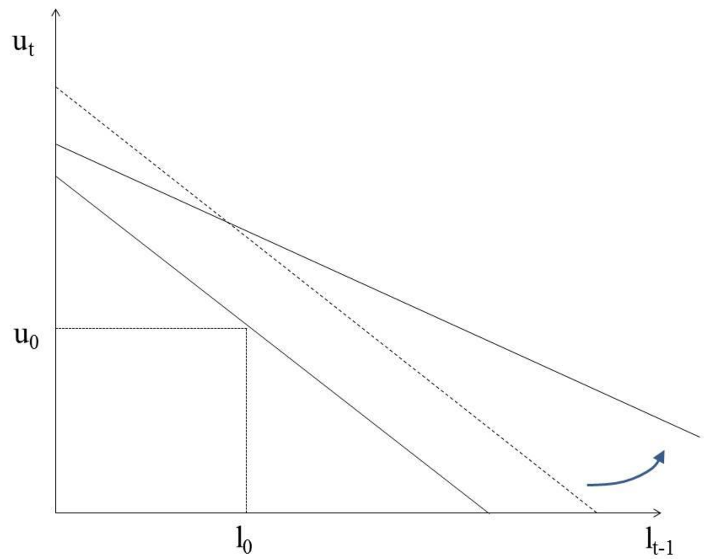

Figure 4. Systemic unemployment

In the present case, as in the previous one, aggregate demand movements, by creating employment adjustments, increase unemployment by shifting the curve outwards. In addition, supply side effects, by modifying the number of operating plants, determine a further impact on unemployment, which rotates the curve leftwards.

It follows that the system can be away from the steady value of frictional unemployment and this can be due to the dynamic interaction of aggregate demand falls and supply adjustments.

5. Concluding Remarks

This paper extends the canonical search theories on the labor market in order to deal with a greater variety of unemployment. While the presence of frictional unemployment is typical of this approach, the existence of unemployment driven by aggregate demand is less studied, even though the “Great recession” would advocate an effort in this direction.

In order to obtain this kind of unemployment, an uncertain environment is assumed where firms have a medium-run horizon and steady-state-consistent expectations. Furthermore, wages are determined by a markup. In this context, firms plan vacancies before the aggregate demand is revealed; if aggregate demand undergoes negative shocks, employment can both affect unemployment and stimulate a process of lay-offs. We show that this process is capable of generating the canonical Beveridge curve and demand driven unemployment coexists with the frictional one.

The model is also extended to a heterogeneous environment, where the results depend not only on the intensive margin but also on the extensive one, represented by the number of operating plants, which, in turn, depend on supply conditions. This gives rise to a simultaneous presence of different kinds of unemployment which generate what we call systemic unemployment.

The paper can be extended in several ways. First of all, one can change the timing of the events so that the recursive model can take a different form. In the second place, one can modify the assumption about wage markup in order to introduce imperfect competition and different hypothesis the mark up movements.

This leads to the third extension. Monetary and credit aspects must be introduced: these must be explicitly considered both to better understand the recent events, as suggested also by Hall (2012) or differently by Delli Gatti *et al*. (2015), and to strengthen the analytics of the model.

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