Search Models of Unemployment*

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1 Introduction

To the average person (perhaps even the average economist), unemployment is often equated to a state of involuntary idleness. Such a view, however, appears inconsistent with the way in which unemployment is actually defined and measured. According to *International Labor Organization* conventions (which are followed by most national labor force surveys), unemployment constitutes those (working-age) individuals who are not employed but who are *actively searching* for work (over the reference period of the survey–e.g., the previous four weeks). Nonemployed (jobless) individuals not engaged in active job-search (including so-called 'discouraged workers') are classified as nonparticipants.

To the extent that active job-search consumes time and other resources, relating unemployment to a state of idleness seems wrong. Furthermore, to the extent that individuals are free to allocate their time across many competing activities, with time devoted to search yielding at least the prospect of a future payoff, the notion of unemployment as an involuntary state is potentially misleading. To understand unemployment–or, at least, unemployment data (as opposed to some other notion of unemployment)–one must therefore entertain a theory that explains the circumstances under which individuals find it in their interest to remain nonemployed while searching for work. Search models of unemployment are designed to do just this.

2 Search Theory

A hallmark of conventional labor market theory (the neoclassical model and its sticky-wage variants) is the assumption that labor is exchanged in a centralized market place. Among other things, a centralized market embodies the idea that there is perfect information concerning the location of all jobs and workers. In any such environment, devoting precious time to an activity like search makes no sense (whether or not the wage is market-clearing). That is, individuals either have a worthwhile job opportunity to exploit or they do not. In the former case, they become employed; in the latter, they become nonemployed (and would be labeled as nonparticipants by standard labor force surveys).

The starting point for any search model of unemployment then is to dispense with the notion of a centralized market place for labor. Instead, the labor market is viewed as a set of decentralized locations, where firms and workers can potentially meet to form mutually beneficial relationships. In a decentralized market, meetings are to some extent

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determined by search effort and to some extent by chance. In many ways, the labor market resembles a matching market for couples. That is, one is generally aware that the opposite side of the market consists of better and worse matches (we seldom take the view that there are *no* potential matches). The exact location of the better matches is unknown, but may be discovered with some effort. In the meantime, it may make sense to refrain from matching with 'substandard' opportunities that are currently available. But since search is costly, it will generally not be optimal to wait for one's 'soulmate' to come along. Furthermore, since relationships are not perfectly durable, there is no reason to expect the stock of singles to converge to zero over time. Nor is it clear, given the technology of match-formation, that having everyone matched at all times (irrespective of match quality) is in any way desirable–even if it is feasible; and even if people generally desire to be matched.

In the context of the labor market then, the key friction that potentially rationalizes job-search (and hence, unemployment) is imperfect information over the location of one's best job opportunity. In such an environment, job search constitutes a form of investment in the acquisition of information. The idea of job-search as an information-gathering activity has been around for some time; see, for example, Stigler (1962) as well as the several papers and references contained in Phelps (1970). Perhaps the most influential early formalization of the theory of job-search is provided by McCall (1970); see also Sargent (1987, Chapter 2). In the next section, I present the basic idea of this classic literature by way of a simple model.

3 A Simple Model

I begin by describing a simple 'one-sided' search model; e.g., the case in which an individual searches for a job opportunity that pays a given wage depending on match quality. Each time period $t = 1, 2, ..., \infty$ is divided into two subperiods that I call stage 1 and stage 2. There will be no intertemporal aspect to individual decision-making, so the model's dynamic equilibrium can be thought of as a sequence of static equilibria.

Each person enters stage 1 endowed with one unit of (indivisible) time, a job opportunity that pays a real wage $w \in [0, \overline{w}]$, and a leisure opportunity that generates a return $0 < b < \overline{w}$. One can interpret b as either an unemployment insurance benefit or, more generally, as the consumption available when nonemployed (e.g., via home production). The real wage w can be interpreted as the quality of the job-worker match associated with any given job opportunity. Assume that individuals do not know the precise location of their best job match (i.e., the match that would yield them $\overline{w}$). However, individuals are assumed to know the distribution of match-qualities associated with the given set of available jobs; let $F(w)$ denote the fraction of job matches that yield a wage no greater than w. The act of job search is modeled as a random draw from $F(w)$.

At the beginning of stage 1, must make a choice: should I search or not? The act of not searching means that time must be allocated during stage 1 across one of two activities: work or leisure. The utility payoff to work is $u(w)$, while the utility payoff to leisure is $u(b)$, where $u'' < 0 < u'$. Conditional on choosing not to search, optimal behavior entails choosing to work iff $w \geq b$. Alternatively, I could choose to search instead. In this case, my time endowment is 'transported' to stage 2. Here, the cost of job search is given by the assumption of *no recall*; i.e., I must abandon my current opportunity w to exercise my search option. Let $w' \sim F(w')$ denote the wage associated with a new job opportunity I find as a result of my search. At this stage, I now have the opportunity to either work or leisure; i.e., I will only choose to work at this new job if $w' \geq b$. Hence, the expected utility payoff from search is given by:

$$S(b) \equiv F(b)u(b) + \int_b^{\overline{w}} u(w')dF(w').$$

Implicit in this discussion is the assumption that consumption levels during stage 1 and 2 are viewed as perfect substitutes. As well, I am assuming the absence of an insurance market.

The problem has been set up here in such a way that it will never be optimal for a person to choose leisure during stage 1. This is because there is always a zero-cost option to consume leisure during stage 2. Hence, the relevant choice is whether to work or search during stage 1. Evidently, the optimal strategy is to set a *reservation wage* $w_R(b)$, such that one should choose work if $w \geq w_R(b)$ and choose search if $w < w_R(b)$. This reservation wage must satisfy:

$$u(w_R) = S(b). \tag{1}$$

That is, a person's reservation wage is defined to be the wage that would make a person just indifferent between working at that wage, or abandoning it in favor of another activity (in this case, job search). In other words, the reservation wage is a measure of an individual's 'choosiness' over job opportunities. Note that as $S'(b) = F(b)u'(b) > 0$, the reservation wage is an increasing function of option value associated with leisure. Intuitively, a person with a good outside option (b) can afford to be more discriminating with respect to the quality of any given job opportunity w.

Thus far, I have described the choice problem of an individual beginning with an endowed wage/leisure opportunity (w, b). I would like to now describe how this behavior translates into the evolution of aggregates over time. To render static decision-making optimal in this environment, assume that all individuals begin each period with a match quality w drawn from the distribution $G(w)$. The interpretation here is that economy experiences a 'structural' shock every period that 'shuffles' individual match qualities, but otherwise leaves aggregate production possibilities unchanged. Following this structural shock, individuals behave in the manner described above. For simplicity, assume that all individuals share a common value for b that remains constant over time.

It is a simple matter now to characterize the equilibrium unemployment rate. At the beginning of each period, individuals are randomly assigned a match quality w, whose distribution is $G(w)$. The fraction $[1 - G(w_R)]$ will choose to exploit their employment opportunity and the fraction $G(w_R)$ will find it optimal to abandon their opportunity in favor of search. Job-searchers find new job opportunites with associated match-qualities w' drawn from the distribution $F(w')$. Those who find a job that pays $w' \geq b$ choose to work; those that find a job that pays $w' < b$ choose leisure instead. Thus, $F(b)$ denotes the fraction of job-searchers who are 'unsuccessful' in their search. Assuming that the reference period for a labor force survey is the length of a period (and that the survey is performed at the end of the period), the equilibrium unemployment rate is given by:

$$U = G(w_R)F(b).$$

In other words, the unemployed are those who: (a) performed no work during the reference period; and (b) were actively searching for work during the reference period.

Associated with the 'steady-state' unemployment rate U are steady-state flows of workers making transitions from employment to unemployment (job destruction) and transitions from unemployment to employment (job creation); these flows are given by:

$$\begin{aligned} JC &= [1 - G(w_R)F(b)]\, U; \\ JD &= G(w_R)F(b)(1 - U). \end{aligned}$$

Any given individual may, of course, experience a variety of employment/unemployment histories.

The model developed above constitutes an example of the modern approach to the theory of unemployment. Note that unemployment here is interpreted as an equilibrium phenomenon; in particular, it is not the product of irrational behavior or markets that fail to clear. Instead, unemployment is the natural by-product of an economy subject to ongoing structural disturbances that depreciate the value of existing employer-employee matches, and where match formation takes time owing to the imperfect information pertaining to the location of new job opportunities.

One by-product of the modern theory of unemployment is that renders obsolete much of the traditional language that was used to describe the phenomenon; i.e., see Rogerson (1997). Consider, for example, the traditional classification of unemployment into its 'voluntary' and 'involuntary' components. In the model developed above, there is a sense in which unemployment is both voluntary and involuntary. It is voluntary in the sense that the model people (as with real people) can choose not to search; and instead allocate time to inferior job opportunities or home production activities. On the other hand, it is also involuntary in the sense that the economic circumstances that compel individuals to become unemployed are often beyond their control. By the same token, however, the same classification might be made for employed workers (e.g., the existence of those who cannot afford not to work; i.e., the so-called working poor). Whether these traditional labels have any substantive meaning, however, is questionable. In particular, note that the well-being of these model people (and presumably, people in reality) does not depend of how we (as theorists) choose to label them.

4 Welfare

A classic question in the theory of the labor market is whether an equilibrium level of unemployment corresponds in any way to an efficient allocation. Not surprisingly, the answer to this question depends critically on the nature of the economic environment; see Diamond (1982), Mortensen (1982), Hosios (1990) and Moen (1997). In the present context, the optimal level of unemployment can be characterized as the solution to the following planning problem:

$$\max_{c, w_R} \left\{ u(c) : c \leq \int_{w_R}^{w} w dF(w) + F(w_R) \left[F(b)b + \int_b^{\overline{w}} w' dF(w') \right] \right\}.$$

The socially optimal reservation wage is given by:

$$w_R^* = F(b)b + \int_b^{\overline{w}} w' dF(w').$$

The optimal unemployment rate corresponds to the equilibrium unemployment rate if $w_R^* = w_R$, where w_R is the solution to (1). As it turns out, this will be the case if $u'' = 0$ (risk-neutral individuals). However, with risk-averse individuals, one can easily establish that $w_R < w_R^*$, which implies here that the equilibrium unemployment rate is too *low*.

The suboptimality of equilibrium in this particular model has nothing to do with search *per se*; rather, it is due to the lack of insurance. The intuition is straightforward: in the absence of a well-functioning insurance market, individuals are too willing to hold on to marginal jobs, rather than risk an even worse outcome in the event of an unsuccessful job-search.

One striking implication of the modern theory of unemployment is that the unemployment rate bears no obvious relation to any sensible measure of social welfare. Consider, for example, two economies A and B, identical in every respect except that $b_A > b_B$ (so that the residents of economy A are in some sense 'wealthier' than those of economy B). In this case, the unemployment rate in economy A will be higher than in economy B. Nevertheless, given the choice, individuals would rather live in the high-unemployment economy. On the other hand, suppose that the two economies differ only in terms of F, with F_A stochastically dominating F_B. In this case, economy A will have lower unemployment and higher welfare. The basic lesson here is that 'economic performance' should not be measured in terms of how individuals choose to allocate their time across competing activities; but rather should be measured in terms of the level and distribution (or stochastic properties) of broadly-defined consumption.

5 Unemployment Insurance

Governments in many countries operate a fiscal policy known as unemployment insurance (UI). UI systems are characterized by transfers of income to those who are unemployed (or otherwise meet certain eligibility requirements) that are typically financed via a payroll tax (or out of general tax revenue). Presumably, the motivation for such transfers rests on the belief that: [1] private insurance markets are unavailable (or work poorly); and [2] self-insurance (via precautionary saving) is either grossly inefficient, or perhaps beyond the means of many workers (a more cynical view interprets UI as one of many government transfer schemes designed to benefit various special interests at the expense of the general taxpayer).

Search models of unemployment have been applied in both positive and normative investigations concerning the effect of UI programs. For example, in the context of the model developed above, let b denote a UI benefit that is financed via a payroll tax τ. For given program parameters (b, τ), the reservation wage now satisfies:

$$u((1-\tau)w_R) = F(b)u(b) + \int_b^{\overline{w}} u((1-\tau)w')dF(w'), \tag{2}$$

which implicitly characterizes $w_R(b, \tau)$. In equilibrium, the tax and benefit level is related by the government budget constraint:

$$\tau \left[\int_{w_R}^{\overline{w}} w dF(w) + F(w_R) \int_b^{\overline{w}} w' dF(w') \right] = F(w_R)F(b)b. \tag{3}$$

For a given UI policy parameter (say, an exogenous level of b), equations (2) and (3) characterize an equilibrium $(\hat{w}_R, \hat{\tau})$. The positive and normative implications of the theory can then be deduced by varying the policy parameter b. Andolfatto and Gomme (1996) consider a similar such experiment, albeit in a considerably richer environment that (among other things) models the UI system in greater detail (in particular, UI programs are typically characterized by several program parameters, including eligibility requirements, replacement rates, and benefit duration parameters).

Several papers have recently examined the issue of how an optimal UI system should be designed. This question becomes particularly interesting when one reasonably assumes that workers have private information concerning the nature of their job opportunities and/or the intensity with which they search. In a classic paper, Shavell and Weiss (1979) demonstrate that an optimal UI program should 'front load' UI payments, with benefit levels declining monotonically over the unemployment spell. The high initial benefit level provides the desired insurance; while the declining benefit profile mitigates adverse incentive effects by stimulating (unobserved) search intensity. Wang and Williamson (1996) and Hopenhayn and Nicolini (1997) flesh out other properties of optimal UI systems in the context of dynamic moral hazard environments. Among other things, these authors report that optimally designed programs can deliver potentially large welfare benefits relative to existing systems.

6 Business Cycles

Search models of unemployment have also been used to interpret various aspects of the business cycle. Naturally, a key set of questions deal with the cyclical properties of unemployment itself. However, researchers have also investigated the extent to which 'search frictions' in the labor market shape the pattern of the business cycle more generally; i.e., see Mortensen and Pissarides (1994), Merz (1995) and Andolfatto (1996).

An empirical relationship that has drawn considerable attention in the literature is the so-called Beveridge curve; i.e., the tendency for unemployment and vacancies to move in opposite directions over the business cycle; e.g., see Blanchard and Diamond (1989). The level of job vacancies, as measured by the help-wanted index, is highly volatile and tends to lead unemployment over the cycle. A natural interpretation of these facts is that as job opportunities become more plentiful, unemployed workers are able to find jobs more easily, with search frictions preventing instantaneous adjustment. Vacancies themselves can be interpreted as the business sector equivalent of unemployed workers. Since finding suitable workers is costly and time-consuming, and since employment relationships once formed are durable, recruiting intensity constitutes a form of capital spending that presumably reacts to actual and expected shocks in much the same way as other forms of capital spending; e.g., see Howitt (1988).

A seminal paper in this area is Pissarides (1985), who appeals to the concept of an aggregate matching technology to model (in a reduced-form manner) the outcome of uncoordinated search in the labor market; see also, Pissarides (2000), and Petrongolo and Pissarides (2001). According to this approach, match formation (job creation) is the product of the aggregate search intensity of workers (unemployment) and firms (vacancies), both of which serve as complementary inputs into an aggregate matching function; i.e., $m_t = M(v_t, u_t)$. Ignoring individual differences, m/v and m/u can be interpreted as the probabilities that vacant jobs and unemployed workers contact each other. If M displays constant returns to scale, then these probabilities depend only on the labor-market tightness variable $\theta \equiv v/u$. In particular, $m/v = q(\theta)$ and $m/u = p(\theta)$, where $q(\theta) \equiv M(\theta, 1)$ and $p(\theta) \equiv M(1, \theta^{-1})$. Note that $q'(\theta) < 1$ and $p'(\theta) > 1$. In other words, firms find it more difficult to find workers in a tighter labor market; while the converse is true for workers.

With a fixed labor force L, the stock of employed workers at date t is given by $L - u_t$. Again note that the stock of employment constitutes a form of capital. Employment-capital depreciates over time as matches dissolve owing to idiosyncratic shocks that affect the viability of individual relationships. Let $0 < \sigma < 1$ denote the fraction of employment relationships that are terminated at the end of each period. In this case, the job destruction flow is given by $\sigma(L - u_t)$. For simplicity, assume that σ is exogenous. At the same time, the stock of employment is replenished by the flow of job creation, $p(\theta_t)u_t$, so that the stock of unemployment evolves over time according to:

$$u_{t+1} = u_t - \sigma(L - u_t) + p(\theta_t)u_t. \tag{4}$$

In a steady-state, the flow of job creation just offsets the flow of job destruction, so that the 'natural' rate of unemployment satisfies (normalizing $L = 1$):

$$u = \left(\frac{\sigma}{\sigma + p(\theta)} \right). \tag{5}$$

Equations (4) and (5) relate the dynamics of the unemployment rate to the labor-market tightness variable θ, as well as to parameters describing the structure of the matching market. In the simple version considered here, the unemployed search passively (workers have one unit of time that they allocate either to work or search at zero utility cost). Consequently, the equilibrium $\theta_t = v_t/u_t$ is determined entirely by vacancy creation, which is endogenized as follows.

Assume that each firm has a single job that, together with a worker, produces $y_t > 0$ units of output. Assume that y_t follows a first-order Markov process with $G(y', y) = \Pr[y_{t+1} \leq y' \mid y_t = y]$. For simplicity, assume that match-quality is identical across all firm-worker pairs and that wages are determined by an exogenous bargaining process that divides output in some manner between firm and worker; i.e., let $0 < \xi < 1$ denote the fraction of output that accrues to the firm (alternatively, one could model wage determination by imposing a Nash bargaining solution). Let J denote the capital value of a firm currently matched with a worker; this value must satisfy the following Bellman equation:

$$J(y) = \xi y + \beta(1 - \sigma) \int J(y')G(dy', y), \tag{6}$$

where $0 < \beta < 1$ denotes a discount parameter. Implicit in this formulation is that the value of the firm falls to zero in the event that the match is dissolved. Note that if match productivity exhibits positive persistence, then $\int J(y')G(dy', y)$ is increasing in y. In other words, a positive productivity shock (increase in y) is associated with information that leads firms to revise upward their estimate of the returns to match formation.

Finally, consider the cost-benefit analysis associated with vacancy creation. Assume that creating (and maintaining) a vacancy entails the flow cost $\kappa > 0$, measured in units of output. A vacant job potentially meets an unemployed worker with probability $q(\theta)$, with the match producing a flow of output beginning in the subsequent period. Let Q denote the capital value of a vacant job; this value must satisfy the following Bellman equation:

$$Q = -\kappa + \beta \left[q(\theta) \int J(y')G(dy', y) + (1 - q(\theta))Q' \right]. \tag{7}$$

Assuming free-entry into vacancy creation, the level of v will expand as long as $Q > 0$. But note that for a fixed level of unemployment u, any expansion in the number of vacancies increases labor-market tightness θ and therefore reduces the success probability $q(\theta)$. In equilibrium, θ adjusts to a point that renders further vacancy creation unprofitable; i.e., $Q = Q' = 0$. Consequently, the equilibrium labor-market tightness variable $\theta(y)$ is determined by:

$$q(\theta)\beta \int J(y')G(dy', y) = \kappa. \tag{8}$$

The economic mechanism at work here can be described as follows. Consider a positive productivity shock. Since the shock is persistent, the return to job creation (contemporaneous recruiting activities that augment the future stock of employment) increases; see (6). Naturally, in response to these bright prospects, firms increase their recruiting activities and create new vacancies. However, as the competition for new workers intensifies, the probability of success falls to the point where further expansion becomes uneconomical; see (8). On impact then, the effect of the shock leaves current unemployment unchanged, but increases the demand for labor (supply of vacancies). The dynamic effects of the shock can then be traced out by appealing to equation (4). In particular, note that since the job-finding probability for workers $p(\theta)$ is increasing in θ, the effect of the shock is to lower the future rate of unemployment. These effects continue to be propagated forward in time through the search mechanism.

7 Current Issues

Several authors have observed that the unemployment rate appears to exhibit a type of cyclical asymmetry; rising sharply at the onset of a recession, but declining only slowly over the course of a subsequent recovery; e.g., see Neftçi (1984) and Hussey (1992). In an influential study, Davis and Haltiwanger (1992) investigate U.S. manufacturing data and report that job destruction appears to be significantly more volatile than job creation over the cycle. The natural conclusion that follows from this body of work is that recessions are attributable to shocks that lead to brief, but sharp, increases in job losses followed by relatively dampened, but prolonged, periods of job creation as the business sector slowly rebuilds its employment-capital; see, for example, Hall (1995).

Shimer (2005a) has recently cast doubt on this 'conventional' view of the cycle. In his detailed examination of CPS data, Shimer concludes that almost all of the cyclical variability in the unemployment rate is attributable to fluctuations in the job-finding probability (and in particular, the job-finding rate associated with transitions from unemployment to employment, rather than from nonemployment to employment). Surprisingly (relative to received wisdom), the separation rate appears to be very nearly acyclical and relatively stable. In addition to these patterns, Shimer reports a very high degree of correlation between the job-finding probability and the vacancy-unemployment ratio.

Taken together, this new body of evidence suggests that, at least for the purpose of understanding cyclical behavior, one may reasonably begin by organizing ideas around a simple Pissarides-style search model along the lines described above; i.e., with a constant labor force L, an exogenous separation probability σ, and a job-finding probability $p(\theta)$ that varies with labor-market tightness. Whether a suitably calibrated version of this model can account for observation, however, remains a topic of current debate; e.g., see Shimer (2005b), Hagedorn and Manovskii (2005), Hall (2005) and Mortensen (2005), as well as Hornstein, Krusell and Violante (2005) for a nice summary.

Apart from cyclical phenomena, several outstanding issues remain unresolved in terms of understanding secular and cross-country measures of labor market activity. At the forefront of these phenomena is the dramatic rise in European unemployment rates relative to the U.S. over the last 35 years; e.g., Ljungqvist and Sargent (1998), and Blanchard and Wolfers (2000). But unemployment is just one of the three major classifications of time-allocation, along with employment and nonparticipation (the latter two of which contain many more people than the former). Rogerson (2001) documents several interesting facts concerning the cross-country differences and low-frequency movements in employment-to-population ratios. Among other things, cross-country differences are large and persistent over time, with considerable movement within the distribution of employment-to-population ratios across countries. Furthermore, while employment and unemployment closely mirror each other at business cycle frequencies, the same is not true at lower frequencies. This latter observation suggests that the commonly-invoked short-cut of abstracting from participation decisions for business cycle analysis is inappropriate when investigating the causes of secular movements and cross-country differences in time-allocation.

On the theoretical front, several issues remain the subject of on-going research. Paramount among these include investigating the microeconomic foundations of the matching technology and the process of wage-determination in decentralized markets. On these and related matters, the interested reader may refer to Rogerson, Shimer and Wright (2005)–a recent survey that contains 167 references while claiming to only 'scratch the surface' of this interesting and rapidly expanding body of research.

8 References

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