Discussion Paper Series

Job Matching, Unemployment, and Efficient Policies

By
Kazuhiro Arai and Hideki Awashima
(Hitotsubashi University)

Discussion Paper No. 17-1, May 2017

Institute of Economic Research
Faculty of Economics

DAITO BUNKA UNIVERSITY

TOKYO, JAPAN 175-8571

Job Matching, Unemployment, and Efficient Policies

By
Kazuhiro Arai and Hideki Awashima
(Hitotsubashi University)

Discussion Paper No. 17-1

May 2017

大東文化大学経済研究所
175-8571 東京都板橋区高島平１－９－１

Job Matching, Unemployment, and Efficient Policies

Kazuhiro Arai and Hideki Awashima
Hitotsubashi University
kazuhiro.arai@topaz.dti.ne.jp

Abstract

This paper attempts multi-agent simulations of job matching that determine the unemployment rate, social welfare, the number of employed persons, firm payoff, and worker payoff without using a matching function. Workers bear transaction costs for job search and interviews, while firms bear those for interviews, orientation, and dismissal. The government may control workers and firms through subsidies or regulations. Social welfare is the sum of the payoffs of all these agents including the government. Different types of workers and firms are considered. The simulation results reveal important determinants of the unemployment rate, social welfare, the number of employed persons, etc. It is shown that flexible labor markets do not necessarily reduce the unemployment rate nor become efficient when transaction costs exist. As the most practical and powerful policies, this paper advocates stabilization of the economy, employment subsidies, and institutionalization of a severance pay rule. Some properties of the segmented labor markets are detected as well. For example, younger workers are more likely to have unstable jobs in external labor markets and some of them will have more stable jobs when they become older.

JEL Classification: J64, J65, J42.

1. Introduction

This paper has three main purposes. The first is to run multi-agent simulations that do not make use of a matching function to demonstrate how unemployment is generated when both workers and firms bear transaction costs to form or dissolve matches in an economy with stochastic shocks. The second is to apply these simulations to attempt welfare analyses of several labor market institutions and government policies. The third is to disclose the structure of unemployment by considering different types of workers and firms in the simulations. A multi-agent simulation approach allows each of the many agents to solve its own problem for itself and enables us to observe the results of their interactions.

There is already abundant literature on search unemployment, but these studies use a matching function. The most representative is Mortensen and Pissarides (1994) and other examples are Blanchard and Diamond (1994), Pissarides (2000), Yashiv (2000), Ljungqvist (2002), Pries (2004), Shimer (2005), Albertini and Fairise (2013), and Postel-Vinay and Turon (2014).

The advantage of using a matching function is described by Petrongolo and Pissarides (2001) as follows:

The attraction of the matching function is that it enables the modeling of frictions in otherwise conventional models, with a minimum of added complexity. Frictions derive from information imperfections about potential trading partners, heterogeneities, the absence of perfect insurance markets, slow mobility, congestion from large numbers, and other similar factors. Modeling each one of these explicitly would introduce intractable complexities in macroeconomic models. The matching function captures their effects on equilibrium outcomes in terms of a small number of variables, usually without explicit reference to the source of the friction.

Models using a matching function are also attractive for the following reasons (Shimer, 2005). Firstly, they offer appealing descriptions of how the labor market functions. Secondly, they have rich and generally intuitive comparative statics. Thirdly, they can easily be adapted to study a number of labor market policy issues, such as unemployment insurance (UI), firing restrictions, and mandatory advanced notification of layoffs.

In spite of these attractive features, the matching function is a black box, which hides some important parts of the mechanism that generates unemployment. In addition, it is unable to show in detail how the unemployment rates differ across different types of workers.[1]

There is a widespread view among neoclassical economists and many macroeconomists that labor market rigidities such as employment protection institutions generate a high rate of unemployment and more flexible labor markets would reduce the unemployment rate. For example Nickel et al. (2005) claim that changes in labor market institutions explain about 55% of the rise in European unemployment from the 1960s to the first half of the 1990s.

This paper claims that the above view is excessively influenced by neoclassical economics, which does not have the concept of transaction costs, and demonstrates that a model with transaction costs produces a quite different view and policy implications. For instance, it will be shown that labor markets that are too flexible lead to a high unemployment rate.

The transaction costs considered in this paper are workers' search and interview costs and firms' interview and dismissal costs. This paper also considers firms' orientation and training costs, which may be regarded as quasi-transaction costs because all new employees need orientation (and some training). The government can control some of these costs through subsidies or regulations, while labor market practices and technological innovations such as the Internet may greatly affect them as well.

Several papers analyze the effects of government policies or labor market institutions that are conceived to reduce the unemployment rate. Fredriksson and Holmlund (2006) argue that imposing a penalty on less active job search is effective in preventing unemployment. Albertini and Fairise (2013) consider the optimal combination of unemployment benefits and layoff taxes that is welfare-enhancing. Ljungqvist (2002) shows that an increase in lay-off costs tends to increase employment by reducing labor reallocation. Postel-Vinay and Turon (2014) demonstrate that ignoring on-the-job search leads to overstatement of the adverse impact of firing costs on employment. However, all of these authors use a matching function.

Other papers have similar aims but do not use a matching function. Topel (1984) claims that current methods of financing UI subsidize the occurrence of unemployment since even the typically rated employer repays only about 75 cents per dollar of UI benefits drawn by his workers. Hopenhayn and Rogerson (1993) show that a tax on job destruction at the firm level with a size equal to one year's wages reduces employment by roughly 2.5% and utility by over 2% measured in terms of consumption owing to the resulting efficiency loss. They do not consider, however, transaction costs, which are important elements of this paper.

Bentolila and Bertola (1990) show in a partial equilibrium model that an increase in lay-off costs increases average employment since it is more likely to prevent lay-offs than to discourage hiring. Based on a behavioral model, Altman (2006) claims that efforts to make labor markets more flexible by weakening the bargaining power of labor so as to reduce the unemployment rate might be unnecessary and counterproductive. Blanchard and Tirole (2008) develop a model that analyzes the optimal UI and layoff taxes, but they do not consider worker search.

In the simulations of this paper, workers undertake fixed-sample-size job search bearing search and interview costs. They are free to be engaged in on-the-job search. They differ in several respects such as productive abilities, ages, search costs, tastes for leisure, and tastes for workplace atmospheres. On the other hand, firms decide how many and which job applicants to hire by bearing interview costs and orientation and training costs. They may dismiss their workers by bearing dismissal costs. As shown in more detail below, they differ in the differences in productivity between high-ability and low-ability workers. They are also different in workplace atmospheres such as the ethicality and friendliness of their members.

Workers' behavior that is usually called job search is described in detail here. Workers firstly search for jobs in the narrow sense, secondly seek jobs, and thirdly get a job. A search in the narrow sense means to acquire job information by using the Internet, asking friends, *and* attending company information sessions. To seek a job means to request an interview and show the intention to work. To get a job means to decide to work at the job.

Most workers bear transaction costs for job search. In particular, they tend to bear a large amount to have interviews.[2] They request interviews only with firms for which they intend to work. Having an interview, however, does not mean that the firm will employ the applicant or she will surely work for the firm because both sides might have other candidates. This paper considers all these aspects of worker search in the broad sense.

Just before each period, each worker decides how many firms to search and how many interviews to request. An interview will reveal the applicant's productive ability to the firm, which then decides whether to make her a job offer. Each firm that advertises recruitment interviews all applicants and offers jobs to some of them. The government may subsidize search or employment as well as regulate dismissal.

There is likely to be a macroeconomic shock just before each period and it causes the economy to fluctuate. Correspondingly, the workers and the firms make the above decisions immediately after the shock and just before each period. In this process all agents make adaptations, i.e., adjust their expectations in accordance with their experience.

The simulations determine the levels of several interesting variables. Of particular interest are the rate of unemployment and social welfare, the latter of which is the sum of the payoffs of all agents including the government. Other interesting variables are the number of employed persons, the firms' profits, and the workers' payoffs.

In addition, the simulations show how the unemployment rates differ among different worker ages, abilities, etc. They also show how dismissal differs among different types of firms. These analyses not only disclose the structure of unemployment but also strengthen the segmented labor market theory developed notably by Doeringer and Piore (1971) and Piore (1971, 1975, 1978). The theory provides a realistic description of the labor market but has been criticized for a lack of theoretical rigor by Cain (1976), Taubman and Wachter (1986), Osterman (1987), and Baker and Holstrom (1995).

The simulations reveal the effects of different kinds of transaction costs on the rate of unemployment, social welfare, and some other interesting variables. They also demonstrate how government interventions affect those variables. An advantage of the approach of this paper is that it can unveil potentially every detail of search unemployment because it does not make use of a matching function.

Section 2 discusses the basic assumptions of the simulation model. Section 3 considers the determination of each firms' wage offer, while Section 4 that of the number of searches by each worker. Section 5 shows how worker-firm matches are formed. Section 6 examines the basic simulation results to verify various factors that determine the unemployment rate and social welfare. Section 7 uses the other results to disclose the structure of unemployment and some properties of the segmented labor markets. Section 8 provides a few concluding remarks.

2. The basic assumptions

This paper considers an economy made up of one industry with fifty firms and one thousand workers.[3] All of these agents are risk-neutral. Tables 1, 2, and 3 are the lists of major parameters for them, while the Appendix shows a list of most of the endogenous variables. Time passes from Period 1 to the infinite future, although it is assumed that each period has a very short time interval just before it. Each worker lives and works up to ten periods. Each period has ten age groups of one hundred members each from age 1 to age 10. Thus, the population of the economy is invariant over time.

The economy fluctuates because of the above shocks. This is shown by the random variable b, which indicates the state of the economy and takes on values of -1, 0, and 1 with probabilities of 0.3, 0.4, and 0.3 respectively, where -1 stands for a recession, 0 normality, and 1 a boom.[4]

In response to the shocks, firms and workers make new decisions in the above intervals. More precisely, all of their decisions are made and executed immediately after the shocks in the following order: Firstly, firms decide whom to dismiss. Secondly, they decide the levels of their wage offers for new employees, while workers decide how many firms to search. Thirdly, workers search for jobs and seek interviews. Fourthly, interviews are held and then jobs are offered. Fifthly, workers quit. Sixthly, workers get employed. Production and wage payment are carried out within each period.[5]

The workers are quite heterogeneous. They differ not only in age and ability but in valuations of leisure, search costs, interview costs, desired workplace atmospheres, subjective expected wage offers, and discount rates. They further differ in some parameter values for their subjective probabilities of receiving job offers and for those of dismissal. As shown in Table 1, these parameters are distributed uniformly among the integers of the domains. The discount rate is an exception and takes on the values of 0.05, 0.06, …, and 0.15 with the same probability. All workers are assumed to have initially the same subjective expected wage offer equal to 75.

The firms are also heterogeneous. It is assumed that a worker's marginal value productivity (MVP) depends in particular on the characteristic of the firm employing him. Firm i's characteristic is denoted by CH_i. The larger the value of this variable, the larger the difference in MVP between high and low ability workers employed by Firm i. This assumption describes universally observable real phenomena where workers with high intelligence, good discipline, good manner, great curiosity, or strong perseverance tend to be more productive in high-tech, capital intensive, modern, bureaucratic, or well-organized firms. Firms learn these personalities mainly through interviews. If they were fully learned through forms of academic and business careers, interviews would be unnecessary in the real economy.

It is assumed that the MVP of a worker with ability x basically equals

(1) $$F_i(x) = 150 + (x-5)CH_i$$

when b=0 and he is 'the first worker' employed by Firm i. The MVP of 'the second' is less than (1) by PR, that of 'the third' by 2PR, etc. This formulation incorporates the above assumption that the larger the value of CH_i, the larger the difference in MVP between high and low ability workers.

When hiring and firing workers, Firm i bears different kinds of transaction costs. The first is interview costs, whose amount per interviewee is denoted by IC. The second is orientation and training costs, whose amount per new employee is denoted by OC_i. The third is dismissal costs, whose amount per dismissed employee is denoted by DC. On the other hand, the government gives a subsidy equal to UEY per worker to the employer.

Consider Firm i at the beginning of a representative period. Let El_i denote the number of workers it employs in the period and W_k the wage for its k-th worker with ability AB_k.[6] Suppose that just before the period it dismissed RN_i workers for the total dismissal costs RN_iDC, had WN_i interviewees by bearing the total interview costs WN_iIC, and newly employed EN_i workers. Let BI(b) denote the magnitude of the effect of the shock on the MVP, where BI is increasing in b. Then its profit in the period equals

(2) $$\pi_i = \sum_{k=1}^{EL_i}\left(\left(1+\frac{PC}{10}\right)BI(b)(F_i(AB_k)-(k-1)PR)-W_k\right)$$
$$-RN_iDC - WN_iIC - EN_iOC_i + EL_iUEY$$

where PC denotes the parameter to be used to examine the effect of a productivity increase.

On the other hand, worker j's payoff in this period is given by

(3) $$u_j = \begin{cases} W_j + 5(RAT_j - NAT_j) - SC_jSN_j - LIC_jIN_j + UF_jSN_jUIS & \text{if working} \\ L_j - SC_jSN_j - LIC_jIN_j + UF_j\,(UIY + SN_jUIS) & \text{if not working} \end{cases}$$

Here W_j is the wage she receives. (RAT_j - NAT_j) measures the difference between the real atmosphere of her workplace RAT_j and what she desires

NAT_j. SC_jSN_j is the product of her search cost and the number of firms she searched just before this period, while LIC_jIN_j is that of her interview cost and the number of interviews she had with some of those firms. UF_jSN_jUIS equals the total amount of subsidies given to her for her search, where UIS is the amount of subsidy per search and UF_j equals one if she is qualified for it and zero otherwise. To be qualified, she needs to have been unemployed not longer than UIT periods and to have been either dismissed or unemployed for at least one period. L_j is her valuation of the leisure from not working and UIY is the amount of UI payment.

The government can control the levels of UIY, UIS, UEY, and DC. This paper considers how they affect the unemployment rate, social welfare, and other interesting variables. Since all agents are assumed to be risk-neutral, the insurance aspects of government policies are not considered here.

3. Determination of wage offers

Immediately before workers undertake job search for each period, Firm i determines and announces the level of W_i for each new employee so as to maximize the present value of its total expected profits in that and the subsequent periods. This section considers this process. For this purpose, some probabilities need to be specified first.

Firm i believes that worker ability has a distribution $P_{ABi}(x)$ with x=1, 2, …, 10, which approximates the normal distribution $N(EAB_i,16)$ where EAB_i is i's subjective average ability of all workers. In addition, it has the belief that each worker searches it with a probability equal to

$$P_{Si} = \begin{cases} \frac{ESN_i}{EF} & \text{if } EF \geq ESN_i \\ 1 & \text{if } EF < ESN_i \end{cases} \tag{4}$$

where ESN_i denotes i's expectation of the number of firms the average worker searches and EF the number of firms that showed the intention to hire workers in the previous period.[7]

Then the probability that n workers search Firm i is derived from the binary distribution $B(WL,P_{si})$, where WL is the total number of searchers in the previous period.[8] The computer ability obliges us to assume that each firm expects not more than three searchers. Thus, the probabilities of having more than three in the above calculation are added to that of having three. Let $P_{SPi}(n)$ denote the newly defined probability that n workers search Firm i (n=0,1,2,3). Then P_{SPi} and P_{ABi} jointly make it possible to compute the probability of each possible combination of the abilities of the workers who search Firm i as will be shown below in relation to Table 4.

Each firm learns its job applicants' abilities only through interviews. Thus, Firm i's subjective probability that a worker who searched it will request an interview with it depends only on W_i and not on his unknown ability. Since this probability can be assumed to be increasing in W_i, it is specified here as

(5) $$P_{WAi}(W_i) = \frac{\beta_{0i}}{100} + \frac{\beta_{1i}}{1000} W_i$$

where $0 \leq P_{WAi}(W_i) \leq 1$.

Even if this firm offers a job to an interviewee, he does not always accept it. When he has more than one job offer, he accepts the one with the highest wage. Hence, Firm i's subjective probability that he will accept its job offer and work for it is assumed to equal

(6) $$P_{EMi}(x, W_i) = \frac{\beta_{2i}}{100} + \frac{\beta_{3i}}{1000} W_i - \frac{\beta_{4i}}{100} x - \frac{\beta_{5i}}{10} (\mathrm{ESN}_i - 1)$$

where $0 \leq P_{EMi}(x, W_i) \leq 1$. This probability is low if the firm's wage offer is low, if his ability is high, or if it expects that workers search many firms.

Workers are free to engage in on-the-job search and quit just before the coming period. A worker does not quit, however, if his current employer is attractive enough in terms of wage and workplace atmosphere. For this reason, it is assumed here that Firm i's subjective probability that its worker with ability x will quit just before the coming period equals

(7) $$P_{LEi}(x, W_i) = 1 - \left(\frac{\beta_{6i}}{100} + \frac{\beta_{7i}}{1000} \big(W_i + 5(AT_i - 5.5)\big) - \frac{\beta_{8i}}{100} x \right)$$

where AT_i denotes Firm i's workplace atmosphere and $0 \leq P_{LEi}(x, W_i) \leq 1$. This probability is low if the wage and the workplace atmosphere are attractive or if the worker ability is low.

Next, we compute the present value of the total expected profits that Firm i is to maximize to determine W_i. This is performed through several steps.

At the first step, let BC denote the number of periods for which the current level of b has continued and EBC_i Firm i's total expected number of periods for which the same level of b will continue including BC. Then (EBC_i – BC) equals the expected number of future periods in which the current level of b will continue. The use of these notations enables us to write Firm i's expected impact of b on its productivity: The expected impact z periods later $\dot{BI}_i(b,z)$ equals BI(b) if $EBC_i - BC > z$ and it equals BI(0) if $EBC_i - BC \leq z$, where BI(0) is interpreted here as the average magnitude. Namely,

$$\dot{BI}_i(b,z) = \begin{cases} BI(b) & \text{if } EBC_i - BC > z \text{ or } z = 0 \\ BI(0) & \text{if } EBC_i - BC \leq z \text{ and } z > 0 \end{cases} \tag{8}$$

The second step computes the expected number of incumbent employees in the coming period. As on-the-job search is allowed, Firm i is likely to lose some of its incumbents just before the coming period. (7) implies that the retention probability of its k-th worker with ability AB_k receiving wage W_k equals $(1 - P_{LEi}(AB_k,W_k))$, so the expected number of incumbents is

$$\dot{EL}_i = \sum_{k=1}^{EL_i}(1 - P_{LEi}(AB_k, W_k)) \tag{9}$$

The third step shows that a worker with ability x who is newly hired by Firm i will generate expected profits t periods later ($t \geq 0$) whose present value equals

$$\dot{\pi}_i(x, W_i, t) =$$

$$\delta_i^t (1 - P_{LEi}(\cdot))^t max\left(RF_{i,t}\left(\left(1 + \frac{PC}{10}\right)\dot{BI}_i(b,t)\left(F_i(x) - \dot{EL}_i \mathrm{PR}\right) - W_i + UEY\right), -DC\right) \tag{10}$$

Here δ_i denotes i's discount factor, i.e., $\delta_i = 1/(1 + s_i)$ for its discount rate s_i. $RF_{i,t}$ equals zero if this worker is dismissed by Period t and one otherwise. It is assumed in (10) that i's expectation of the number of incumbents is the same as (9) over time.

The fourth step is to use (10) to write the present value of Firm i's total expected profits from a worker with ability x when he has an interview with it as[9]

$$\ddot{\pi}_i(x, W_i) = P_{EMi}\left(\sum_{k=0}^{10-\mathrm{SLA}} \dot{\pi}_i(x, W_i, k) - OC_i\right) \tag{11}$$

Here, Firm i regards the age of each job searcher as SLA, which is the average age of those who were unemployed and those who searched on the job in the previous period, because it is unknown when W_i is determined.[10]

The fifth step is to use these results to express the present value of Firm i's total expected profits from a worker with ability x when he has just searched it. Note that if the value of (11) is negative, the firm does not offer a job, but it bears interview cost IC with probability $P_{WAi}(W_i)$. Therefore, the above present value equals

$$\tilde{\pi}(x, W_i) = P_{WAi}(\cdot)(max(\ddot{\pi}_i(\cdot)\ ,0)\ - IC) \quad (12)$$

The sixth step is to compute the present value of the total expected profits by clarifying what abilities of workers search Firm i. Table 4 shows the probable cases where the number of searchers is positive. When it is one (two, three), there are ten (resp. one hundred, one thousand) probable ability patterns with the corresponding probabilities. The information in Table 4 enables us to compute the present value of the total expected profits.

A note follows. When Firm i offers jobs to two applicants, it needs to consider the probability that the first candidate declines its job offer. Thus, the expected MVP of the second candidate needs to decrease by $\left(\dot{E}L_i + P_{WAi}(W_i)P_{EMi}(x, W_i)\right)$ PR. Since the MVP is decreasing in the number of workers and that of the higher ability worker is higher, the firm regards him as the first. A similar note applies to the case where the firm offers jobs to three.

The seventh and final step is to maximize the above present value of the total expected profits with respect to W_i.[11] If the maximized value is non-positive, the firm does not offer a job, i.e., it announces costlessly on its homepage that W_i =0. This process determines the level of W_i.

4. Determination of the number of job searches

This section analyzes how each worker determines the number of job searches just before each period. It is determined so as to maximize the benefit of job searches, which is computed through several steps as follows.

At the first step, note that worker j's benefit of job searches roughly equals the difference between the expected payoff she will earn in a newly hired firm and what she earns by keeping her current status. The latter is

$$OPC_j(t) = \begin{cases} \mathrm{RW}_j + 5(RAT_j - \mathrm{NAT}_j) & \text{if employed currently} \\ L_j + UF_{j,t}\ \ UIY & \text{if not employed currently} \end{cases} \quad (13)$$

If she is employed currently, her current payoff derives from the wage RW_j and the workplace atmosphere RAT_j she currently enjoys. If she is not, it derives from the leisure and UI payment she currently obtains. $UF_{j,t}$ denotes UF_j t periods later. [12]

We note at the second step that the above expected payoff depends on the probability that she will be dismissed k periods later by the firm that newly hires her for wage y. This probability is specified as

$$(14) \qquad \dot{P}_{DIj}(y,k) = \begin{cases} \frac{\alpha_{2j}}{100} - \frac{5}{1000}AB_j + \frac{\alpha_{3j}}{1000}y & \text{if } k > 0 \\ 0 & \text{if } k = 0 \end{cases}$$

where $0 \leq \dot{P}_{DIj}(y,k) \leq 1$. It is lower if her ability is higher or if the offered wage is lower.

The third step uses the above specifications to compute the present value of her benefit t periods later by subtracting the opportunity cost shown in (13) from the expected payoff in the newly hired firm. It equals

$$(15) \qquad \dot{u}_j(y,t) = \gamma_j^t \prod_{k=0}^{t}\left(1 - \dot{P}_{DIj}(y,k)\right)\left(\left(y + 5(5.5 - \mathrm{NAT}_j) - OPC_j(t)\right) + \left(\frac{\dot{P}_{DIj}(y,t)}{1 - \dot{P}_{DIj}(y,t)}\right)DC\right)$$

where γ_j is worker j's discount factor, i.e., $\gamma_j = 1/(1 + r_j)$. Since information about the workplace atmosphere of this firm is unavailable before working there, the value is assumed to be 5.5 or the average. The term that includes DC is for the severance pay that may be made t periods later. This paper considers the case where the dismissal cost equals the severance pay.

The fourth step is to sum the above benefit over her remaining periods. Since she needs to bear interview cost LIC_j to get hired, the summed benefit net of this cost equals the first component in the parentheses on the right hand side of (16) below. If it is negative, she will not request an interview. This implies that the present value of the expected benefit she will obtain by searching a firm that offers wage y and receiving a job offer is given by

$$(16) \qquad \ddot{u}_j(y) = max\left(\sum_{k=0}^{10-AG_j} \dot{u}_j(y,k) - \mathrm{LIC}_j, \quad 0\right)$$

where AGj denotes her age.

The fifth step is to assume that she has a subjective probability density function $P_{wj}(y)$ of wage offers, where y=1,2,…,150. This function is devised to approximate the normal distribution $N(EW_j,400)$.

The sixth step is to specify the probability that she will receive a job offer from a firm with which she will have an interview. It is assumed to depend on her ability AB_j and the wage offer y. Since the firm is more likely to offer a job if her ability is higher and the offered wage is lower, it is specified here as

$$(17) \qquad P_{IEj}(y) = \begin{cases} \frac{\alpha_{0j}}{100} + \frac{5}{1000}AB_j - \frac{\alpha_{1j}}{1000}y & \text{if } \ddot{u}_j(y) > 0 \\ 0 & \text{if } \ddot{u}_j(y) = 0 \end{cases}$$

where $0 \leq P_{IEj}(y) \leq 1$.

The seventh step is to compute the expected value of the above benefit for each number of searches. Suppose she searches SN_j firms that offer wages y_1, y_2, …, where $y_1 > y_2 >$…. Since workplace atmosphere is unknown to her when searching, the expected value is computed by considering only these wages as well as search costs and search subsidies. Use of (16) shows it equals $P_{IEj}(y_1)\ddot{u}_j(y_1) - SC_j + UF_jUIS$ when SN_j=1, $P_{IEj}(y_1)\ddot{u}_j(y_1) + \left(1 - P_{IEj}(y_1)\right)P_{IEj}(y_2)\ddot{u}_j(y_2) - 2\left(SC_j - UF_jUIS\right)$ when SN_j=2, and so forth. Thus, the present value of the expected benefit of searching SN_j firms equals

$$(18) \qquad \tilde{u}_j(SN_j) = \begin{cases} P_{IEj}(y_1)\ddot{u}_j(y_1) + \sum_{h=2}^{SN_j}\left(\prod_{m=1}^{h-1}\left(1 - P_{IEj}(y_m)\right)P_{IEj}(y_h)\ddot{u}_j(y_h)\right) - SN_j\left(SC_j - UF_jUIS\right) & \text{if } SN_j > 1 \\ P_{IEj}(y_1)\ddot{u}_j(y_1) - \left(SC_j - UF_jUIS\right) & \text{if } SN_j = 1 \end{cases}$$

The eighth step is to clarify the patterns of wage offers for each number of searches like Table 5. $P_{Wj}(y)$ produces the corresponding probabilities of those patterns. These considerations and (18) enable us to compute the present value of the expected benefit of her search for each number of searches.

The ninth is the final step, where she chooses SN_j so as to maximize the above benefit, although she will not undertake search if the maximized value is non-positive. As before, the computer ability requires $0 \leq SN_j \leq 3$.

5. Matching, adaptations, and dismissal

This section examines how worker-firm matches are determined. On the one hand, job searchers request interviews if (16) is positive. On the other hand, after holding interviews, Firm i chooses the applicant with the highest ability and computes the expected profit he generates or

$$(19) \qquad P_{EMi}(\cdot)\left(\sum_{k=0}^{10-x_2} \dot{\pi}_i(x_1, W_i, k) - OC_i\right)$$

where x_1 is his ability and x_2 his age, while P_{EMi} denotes i's subjective probability that he will accept its job offer. If this becomes positive, it offers a job to him. Next it applies the same procedure to the applicant with the second highest ability, then to the one with the third highest ability.

If worker j receives job offers, she chooses to work for the firm offering the highest wage. If not, she remains in her current status except in the case where she leaves her current employer and chooses not to work.

The simulations of this paper introduce simple adaptive behavior. It is assumed here that worker j's expected wage offer is adjusted as

$$EW_{j,t} = \frac{EW_{j,t-1} + \bar{W}_{j,t-1}}{2} \quad (20)$$

where $EW_{j,t}$ denotes her expected wage offer just before Period t and $\bar{W}_{j,t-1}$ the average wage observed in her searches just before Period t-1.[13]

Firm i's adaptation involves modifying its expectation of the average worker ability in its interview process.

$$EAB_{i,t} = \frac{EAB_{i,t-1} + \overline{AB}_{i,t-1}}{2} \quad (21)$$

where $EAB_{i,t}$ denotes the average ability expected just before Period t and $\overline{AB}_{i,t-1}$ the average ability observed in its interview process just before Period t-1.

Firm i also modifies ESN_i. It is assumed here for simplicity that the expected number equals that just before the previous period plus (minus) one if the actual number of searchers it had just before the previous period was larger (less) than it had expected. If both are the same, no modification is made. Since we have assumed that $1 \leq ESN_i \leq 3$, this modification is made only when this condition is satisfied.

In response to a shock, each firm decides whether to dismiss some of its workers. For Firm i to examine whether to dismiss its workers is almost equivalent to examining whether to offer jobs to them when it has no employees. The former, however, has a few differences from the latter. The first is that the workers accept job offers with certainty (P_{EMi}=1). The second is that the offered wages may differ among them since they were hired in different timings. The third is that the firm does not have to bear interview or training costs (IC=OC_i=0). The fourth is that it has to pay DC when it does not offer a job, i.e., when it dismisses the worker.

Firm i's profit maximization requires that it examine whether to dismiss its workers in the order of the magnitude of each worker's difference between MVP and wage, i.e., $F_i(AB_k)$-W_k. It dismisses a worker if the present value of the expected loss he will generate is larger than the dismissal cost.

Hence, the criterion for dismissal of the r-th worker in the above order is that

$$\sum_{k=0}^{10-x_{2,r}} \dot{\pi}_i(x_{1,r}, x_{3,r}, k) + \mathrm{DC} \qquad (22)$$

is negative, where $x_{1,r}$ is his ability, $x_{2,r}$ his age, $x_{3,r}$ the wage he is supposed to receive.

More precisely, when judging whether to dismiss the first worker, zero is substituted in $\dot{EL}_i$ in (10) to determine the sign of (22). In the case of the second, the same substitution is necessary if the firm has decided to dismiss the first. If not, it is necessary to substitute $(1\text{-}P_{LEi}(x_{1,1},x_{3,1}))$ or the probability that the first will not quit. In the case of the third, zero is substituted if it has decided to dismiss the first and second. If it dismisses the second but not the first, $(1\text{-}P_{LEi}(x_{1,1},x_{3,1}))$ needs to be substituted. If it dismisses the first but not the second, $(1\text{-}P_{LEi}(x_{1,2},x_{3,2}))$ needs to be substituted. If it dismisses neither the first nor the second, $(1\text{-}P_{LEi}(x_{1,1},x_{3,1}))$+ $(1\text{-}P_{LEi}(x_{1,2},x_{3,2}))$ needs to be substituted. The other cases are similar.

6. Simulation results: The unemployment rate and social welfare

Although the above multi-agent simulation model has an infinite time horizon, computation was carried out for the first fifty periods and the tables below show mostly the average values in those periods. The first few periods tend to have slightly 'abnormal' results, but they become negligible in those averages. In order to analyze the effects of various factors of unemployment, a set of different simulations were run for different parameter values as shown in Table 6. Each simulation in it is numbered with Simulation 1 being the basis for comparison. Only the values different from those for Simulation 1 are shown for the other simulations. All the other parameters in Tables 1 through 3 are given the same values. It needs to be added, however, that the specific firms each job searcher searched differ across simulations.[14]

Obviously the simulation results obtained by the above method depend on the initially given set of parameter values. Different results are obtained if a different set of values are given. The authors tried several different sets of simulations based on different values and found that they produce mostly similar results. The discussions in this and the next sections are based mainly on the set of simulation results that are shown as representative in the tables below but partly use some results from other sets of simulations.

Table 7 shows basic simulation results. Special attention is paid to the unemployment rate and social welfare. The former stands for the portion of those who undertook job search but became unemployed among those with the intention to work. The latter is defined as firm payoff plus worker payoff minus government subsidies, where firm payoff equals the sum of the profits of all firms while worker payoff the sum of the payoffs of all workers.

We first make a comparison between Simulations 1 and 2. The difference is only the values of BI(b), i.e., BI(-1)=0.8, BI(0)=1.0, BI(1)=1.2 in the former, while BI(-1)=0.6, BI(0)=1.0, BI(1)=1.4 in the latter. Namely, the fluctuation in the latter is a mean-preserving spread of that in the former.

Result 1: The unemployment rate, social welfare, the number of employed persons, firm payoff, and worker payoff are all worse in a more fluctuating economy.

This is derived under the assumption that all agents are risk-neutral.

Policy Implication 1: Even if firms and workers are risk-neutral, government policies that stabilize the economy improve both the unemployment rate and social welfare.

The second comparison is between Simulations 1 and 3. Productivity is higher in the latter.

Result 2: A productivity increase improves the unemployment rate, social welfare, the number of employed persons, firm payoff, and worker payoff.

Policy Implication 2: Government policies that increase worker productivity improve the unemployment rate and social welfare.

Thirdly, we examine Simulations 1, 4, and 5. Worker search costs are twice or three times as high in the latter two. The results are not simple.

Result 3: Higher worker search costs tend to improve the unemployment rate, social welfare, the number of employed persons, and firm payoff, but reduce worker payoff.

The worker payoff in Simulation 5 is slightly higher than that in Simulation 4 although worker search costs are higher in the former. The comparison between these two simulations implies that there are cases in which higher search costs improve all the above indices. However, higher worker search costs decrease worker payoff in many simulations. The authors have a result in which too high worker search costs increase the unemployment rate and decrease the number of employed persons. Result 3 might be slightly counter-intuitive, but reasonably high worker search costs tend to be beneficial as they may reduce firm transaction costs and worker mobility.

Policy Implication 3: Policies that reduce worker search costs may increase the unemployment rate and reduce social welfare.

Too generous services of public employment agencies may increase the rate of unemployment. Job searches that rely heavily on the Internet may have a similar effect. Decreases in workers' search costs are likely to increase firms' transaction costs. These findings suggest that it is naïve to assume that lower search costs reduce the unemployment rate.

Fourthly, we compare Simulations 1 and 6. Worker interview costs are twice as high in the latter. One may expect a result similar to that of the third comparison, but there is some difference.

Result 4: If worker interview costs are high, the unemployment rate is low, the number of employed persons is large, and firm payoff is high, but both worker payoff and social welfare are low.

Higher worker interview costs again make workers less mobile and firm transaction costs correspondingly lower. Yet a difference arises since workers request interviews only when they expect to improve their current status. In contrast, job searches are mostly for information collection. High interview costs tend to deprive workers of their otherwise lucrative opportunities.

The fifth comparison is between Simulations 1 and 7. Firm interview costs are twice as high in the latter.

Result 5: If firm interview costs are high, the unemployment rate is high, the number of employed persons is small, and firm payoff, worker payoff, and social welfare are all low.

Policy Implication 4: Policies that reduce firm interview costs improve all of the unemployment rate, the number of employed persons, social welfare, firm payoff, and worker payoff.

Such policies are likely to entail costs, so their cost performance needs to be considered.

The sixth comparison is between Simulations 1 and 8. Firm orientation and training costs are twice as high in the latter.

Result 6: If orientation and training costs are high, the unemployment rate is high, the number of employed persons is small, and firm payoff, worker payoff, and social welfare are all low.

Since the MVP is assumed to be the same between Simulations 1 and 8, a shift from the latter to the former is interpreted as an increase in the rate of return to human capital investment.

Result 7: If orientation and training have higher returns, the unemployment rate is lower and the number of employed persons is larger, and firm payoff, worker payoff, and social welfare are all higher.

This is similar to Result 2.

Next comparison is made between Simulations 1 and 9. The latter has a UI system in which an unemployed person receives payment for not more than two periods. In order to distinguish between the effects of income compensation and search subsidies of such a system, it is assumed here to apply to those who have just been dismissed or have experienced one period of unemployment even if they do not undertake searches. The effect of search subsidies is discussed below.

Result 8: A UI system of income compensation tends to increase the unemployment rate and decrease the number of employed persons, but it increases worker payoff and social welfare. It either increases or decreases firm payoff.

Table 7 suggests that this system decreases firm payoff, but the opposite result is obtained in some other simulations. Other simulations also have a case where this system reduces the unemployment rate. Note that the insurance payment is deducted when computing social welfare.

The eighth comparison is between Simulations 1 and 10. In the latter, the government provides job searchers with subsidies, which are deducted from social welfare.

Result 9: When the government subsidizes worker search, social welfare and firm payoff decrease, although worker payoff increases. The unemployment rate and the number of employed persons either become better or worse.

The second part of the above result relies on other simulation results as well. A UI system that has the effect of reducing worker search costs can have adverse effects. Government subsidies for job searches may prompt them and increase the total transaction costs in the economy.

Ninthly we compare Simulations 1 and 11. In the latter, the government subsidizes firms for employment. This policy has strikingly favorable effects.

Result 10: If the government subsidizes firms in proportion to their number of employees, the unemployment rate, social welfare, the number of employed

persons, firm payoff, and worker payoff all improve.
It should be noted again that the subsidies are deducted when computing social welfare. The above two comparisons have the following implication.
Policy Implication 5: The government should subsidize employment rather than worker searches.

Is there a way to eliminate the government deficit created by the above policy without worsening the economy? Simulation 12 is a trial based on this question, where the government taxes worker incomes so that it does not have a deficit. A comparison between Simulations 1 and 12 reveals that the policy combination of employment subsidies and income tax improves the unemployment rate, the number of employed persons, and firm payoff, but reduces worker payoff and social welfare, the latter of which now contains net government revenues. The authors have not yet found simulation results with improved social welfare for this policy combination. However, since the level of social welfare in Simulation 11 is larger than that in Simulation 1, a different tax method such as a poll tax system would eliminate the government deficit.

The final comparison is between Simulations 1 and 13. In the latter, firms provide their dismissed workers with severance pay, which becomes their dismissal costs.
Result 11: A severance pay rule improves the unemployment rate, social welfare, and worker payoff, although it either betters or worsens firm payoff. The part regarding firm payoff relies on other simulation results as well. It can be shown that this rule greatly decreases the dismissal rate.
Policy Implication 6: Since firms do not always have incentives to institute a severance pay rule, the government should force them to have such a rule to improve the unemployment rate and social welfare.

From the above considerations a conclusion can be drawn regarding practical policies. The most powerful policies that reduce the unemployment rate and increase social welfare are stabilization of the economy, employment subsidies, and institutionalization of a severance pay rule.

7. Simulation results: The structure of unemployment

This section analyzes mainly how the unemployment rates differ across different worker groups. Table 8 is compiled from Simulation 1 to reveal the relationships between basic worker/firm attributes and values of unemployment related variables. It makes it possible to disclose the structure of unemployment and detect the properties of the segmented labor markets.

The row for Age/Unemployment Rate in the table shows how the rates of unemployment differ among different worker ages. The result has a highly significant negative relationship between age and the unemployment rate, which is consistent with the real economy. The three youngest ages have the highest rates, while ages 7, 8, and 9 have the lowest. Interestingly the rate of the oldest workers is slightly high.

Result 12: The rate of unemployment of younger workers tends to be high, but that of the oldest workers is not the lowest.

Younger workers tend to have fewer search experiences and less likely to obtain suitable jobs. As workers grow older, they are more likely to encounter firms that better suit their abilities and preferences. The unemployment rate of the oldest age group is slightly high because their short future lessens the returns to their investment in job searches and makes unemployment resulting from fewer searches relatively attractive. Another reason is that the oldest workers are more likely to become unemployed due to fewer searches in order to utilize the system of unemployment payments.

These observations are nearly consistent with the segmented labor market theory in which younger workers tend to work in unstable external labor markets and some of them will be employed later in internal labor markets. In fact the row for Age/Number of Searches in the table shows the following.

Result 13: There is a very significant negative relationship between age and the number of job searches.

The row for Age/Quit Rate uncovers a related result.

Result 14: There is a negative relationship between age and the quit rate.

The row for Ability/Unemployment Rate clarifies the relationship between worker ability and the unemployment rate. It is negative and significant.

Result 15: The lower the worker ability, the higher the unemployment rate.

This is consistent with the real economy and the segmented labor market theory where those who are less mobile, i.e., those who are employed in internal labor markets, tend to have higher trainability.

It can be seen in the row for Characteristic/Dismissal Rate that there is a nearly significant negative relationship between firm characteristic and dismissal rate.

Result 16: The larger the difference in productivity between high and low ability workers, the lower the dismissal rate of the firm.

This is another result that strengthens the segmented labor market theory. This phenomenon is primarily due to the fact that firms with larger values of CH_i are unlikely to dismiss high-ability workers once hired because most new searchers they encounter are those with lower abilities in comparison.

Next, we see the relationship between worker search cost and the rate of unemployment. The row for Search Cost/Unemployment Rate shows that the rate of unemployment of those whose search cost equals 10 is more than twice as high as those of the others.

Result 17: Those whose search cost is the highest have the highest unemployment rate.

This result partially describes the real economy and is likely to induce many to advocate a policy subsidizing worker search to reduce unemployment. As Result 9 shows, however, such a policy tends to reduce social welfare and may increase the rate of unemployment of the whole economy. This could be an example of a policy based on a microeconomic observation that leads to an unpredicted result.

The row for Atmosphere/Unemployment Rate demonstrates the relationship between the atmosphere desired by workers and the rate of unemployment.

Result 18: Those who desire a better workplace atmosphere tend to be more likely to be unemployed.

The row for Leisure/Unemployment Rate shows the relationship between the valuations workers put on leisure and the rate of unemployment.

Result 19: Those who place a higher value on leisure tend to be more likely to be unemployed.

Perhaps these two results are also partially consistent with the real economy.

8. Concluding remarks

This paper attempted multi-agent simulations that determine the rate of unemployment, social welfare, the number of employed persons, and so forth without using a matching function. Workers and firms bear transaction costs for job matching, while the government may control them through subsidies or regulations. Different types of workers and firms were considered to analyze the structure of unemployment and detect some properties of the segmented labor market theory. Several policy implications were derived.

Since major results and policy implications are itemized in Sections 6 and 7, only a few remarks are added here. First, against the neoclassical economic view, highly flexible labor markets are not necessarily efficient when firms and workers bear transaction costs. Secondly, the government can play an important role in improving employment and social welfare, and should act to subsidize employment and institute a severance pay rule as well as stabilize the economy. Thirdly, the unemployment rates are quite different across different types of workers. Lastly, it should be added that although simulations are not good at making general propositions, they reveal what happens in certain conditions and help advance counter intuitive hypotheses.

Notes

1. Some authors point out limitations of the use of a matching function. Several examples follow. Cole and Rogerson (1999) demonstrate that the Mortensen-Pissarides model can account for the business-cycle facts only if the average duration of a nonemployment spell is relatively high—about nine months or longer. Hall (2005) argues that this model, which is based on a Nash bargain, cannot explain the magnitude of movements in recruiting activity. Shimer (2005) is critical since it requires implausibly large shocks to labor productivity to create substantial variation in such basic variables as unemployment, vacancies, and the vacancy to unemployment ratio. Beauchemin and Tasci (2014) claim that it lacks a mechanism that would give rise to procyclical labor reallocation and procyclical matching efficiency.
2. The authors know a country where a typical job applicant needs to go through two or three interviews with a firm with different interviewers in each. Usually, detailed knowledge of the firm and industry is necessary for those interviews. However, the simulations here assume that each firm requires only one interview of each job applicant.
3. Even those who have no intention to work are called workers in this paper for simplicity.
4. Even when b=0, we say for simplicity that there is an economic shock.
5. There is neither dismissal nor quitting before the first period. The

difference between the first and the other periods may not be explicitly referred to below to simplify exposition.

6. Strictly speaking, the subscript of W_k and AB_k should be the worker's name, but this paper uses notations that economize symbol usage. Similar notes also apply to other parts of the paper, but these will not cause misunderstandings.

7. It is assumed that the level of EF becomes known through the government and/or mass media and EF=50 when computing (4) just before the first period.

8. It is assumed again that the level of WL becomes known through the government and/or mass media and WL=1000 for B(WL, P_{si}) just before the first period.

9. Worker abilities are unknown before interviews but the variable x for ability needs to be introduced here to compute the expected value later.

10. SLA is a number rounded off to the nearest integer. The firms regard the age of all searchers as the average age of 5.5 just before the first period. The information about SLA is assumed to be provided by the government and/or mass media.

11. The simulations of this paper consider wage levels from 1 to 150, which is not unreasonable since the average wage chosen by the firms is mostly in the range between 60 and 100.

12. The current status just before the first period is 'not employed currently.'

13. If she did not search just before Period t-1, her expected wage remains the same as before. A similar note applies to the firm adaptation below.

14. Strictly speaking, $P_{ABi}(x)$ and $P_{wj}(y)$ are also different across the simulations, but these are very minor differences.

References

Albertini, Julien, and Fairise, Xavier, "Search Frictions, Real Wage Rigidities and the Optimal Design of Unemployment Insurance," *Journal of Economic Dynamics and Control,* September 2013, v. 37, iss. 9, pp. 1796-1813

Altman, Morris, "Involuntary Unemployment, Macroeconomic Policy, and a Behavioral Model of the Firm: Why High Real Wages Need Not Cause High Unemployment," *Research in Economics,* June 2006, v. 60, iss. 2, pp. 97-111

Baker, George, and Holmstrom, Bengt, "Internal Labor Markets: Too Many

Theories and Too Few Facts." *American Economic Review,* vol. 84, 1995, pp.255-59.

Beauchemin, Kenneth, and Tasci, Murat; "Diagnosing Labor Market Search Models: A Multiple-Shock Approach." *Macroeconomic Dynamics,* April 2014, v. 18, iss. 3, pp. 548-72

Bentolila, Samuel, and Bertola, Giuseppe. (1990). 'Firing costs and labour demand: how bad is Eurosclerosis?', *Review of Economic Studies,* vol. 57, no. 3, pp. 381–402.

Blanchard, Olivier Jean, and Diamond, Peter A. "Ranking, Unemployment Duration, and Wages," *Review of Economic Studies,* July 1994, v. 61, iss. 3, pp. 417-34

Blanchard, Olivier J., and Tirole, Jean, "The Joint Design of Unemployment Insurance and Employment Protection: A First Pass," *Journal of the European Economic Association,* March 2008, v. 6, iss. 1, pp. 45-77

Cain, Glen. G., "The Challenge of Segmented Labor Market Theories to Orthodox Theory: A Survey," *Journal of Economic Literature*, vol. 14, 1976, pp. 1215-57.

Cole, Harold L., and Rogerson, Richard, "Can the Mortensen-Pissarides Matching Model Match the Business-Cycle Facts?" *International Economic Review,* November 1999, v. 40, iss. 4, pp. 933-59

Doeringer, Peter, B., and Piore, Michael, *Internal Labor Markets and Manpower Analysis*. Heath and Company: Massachusetts, 1971.

Fredriksson, Peter, and Holmlund, Bertil, "Improving Incentives in Unemployment Insurance: A Review of Recent Research," *Journal of Economic Surveys,* July 2006, v. 20, iss. 3, pp. 357-86

Hall, Robert E., "Employment Fluctuations with Equilibrium Wage Stickiness," *American Economic Review,* March 2005, v. 95, iss. 1, pp. 50-65

Hopenhayn, Hugo, and Rogerson, Richard, "Job Turnover and Policy Evaluation: A General Equilibrium Analysis," *Journal of Political Economy,* October 1993, v. 101, iss. 5, pp. 915-38

Ljungqvist, Lars, "How Do Lay-Off Costs Affect Employment?" *Economic Journal,* October 2002, v. 112, iss. 482, pp. 829-53

Mortensen, Dale T., and Pissarides, Christopher A. "Job Creation and Job Destruction in the Theory of Unemployment." *Review of Economic Studies*, 1994, *61*(3), pp. 397–415.

Nickell, Stephen, Nunziata, Luca, and Ochel, Wolfgang, "Unemployment in the OECD Since the 1960s: What Do We Know?" *Economic Journal,* January 2005, v. 115, iss. 500, pp. 1-27

Osterman, Paul. "Choice of Employment Systems in Internal Labor Markets." *Industrial Relations,* vol. 26, 1987, pp. 46-67.

Petrongolo, Barbara, and Pissarides, Christopher A. "Looking into the Black Box: A Survey of the Matching Function." *Journal of Economic Literature*, 2001, *39*(2), pp. 390–431.

Piore, Michael J., "The Dual Labor Market: Theory and Implications," in D. M. Gordon ed. *Problems of Political Economy: An Urban Perspective.* Heath: Lexington, Mass., 1971.

Piore, Michael J., "Notes for a Theory of Labor Market Stratification," in R. C. Edwards, M. Reich, and D. M. Gordon eds., *Labor Market Segmentation,* Heath: Lexington, Mass., 1975.

Piore, Michael J., "Dualism in the Labor Market: A Response to Uncertainty and Flux. The Case of France." *Revue Economique,* vol.19, 1978, pp.26-48.

Pissarides, Christopher. A. (2000) *Equilibrium Unemployment Theory*, Cambridge: MIT Press.

Postel-Vinay, Fabien, and Turon, Helene, "The Impact of Firing Restrictions on Labour Market Equilibrium in the Presence of On-the-Job Search," *Economic Journal,* March 2014, v. 124, iss. 575, pp. 31-61

Pries, Michael J., "Persistence of Employment Fluctuations: A Model of Recurring Job Loss," *Review of Economic Studies,* January 2004, v. 71, iss. 1, pp. 193-215

Shimer, Robert, "The Cyclical Behavior of Equilibrium Unemployment and Vacancies," *American Economic Review,* March 2005, v. 95, iss. 1, pp. 25-49

Taubman, Paul, and Wachter, Michael L., "Segmented Labor Markets." In O. Ashenfelter and R. Layard eds. *Handbook of Labor Economics,* vol.2, North-Holland: Amsterdam, 1986.

Topel, Robert H., "Experience Rating of Unemployment Insurance and the Incidence of Unemployment," *Journal of Law and Economics,* April 1984, v. 27, iss. 1, pp. 61-90

Yashiv, Eran, "The Determinants of Equilibrium Unemployment," *American Economic Review,* December 2000, v. 90, iss. 5, pp. 1297-1322

Appendix

List of endogenous variables

Variable	Definition
$\dot{BI}_i$	Firm i's expected impact of b on its MVP
EF	number of firms that intended to hire workers in the previous period
EL_i	number of workers Firm i employs
$\dot{EL}_i$	Firm i's expected number of incumbents
EN_i	number of new employees of Firm i
F_i	MVP of a worker employed by Firm i
IN_j	number of interviews Worker j has
OPC_j	expected payoff Worker j has by keeping her current status
P_{ABi}	Firm i's subjective probability density function of worker ability
$\dot{P}_{DIj}$	Worker j's subjective probability that she will be dismissed
P_{EMi}	Firm i's subjective probability that an interviewee will accept its job offer and work for it
P_{IEj}	Worker j's subjective probability that she will receive a job offer from a firm with which she will have an interview
P_{LEi}	Firm i's subjective probability that its worker will quit just before the coming period
P_{Si}	Firm i's subjective probability that each worker will search it
P_{SPi}	probability that n workers search Firm i
P_{WAi}	Firm i's subjective probability that a worker who searched it will request an interview
P_{Wj}	Worker j's subjective probability density function of wage offers
RAT_j	real atmosphere of Worker j's workplace
RN_i	number of workers Firm i dismissed just now
RW_j	Worker j's current wage
SN_j	number of firms Worker j searches
$\dot{u}_j$	present value of Worker j's benefit obtainable t years later from the newly hired firm

$\ddot{u}_j$	present value of Worker j's total benefit obtainable from the newly hired firm
$\tilde{u}_j$	present value of Worker j's expected benefit of searching firms
UF_j	Worker j's qualification for unemployment subsidies
W_i	Firm i's wage offer
W_j	wage Worker j receives
WL	total number of searchers in the previous period
WN_i	number of interviewees of Firm i
$\dot{\pi}_i$	present value of Firm i's expected profits t periods later generated by a newly hired worker
$\ddot{\pi}_i$	present value of Firm i's total expected profits from an interviewed worker
$\approx\!\pi$	present value of Firm i's total expected profits from a worker who searches it

Table 1. Distributions of major firm parameters

Parameter	Definition	Distribution
AT_i	Firm i's workplace atmosphere	1-10
CH_i	Firm i's productivity-related characteristic	6-15
EAB_i	Firm i's subjective average ability of all workers (subject to adaptation)	4-7
EBC_i	Firm i's expected number of periods for which the current level of economic state continues	1-5
ESN_i	Firm i's expectation of the number of firms the average worker searches (subject to adaptation)	1-3
OC_i	Firm i's orientation and training cost per new employee	$CH_i * 2$
s_i	Firm i's discount rate	0.05-0.15
β_{0i}	Firm i's parameter for its subjective probability of the worker's having an interview with it	31-40
β_{1i}	Firm i's parameter for its subjective probability of the worker's having an interview with it	1-5
β_{2i}	Firm i's parameter for its subjective probability of the worker's accepting its job offer	21-30
β_{3i}	Firm i's parameter for its subjective probability of the worker's accepting its job offer	1-5
β_{4i}	Firm i's parameter for its subjective probability of the worker's accepting its job offer	1-5
β_{5i}	Firm i's parameter for its subjective probability of the worker's accepting its job offer	1-3
β_{6i}	Firm i's parameter for its subjective probability of the worker's leaving it	1-30
β_{7i}	Firm i's parameter for its subjective probability of the worker's leaving it	1-5
β_{8i}	Firm i's parameter for its subjective probability of the worker's leaving it	1-5

*2 indicates a multiplication.

Table 2. Distributions of major worker parameters

Parameter	Definition	Distribution
AB_j	Worker j's productive ability	1-10
AG_j	Worker j's age	1-10
EW_j	Worker j's subjective expected wage offer (subject to adaptation)	75 in period 1
L_j	Worker j's valuation of leisure	1-10
LIC_j	Worker j's costs of having an interview	16-20
NAT_j	workplace atmosphere desired by Worker j	1-10
r_j	Worker j's discount rate	0.05-0.15
SC_j	Worker j's costs of job search	6-10
α_{0j}	Worker j's parameter for job offer probability	81-100
α_{1j}	Worker j's parameter for job offer probability	1-5
α_{2j}	Worker j's parameter for dismissal probability	1-20
α_{3j}	Worker j's parameter for dismissal probability	1-3

Table 3. Parameters common to all agents

Parameter	Definition
b	economic state
BC	number of periods for which the current level of economic state has continued
BI	magnitude of the impact of economic state on the marginal value productivity
DC	dismissal cost (severance pay) per dismissed worker
IC	firm interview cost per interviewee
PC	parameter for a productivity increase
PR	value by which the marginal product decreases within the same firm
SLA	average age of those who were unemployed or those who searched on the job in the previous period (adjusted each period)
UEY	employment subsidy paid per worker to the employing firm
UIS	subsidy per search given to an unemployed person
UIT	maximal number of periods of unemployment insurance payment
UIY	insurance money paid in a period to an unemployed person

Table 4. Patterns and probabilities of the abilities of workers who search Firm i

Number of Searchers	Probability	First Searcher	Second Searcher	Third Searcher	Probability
1	$P_{SPi}(1)$	1			$P_{ABi}(1)$
. . . .		2			$P_{ABi}(2)$
		. . .			
		10			$P_{ABi}(10)$
2	$P_{SPi}(2)$	1	1		$P_{ABi}(1) * P_{ABi}(1)$
. . . .		1	2		$P_{ABi}(1) * P_{ABi}(2)$
		. . .			
		10	10		$P_{ABi}(10) * P_{ABi}(10)$
3	$P_{SPi}(3)$	1	1	1	$P_{ABi}(1) * P_{ABi}(1) * P_{ABi}(1)$
. . . .		1	1	2	$P_{ABi}(1) * P_{ABi}(1) * P_{ABi}(2)$
		. . .			
		10	10	10	$P_{ABi}(10) * P_{ABi}(10) * P_{ABi}(10)$

Table 5. Patterns and probabilities of wage offers

Number of Searched Firms	y_1	y_2	y_3	Probability
1	1			$P_{wj}(1)$
.	2			$P_{wj}(2)$
.	.			.
.	.			.
.	150			$P_{wj}(150)$
2	1	1		$P_{wj}(1) * P_{wj}(1)$
.	2	1		$P_{wj}(2) * P_{wj}(1)$
.	.			.
.	.			.
.	150	150		$P_{wj}(150) * P_{wj}(150)$
3	1	1	1	$P_{wj}(1) * P_{wj}(1) * P_{wj}(1)$
.	2	1	1	$P_{wj}(2) * P_{wj}(1) * P_{wj}(1)$
.	.			.
.	.			.
.	150	150	150	$P_{wj}(150) * P_{wj}(150) * P_{wj}(150)$

Table 6. Values of the parameters

	IC	OC	SA	PR	UIS	UIY	UIT	UEY	PC	LTR	BI	SC	LIC
1	5	*1	0	2.5	0	0	0	0	0	0	(0.8, 1.0, 1.2)	*1	*1
2											(0.6, 1.0, 1.4)		
3									1				
4												*2	
5												*3	
6													*2
7	10												
8		*2											
9						40	2						
10					20		2						
11								10					
12								10		13			
13			25										

*1, *2, and *3 indicate multiplications.

Table 7. The Unemployment rate and social welfare

	Unemployment Rate	Number of Employees	Firm Payoff	Worker Payoff	Social Welfare
1	6.35	936.02	23925.38	61067.46	84992.84
2	10.76	892.02	20390.36	58008.58	78398.94
3	5.65	943.48	30685.48	72514.86	103200.34
4	5.67	942.36	26043.56	59399.40	85442.96
5	4.31	955.10	29556.44	59482.02	89038.46
6	6.02	938.48	24589.33	51278.26	75867.59
7	19.07	808.78	4220.26	42976.62	47196.88
8	8.49	914.38	22569.28	55360.42	77929.70
9	6.58	927.72	23001.49	65623.54	87088.23
10	6.80	932.00	22806.62	64008.84	78860.66
11	5.75	942.36	31693.18	66541.56	88809.14
12	5.36	945.06	25848.64	54098.54	80713.62
13	5.93	940.58	23465.80	63167.68	86633.48

Table 8. Structure of unemployment

	1	2	3	4	5	6	7	8	9	10	Correlation Coefficient	p
Age/Unemployment Rate	8.64	10.38	7.42	6.60	5.66	5.28	4.62	4.66	4.54	5.71	−0.83	0.00
Age/Number of Searches	2.98	2.13	1.07	0.71	0.53	0.46	0.42	0.37	0.33	0.24	−0.84	0.00
Age/Quit Rate		43.89	15.63	7.29	4.34	2.49	1.84	1.41	0.93	0.18	−0.75	0.01
Ability/Unemployment Rate	42.39	16.92	3.25	1.08	0.10	0.02	0.02	0.00	0.00	0.00	−0.70	0.03
Characteristic/Dismissal Rate	4.64	11.16	3.37	3.20	4.84	2.12	2.22	5.15	0.88	2.74	−0.55	0.10
Search Cost/Unemployment Rate						5.85	6.36	6.19	6.04	12.89	0.72	0.17
Atmosphere/Unemployment Rate	5.22	6.29	6.15	6.37	6.04	5.43	6.93	5.94	7.78	7.22	0.66	0.04
Leisure/Unemployment Rate	5.78	5.73	5.77	6.52	6.58	6.09	7.15	6.27	6.79	6.85	0.76	0.01

Numbers 1 through 10 in the top row indicate the levels of the parameters written before the slash marks in the first column. The other numbers are the corresponding values of the variables written after the slash marks. The levels of Characteristic should actually be those indicated above plus 5 as shown in Table 2, a simplification to economize space.