Endogenous Labor Force Participation and Firing Costs

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Abstract

I construct a matching model to explain the labor market transition between employment, unemployment and nonparticipation, and evaluate the quantitative effects of firing costs. The model has several features that are distinguished from previous studies: endogenous labor force participation, different job-search decisions and imperfect insurance markets. I find that the model is able to account for the U.S. labor market, especially the gross labor-force transition rates. I also find that firing costs as a type of firing tax have a negative effect on the layoff rate, the job-finding probability and the participation rate. In particular, the effect of a decrease in the job-finding probability is greater than the effect of a decrease in the layoff rate, and this results in an increase in the unemployment-to-population ratio. Finally, firing costs make individuals' job tenures longer and skew the asset distribution to the right.

Keywords: Search and Matching, Labor Force Participation, Firing Costs

JEL Classification: E24, J21, J64, J65

*The views expressed herein are those of the author and do not necessarily reflect the views of the Bank of Korea.

1 Introduction

Any policy that affects one of the three states of employment, unemployment and out-of-the-labor-force (OLF) also affects other states, because the employment-to-population ratio, unemployment rate and participation rate are jointly determined. For that reason, this paper builds up a model having both a labor force participation decision and a job search decision, and evaluates labor market policies such as firing costs.

Most existing studies which explain the dynamics of individual labor market decisions have postulated a fixed labor force size and analyzed models having only two labor force states: employment and unemployment. In reality, however, the labor force size is not fixed, because people move not only within the labor force but also into and out of it. The models with only employment and unemployment cannot account for individuals who move in and out of the labor force. In addition, since the unemployed in these models cannot but search for work, the models cannot capture the labor force participation decision through the job search decision, either. For that reason, I introduce another labor force status, *out-of-the-labor-force* (OLF), and make a distinction between unemployment and OLF to fully characterize the possible individual labor force decisions.

There have been other attempts to explain the individual search decisions based on models having employment, unemployment and OLF. Garibaldi and Wasmer (2005), Hæfke and Reiter (2006) and Pries and Rogerson (2008), among others, extend the Mortensen and Pissarides (1994) matching model to incorporate OLF. However, these studies have limitations in terms of predicting individual labor market transitions.

The first type of distinction between unemployment and OLF *à la* Garibaldi and Wasmer (2005) and Hæfke and Reiter (2006) is made on the basis of whether a person is searching or not. The unemployed are defined as those who are searching for work, and nonparticipants as those who are not searching for work. Since the unemployed find a job with some probability but nonparticipants thus do not, transitions from OLF to employment are not made. For that reason, Hæfke and Reiter (2006) set the model period to one-week, to enable the transitions from OLF to employment in their model. We cast doubt on that method, however, because their classification is inconsistent with the classification of the Current Population Survey (CPS), and even the steady-state version of their model does not very well predict what the data on the transition probabilities show.

The second type of distinction *à la* Pries and Rogerson (2008) is made on the basis of whether a person is searching actively or inactively. The unemployed are defined as those who are searching actively, and nonparticipants as those who are searching inactively. An active search implies a search with high intensity and an inactive search one done with low intensity, so that an active searcher has a high job-finding probability and an inactive searcher a low one. Since all nonparticipants have employment opportunities, Pries and Rogerson (2008) can explain a high transition rate from unemployment to employment and a low transition rate from OLF to employment. In the actual data, however, not all nonparticipants are actually job-searchers. Moreover, we cannot find such large flows from unemployment to OLF without sizable idiosyncratic shocks such as market or non-market productivity shocks.

In this paper, I build up a matching model in which workers are risk-averse and can be employed, unemployed or out of the labor force. Workers who have employment opportunities decide whether to work or not, while workers who have no employment opportunities decide whether to search or not. The job-finding process has two steps. In the first step, each worker receives a piece of information on possible employment opportunities. Those who have a more promising piece of information are more likely to search, and based on how promising the information is each worker decides whether to search or not. In the second step, workers who decide to search make search efforts and take costly actions. In the model, the search decision then depends on the quality of search signal, meaning "how promising a piece of information is," and on the worker's asset holdings.

I also attempt to make labor force classifications consistent with the CPS. According to the CPS definition, the unemployed are persons aged 16 years and older who had no employment during the reference week and had made specific efforts to find employment sometime during the four-week period ending with the reference week. The CPS definition of unemployment captures two important features of unemployment. The first is that the unemployed did search for work during the last four weeks before the survey interview. The second is that they were not employed at the time of the interview. In the standard Mortensen and Pissarides (1994) matching model, in which there are only employment and unemployment, the unemployed include both those who have not found employment or have separated and those who are currently looking for work. The law of motion for unemployment from the standard model shows that the current-period unemployment is then determined by the former group, while determining the latter group.

To be consistent with the CPS, in this paper, persons in the state of unemployment are defined as those who search but do not find employment, as well as those who have worked and separated involuntarily.[1] Nonparticipants are on the other hand defined as those who do not search or those who have worked and quit voluntarily. In addition to the assumption that workers are risk-averse, it is also assumed that there are no available insurance markets. Workers save and accumulate an interest-bearing asset which can be used to smooth their consumption across labor force states.

I find that my model is able to account for the U.S. labor market, especially the gross labor-force transition rates. This is in marked contrast to the Pries and Rogerson (2008) model, in which the large flows from unemployment to OLF, the so-called discouraged worker effect, are not found without idiosyncratic shocks such as market or non-market productivity shocks. Second, the model also accounts for the transitions from OLF to the labor force in an intuitively appealing way. In particular, this can be done without assuming that nonparticipants have employment opportunities or adjusting the time period of the model.

When it comes to the effects of firing costs as a type of firing tax, numerical experiments show two important effects. First, we find that firing costs have a negative effect on both the layoff rate and the job-finding probability. In other words, firing costs reduce the number of endogenous separations as well as that of vacancies posted. For reasonable parameter values, the effect of a decrease in the job-finding probability is greater than the effect of a decrease in the layoff rate, and this results in an increase in the unemployment-to-population ratio. Second, firing costs also have a negative effect on the participation rate. A decrease in the layoff rate makes individuals' job tenures longer and causes a skewing of asset distribution to the right. The number of workers who are located outside the participation margin increases, and the participation rate decreases.

Early investigations of the effects of firing restrictions were undertaken by Bentolila and Bertola (1990) and Bertola (1990), who analyzed a partial equilibrium model to study the consequences of firing and hiring costs in the labor demand of a monopolist. Hopenhayn and Rogerson (1993) were the first to perform a general equilibrium analysis, but they did not consider search frictions and incomplete insurance markets. They find that a tax on job destruction has a sizable negative impact on total employment, and welfare losses are large. Later on, Alvarez and Veracierto (2001) extended Hopenhayn and Rogerson (1993) model and introduced labor market frictions and incomplete insurance markets. Unlike Hopenhayn and Rogerson (1993), they find that firing restrictions can have large positive

[1] Krusell et al. (2008) define the unemployed as those who would like to work at the given market wage rate but are not able to find employment.

effects on employment and welfare. They do not, however, consider endogenous labor force participation decisions.[2] To my knowledge, this is the first work which investigates the effects of firing costs under environments of an incomplete market and endogenous labor force participation decisions.

This paper is structured as follows. The model economy is introduced in Section 2, and is calibrated in Section 3. The steady-state equilibrium of the model and the effects of firing costs are analyzed in Section 4. Section 5 concludes.

2 Model

The model is a variant of the Mortensen and Pissarides (1994) matching model and the Bils, Chang and Kim (2007) model. In my model, workers can be employed, unemployed or out of the labor force.

2.1 Environments

There is a continuum of infinitely-lived and risk-averse workers with total mass equal to one. Each worker has preferences defined by

$$E_0 \sum_{t=0}^{\infty} \beta^t \Big\{ \ln c_t + B^u I_t^s \big(1 - I_t^w\big) + B^o \big(1 - I_t^s\big)\big(1 - I_t^w\big) \Big\} \tag{1}$$

where $0 < \beta < 1$ is the discount factor and c_t is consumption. I_t^w is an indicator function which takes a value of one if the worker is working and zero otherwise. I_t^s is an indicator function which takes a value of one if the worker is looking for a job and zero otherwise. Parameters B^u and B^o denote the utilities from leisure when looking for a job and out of the labor force, respectively.

A worker who has asset holdings a_t faces the following budget constraint:

$$c_t + a_{t+1} = (1+r)a_t + w_t I_t^w + h\left(1 - I_t^w\right) \tag{2}$$

$$a_{t+1} \geq 0 \tag{3}$$

[2] Ljungqvist (2002) studies the effects of higher layoff costs in a matching model, but he does not consider worker heterogeneity, incomplete markets or nonparticipation. Veracierto (2007) also evaluates the effects of tenure-dependent firing taxes. Although he explicitly considers nonparticipation, he does not have heterogeneity because his model is based on the Lucas and Prescott (1974) island model.

where a_{t+1} is the next-period asset holdings, w_t wages and h household production. Workers are not allowed to borrow, so that a_{t+1} is greater than zero.

There is also a continuum of identical firms (or entrepreneurs). Each firm maximizes the discounted present value of profits:

$$E_0 \sum_{t=0}^{\infty} \left(\frac{1}{1+r} \right)^t \pi_t \tag{4}$$

where π_t is the firm's profit in period t. With the assumption of a small open economy, the interest rate r is given exogenously.

In each period, firms can be active or vacant. An active firm is one that is matched with a worker and is currently producing output using a production technology, denoted by z, which z is idiosyncratic match-specific productivity and follows an AR(1) process in logs:

$$\ln z' = \rho \ln z + \epsilon \tag{5}$$

where ρ is the persistence parameter and ϵ is a normal random variable with mean 0 and standard deviation σ. We let $\pi\left(z_j | z_i\right)$ denote the discretized Markov process which is equivalent to $\Pr\left[z_{t+1} = z_j | z_t = z_i\right]$. All active firms face an exogenous separation probability, denoted by λ.

A vacant firm is one that is posting a vacant position and looking for a worker. At the end of each period, all vacant firms find a worker with some probability, denoted by q, and production begins at the highest value of match-specific shock, denoted by $\overline{z}$. I assume that firms can create a job without cost, but have to pay k units of the consumption good to post a vacant position.

The number of new matches between vacancies and job-searchers is determined by a matching function which ensures that the probability of finding a job and of filling a vacancy lies between 0 and 1. Following den Haan, Ramey and Watson (2000) and Hagedorn and Manovskii (2008), I choose

$$m\left(u, v\right) = \frac{uv}{\left(u^\alpha + v^\alpha\right)^{1/\alpha}} \tag{6}$$

where u is an efficiency unit of the number of job-searchers, v is the number of vacancies and α is the parameter of the matching function. A job-seeker who has search intensity or search signal quality s will find a job with probability $sp\left(\theta\right) = sm\left(u, v\right)/u = s\left(1 + \theta^{-\alpha}\right)^{-1/\alpha}$, and a firm will meet a worker with probability $q = m\left(u, v\right)/v = \left(1 + \theta^\alpha\right)^{-1/\alpha}$, where θ denotes the vacancy-to-searcher ratio.

2.2 Information Quality

The individual job search decision consists of two parts. In the first part, each individual obtains job related information without any effort or any cost. For example, one can look over the help wanted classifieds when reading a newspaper or one can hear from friends about vacancy openings. Based on such costless information, each individual constructs an expectation about the job-finding probability and then decides whether to search or not. In the second part, individuals who decide to search have to take costly actions to obtain a job, such as filling out applications, writing resumes, and going to job interviews.[3]

I extend the Mortensen and Pissarides (1994) and Bils, Chang and Kim (2007) matching models to allow people to react to information quality. There are many locations in the model economy among which some have vacancies. Workers do not know the locations where matches actually take place, but firms know. Each person who does not have employment opportunities receives a signal with quality (or precision) s, where the signal indicates the locations where matches take place and the attached quality shows the validity of the signal. Once a person receives a signal with quality s, the signal is correct with probability s while it is meaningless with probability $1-s$. The probability that a person arrives at the locations with vacancies is then s.

Signal quality is generated by the following logistic function of random variable x, because signal quality s lies between 0 and 1:

$$s = \frac{e^x}{1+e^x} \tag{7}$$

where random variable x follows an AR(1) process:

$$x' = \rho_x x + (1-\rho_x)\,\overline{x} + \eta \tag{8}$$

where $\overline{x}$ is the unconditional mean, ρ_x is the persistence parameter and η is a normal random variable with mean 0 and standard deviation σ_η. We let $\pi_s\left(s_j|s_i\right)$ denote the discretized Markov process which is equivalent to $\Pr\left[s_{t+1}=s_j|s_t=s_i\right]$. Meanwhile, workers who have employment opportunities but decide not to work also receive signal quality s_i

[3]For more details, see Moon (2007).

with probability $\widetilde{\pi}_s(s_i)$, which is the discretized unconditional probability distribution $\Pr[s_t = s_i]$.

2.3 Labor Force Classification

At the beginning of each period, there are three types of workers (based on the classifications made one period before): employed, unemployed and OLF. Workers who are classified as unemployed or OLF in the last period receive a signal with quality and then choose to search or not. If they choose not to search, they are classified as *OLF*. If they choose to search, then they are classified as either *employed* or *unemployed*, depending upon the match outcomes. That is, those who search and find employment are classified as *employed*, and those who search but do not find employment as *unemployed*.

The employed, who observe an idiosyncratic match-specific productivity shock, choose whether to work on their current jobs or not. Those choosing to work separate with probability λ at the end of that period. The separatees are classified as *OLF* if the exogenous separations are regarded as voluntary separations, while those who do not separate are classified as *employed*. On the other hand, those who choose not to work receive a signal with quality, and then decide whether to search or not. Their labor force classifications are made in the same way as for unmatched workers.

2.4 Recursive Equilibrium

2.4.1 Value Functions

The individual worker's problem can be formulated recursively. Let $W(a,z)$ denote the value function for a worker who decides to work, $U(a,s)$ the value function for a worker who decides to search and $O(a,s)$ the value function for a worker who decides to neither work nor search, where a denotes asset holdings, z idiosyncratic match-specific productivity, and s signal quality.

A worker who does not have employment opportunities decides whether to search or not based on his(her) signal quality. The unmatched workers solve the following decision problem:

$$N(a,s) = \max\Big\{U(a,s), O(a,s)\Big\} \tag{9}$$

We let $I^s(a,s)$ denote the unmatched worker's decision function which is 1 if $U(a,s) \geq O(a,s)$ and otherwise zero.

The value function for a worker who decides to search is given by

$$
\begin{aligned}
U(a,s) &= \max_{c_u, a'_u} \Big\{ \ln c_u + B^u + \beta (1-sp) E\Big[N(a'_u, s') \,|s\Big] \\
&\qquad + \beta sp E\Big[\max\Big\{W(a'_u, \overline{z}), N(a'_u, s')\Big\}|s\Big]\Big\}
\end{aligned} \tag{10}
$$

subject to

$$
\begin{aligned}
c_u + a'_u &= (1+r)a + h \\
a'_u &\geq 0
\end{aligned}
$$

The value function for a worker who decides to neither work nor search is given by

$$
O(a,s) = \max_{c_o, a'_o} \Big\{ \ln c_o + B^o + \beta E\Big[N(a'_o, s') \,|s\Big]\Big\} \tag{11}
$$

subject to

$$
\begin{aligned}
c_o + a'_o &= (1+r)a + h \\
a'_o &\geq 0
\end{aligned}
$$

A worker who has an employment opportunity decides whether to work or not after (s)he observes the idiosyncratic match-specific productivity shock. Matched workers solve the following decision problem:

$$
\max\Big\{W(a,z), N^e(a)\Big\} \tag{12}
$$

where $N^e(a) = \sum_i N(a, s_i)\, \widetilde{\pi}_s(s_i)$. We let $I^w(a,z)$ denote the matched worker's decision function, which is 1 if $W(a,z) \geq N^e(a)$ and otherwise zero.

The value function for a worker who decides to work is given by

$$
\begin{aligned}
W(a,z) &= \max_{c_w, a'_w} \Big\{ \ln c_w + \beta \lambda N^e(a'_w) \\
&\qquad + \beta (1-\lambda) E\Big[\max\Big\{W(a'_w, z'), N^e(a'_w)\Big\}|z\Big]\Big\}
\end{aligned} \tag{13}
$$

subject to

$$
\begin{aligned}
c_w + a_w' &= (1+r)a + w(a,z) \\
a_w' &\geq 0
\end{aligned}
$$

The firm's problem is also formulated recursively. Let $J(a,z)$ denote the value function to a firm matched with a worker. The value function of a matched firm is then

$$
\begin{aligned}
J(a,z) &= z - w(a,z) + \frac{1}{1+r}\lambda(V-\chi) \\
&\quad + \frac{1}{1+r}(1-\lambda)E\Big[\max\Big\{J(a_w'(a,z),z'),V-\chi\Big\}|z\Big]
\end{aligned} \tag{14}
$$

where V is the value of unfilled vacancy, $a_w'(a,z)$ the matched worker's optimal saving function, and χ the firing cost the firm pays when the match is broken up.

The equilibrium number of job vacancies is determined by the following free-entry condition which states that vacancies earn zero profits, $V=0$:

$$
k = \frac{1}{1+r}q(\theta)E\Big[\max\Big\{J(a_u'(a,s),\overline{z}),V\Big\}\Big] \tag{15}
$$

where k is the job posting cost, $q(\theta)$ the firm's matching probability, $a_u'(a,s)$ the job-searcher's optimal saving function, and the expectation operator E is taken with respect to the next period distribution of workers who arrive at the locations with vacancies.

2.4.2 Wage Determination

Let $S(a,z)$ denote the match surplus between a worker and a firm. The match surplus is defined to be the sum of the payoffs of the worker and the firm, depending upon whether or not work occurs at that period:

$$
S(a,z) = W(a,z) - N^e(a) + J(a,z) - V + \chi \tag{16}
$$

The wage is derived by assuming that fixed fractions of the surplus accrue to the worker and to the firm. That is, the total match surplus is shared according to the Nash product:

$$
w(a,z) = \arg\max\Big(W(a,z) - N^e(a)\Big)^{\gamma}\Big(J(a,z) - V + \chi\Big)^{1-\gamma} \tag{17}
$$

subject to the match surplus given in Eq(16), where γ is the worker's bargaining power.

2.4.3 Distributions of Workers

Let $\phi^m(a,z)$ denote the beginning-of-period number of matched workers and $\phi^n(a,s)$ the beginning-of-period number of unmatched workers. Recall that the matched workers are those who have an employment opportunity and the unmatched workers those who do not. Matched workers then choose whether to work or not, and unmatched workers whether to search or not.

First, the number of employed workers, $\mu^e(a,z)$, is

$$\mu^e(a,z) = I^w(a,z)\,\phi^m(a,z) \tag{18}$$

Second, the number of job-seekers, $\mu^u(a,s)$, is

$$\mu^u(a,s) = I^s(a,s)\left\{\widetilde{\pi}_s(s)\sum_z\Big[1 - I^w(a,z)\Big]\phi^m(a,z) + \phi^n(a,s)\right\} \tag{19}$$

Finally, the number of nonparticipants, $\mu^o(a,s)$, is

$$\mu^o(a,s) = \Big[1 - I^s(a,s)\Big]\left\{\widetilde{\pi}_s(s)\sum_z\Big[1 - I^w(a,s)\Big]\phi^m(a,z) + \phi^n(a,s)\right\} \tag{20}$$

For all (a',z'), the next-period number of matched workers, $\phi^m(a',z')$, satisfies

$$\phi^m(a',z') = \sum_{\Omega^w}\pi(z'|z)(1-\lambda)\,\mu^e(a,z) + 1\{z' = \overline{z}\}\sum_{\Omega^u} sp\mu^u(a,s) \tag{21}$$

where $1\{A\}$ is an indicator function which takes one if A is true and for all (a',s'), the next-period number of unmatched workers, $\phi^n(a',s')$, satisfies

$$\begin{aligned}\phi^n(a',s') \;&=\; \widetilde{\pi}_s(s')\sum_{\Omega^w}\lambda\mu^e(a,z) + \sum_{\Omega^u}\pi_s(s'|s)(1-sp)\,\mu^u(a,s)\\ &\quad + \sum_{\Omega^o}\pi_s(s'|s)\,\mu^o(a,s)\end{aligned} \tag{22}$$

where $\Omega^w = \{(a,z)\,|a' = a'_w(a,z)\}$, $\Omega^u = \{(a,s)\,|a' = a'_u(a,s)\}$ and $\Omega^o = \Big\{(a,s)\,|a' = a'_o(a,s)\Big\}$.

2.4.4 Definition of Equilibrium

Equilibrium consists of value functions $\{W(a,z),\ U(a,s),\ O(a,s),\ N(a,s),\ J(a,z),\ V\}$, optimal consumption and saving functions $\{c_w(a,z),\ c_u(a,s),\ c_o(a,s),\ a'_w(a,z),\ a'_u(a,s),\ a'_o(a,s)\}$, optimal decision functions $\{I^w(a,z),\ I^s(a,s)\}$, Nash bargaining wages $w(a,z)$, a vacancy-to-searcher ratio θ, and a law of motion for the distribution $(\phi^{m\prime}, \phi^{n\prime}) = T(\phi^m, \phi^n)$, such that

1. Taking the vacancy-to-searcher ratio, the Nash bargaining wages, the measures of workers, and the law of motion as given, the optimal saving functions $a'_w(a,z)$, $a'_u(a,s)$ and $a'_o(a,s)$ solve the Bellman equations (13), (10), and (11), respectively.

2. Taking the value functions, the measures of workers and the law of motion as given, the decision functions $I^w(a,z)$ and $I^s(a,s)$ solve (12) and (9), respectively.

3. Taking the value functions as given, the Nash bargaining wages solve (17).

4. Taking the Nash bargaining wages, the decision functions, the firm's value functions, the measures of workers and the law of motion as given, the free-entry condition is satisfied.

5. Taking the optimal saving functions and the decision functions as given, the law of motion for the distribution is described in (18)-(22).

2.4.5 Labor Force States

As mentioned above, the unemployed are defined as the job-searchers who look for work but do not find employment, and those who find employment are then classified as employed. The employment rate, denoted by E, is given by

$$E = \sum_{a,z} (1-\lambda)\, \mu^e(a,z) + \sum_{a,s} sp\mu^u(a,s) \tag{23}$$

The unemployment-to-population ratio is given by

$$U = \sum_{a,s} (1-sp)\, \mu^u(a,s) \tag{24}$$

Finally, since OLF consists of those who have been working but separated exogenously with probability λ and those who do not search, the nonparticipation rate is given by

$$O = \sum_{a,z} \lambda \mu^e (a, z) + \sum_{a,s} \mu^o (a, s) \tag{25}$$

3 Calibration

A time period is normalized to be one month, and the interest rate r is therefore set to .4868 percent, equivalent to an annual interest rate of 6 percent. The worker's bargaining power γ is set to .5. Following Andolfatto (1996), the worker-finding probability is set to $q = .5358$ which is equivalent to quarterly worker-finding probability .9. The aggregate job-finding probability p is set to .9, so that the steady state vacancy-to-searcher ratio θ is given by 1.69. Given p, q and θ, I choose α which satisfies $q = (1 + \theta^\alpha)^{-1/\alpha}$, so that α is set to 2.4543.[4] I assume that household production h is 10 percent of the average wage. The monthly discount factor β is chosen so that the model economy displays an average level of assets equal to 36 months of labor earnings.[5] A monthly exogenous separation rate of 1.5 percent is chosen because the transition rate from working to nonworking is about 3 percent in Table 1. I assume that half of separations are exogenous, so that $\lambda = .015$. Following Bils, Chang and Kim (2007), the persistence of the match-specific shock ρ and the standard deviation of the match shock σ are set to .97 and .0058, respectively. I choose B^u and B^o so that the employment rate and the unemployment-to-population ratio of the model economy are close to the U.S. data, 61.67 percent and 4.06 percent, respectively.[6] Finally and most importantly, the mean of signal quality which takes a value between 0 and 1 is set to .5, so that the unconditional mean of signal-generating random variable x is $\overline{x} = 0$. By assuming the persistence of the signal-generating random variable is the same as the persistence of the match-specific shock, ρ_x is set to .97. I vary only the standard deviation of the signal quality shock σ_η, so that the model economy replicates the U.S. gross labor force transition rates given in Table 1. All parameter values are summarized in Table 2

[4] den Haan, Ramey and Watson (2000) choose 1.27.

[5] Bils, Chang and Kim (2007) choose the discount factor so that the model economy displays an average of assets equal to 18 months of labor earnings. In their model, however, there is no nonparticipation.

[6] During Jan. 1978 - Dec. 2005, the seasonally adjusted BLS series show that the employment rate is 61.67 percent, the unemployment-to-population ratio 4.06 percent, the nonparticipation rate 34.28 percent and the unemployment rate 6.19 percent.

Table 1: Gross Labor-Force Transition Rates for the CPS, 1978-2005, Percent Per Month

(1) Unadjusted

		To		
		Working	Unemployed	Not in Labor Force
From	Working	95.62	1.49	2.89
	Unemployed	26.66	51.23	22.11
	Not in Labor Force	4.63	2.56	92.82

(2) Adjusted with Abowd and Zellner (1985, Table 5) correction

		To		
		Working	Unemployed	Not in Labor Force
From	Working	97.05	1.19	1.76
	Unemployed	22.33	63.42	14.25
	Not in Labor Force	2.79	2.27	94.94

Source: Robert Shimer's tabulations of raw data from the CPS

Table 2: Parameter Values

Parameter	Description	Values
r	monthly interest rate	.004868
γ	worker's bargaining power	.5
θ	steady-state vacancy-to-searcher ratio	1.69
α	matching function parameter	2.4543
h	household production	.104
β	discount factor	.994718
λ	exogenous separation rate	.015
ρ	persistence of match-specific shock	.97
σ	standard deviation of the shock	.0058
ρ_x	persistence of the signal quality	.97
$\overline{x}$	unconditional mean of the signal quality	0
σ_η	conditional standard deviation of the signal quality	.4
B^u	utility from leisure when searching	.9788
B^o	utility from leisure when out of the labor force	1.0956

4 Results

In this section, I begin by presenting the results from the model of search intensity developed by Pries and Rogerson (2008), and then turn to the model of signal quality.

4.1 Investigating the Model of Search Intensity

I examine the model of search intensity developed by Pries and Rogerson (2008). Pries and Rogerson (2008) classify people on the basis of whether a person is searching actively or inactively. The unemployed are those who search actively with intensity s^h, while nonparticipants are those who search inactively with intensity s^l. The unemployed workers' and nonparticipants' job-finding probabilities are given by $s^h p$ and $s^l p$, respectively, where p is the aggregate job-finding probability. To be consistent with the model described in Section 2, I develop a model of search intensity in which workers are risk-averse. The detailed model is given in the Appendix.

All parameters are set according to Table 2 except for β, B^u, B^o, s^h and s^l. Similarly, the monthly discount factor, β, is chosen so that the model economy displays an average level of assets equal to 36 months of labor earnings. The utilities from leisure when looking for a job, B^u, and when out of the labor force, B^o, are set to .9246 and 1.0679, respectively, so that the employment rate and the unemployment-to-population ratio of the model economy are close to the U.S. data, 61.67 percent and 4.06 percent. The search intensity when unemployed, s^h, and the search intensity when out of the labor force, s^l, are set to .247 and .031, respectively, so that the transition rates from unemployment to employment and from OLF to employment are also close to the U.S. data, 22.33 percent and 2.79 percent, respectively.

Table 3: Parameter Values for Model of Search Intensity

Parameter	Description	Values
β	discount factor	.994839
s^h	high search intensity	.247
s^l	low search intensity	.031
B^u	utility from leisure when searching	.9246
B^o	utility from leisure when out of the labor force	1.0679

Table 4 displays the aggregate statistics of the model of search intensity. It is worth noting that in the second panel of Table 4 there are no transitions from unemployment to OLF. To see why this happens, we need to look at Figure 1. Figure 1 demonstrates that the distinction between unemployment and OLF is made based on the amount of assets. Those who accumulate more than a certain amount of assets become nonparticipants and search for work inactively, while those who accumulate less than a certain amount of assets remain unemployed and search actively. Since all workers in the model have insufficient income while they are not working and face borrowing constraints, they cannot move from unemployment to OLF.

Table 4 also shows that the transition rates from unemployment to employment and from OLF to employment can be explained by the job-finding probabilities, $s^h p$ and $s^l p$, which are 22.2 percent ($= .247 \times .9$) and 2.8 percent ($= .031 \times .9$), respectively. Since the unemployed cannot move to OLF, the transitions from unemployment to unemployment consist of the unemployed who do not find employment. On the other hand, the transitions from OLF to unemployment involve those who find no employment, lose assets while they are out of the labor force, and realize that an active search is better than an inactive search.

Table 4: Model of Search Intensity

(1) Aggregate Statistics

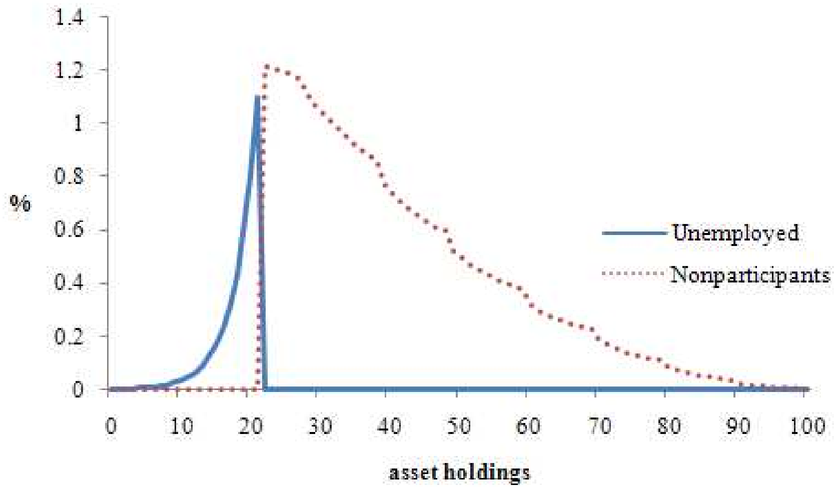
E	U	O	$U/(E+U)$	$\overline{w}$	$\overline{a}$
61.67%	4.06%	34.27%	6.18%	1.03	35.56

(2) Transition Rates

		To		
		Employed	Unemployed	OLF
From	Employed	96.97	0.28	2.76
	Unemployed	22.37	77.63	<u>0.00</u>
	OLF	2.81	2.15	95.04

Note: E denotes the employment rate, U the unemployment-to-population ratio, O the nonparticipation rate, $\overline{w}$ average wages, and $\overline{a}$ average asset holdings.

Figure 1: Steady State Distribution from Model of Search Intensity



4.2 Model of Signal Quality: Steady State without Firing Costs

I turn now to *the model of signal quality* developed in Section 2. The results are given in Table 5 and Figure 2. Table 5 displays the model statistics, and Figure 2 shows the steady state distribution of the unemployed and nonparticipants over their asset holdings.

In the model of signal quality, the unemployed are defined as those who search but do not find employment, and it is assumed that each unmatched worker observes signal quality. Each individual's job-finding probability is expressed as the aggregate job-finding probability weighted by the signal quality in his hands, *sp*, and we focus on a worker's *threshold signal quality*, the signal quality at which the worker is indifferent between searching and non-searching.

Figure 2, in which the distribution of the unemployed and the distribution of nonparticipants overlap, demonstrates that those who hold more assets are less likely to search because they have a high threshold signal quality, while those holding less assets are more likely to search because they have a low threshold. It is straightforward that those having high threshold signal qualities also have high possibilities of finding jobs if they decide to search.

Note that the model of signal quality is able to show the transitions from unemployment to OLF, 10.7 percent, given in the second panel of Table 5. This is in marked contrast to the result from the model of search intensity. How can we explain those who move from unemployment to OLF? The transitions from unemployment to OLF are made when

Table 5: Model of Signal Quality

(1) Aggregate Statistics

E	U	O	$U/(E+U)$	$\overline{w}$	$\overline{a}$
61.70%	4.06%	34.23%	6.18%	1.04	35.76

(2) Transition Rates

		To		
		Employed	Unemployed	OLF
	Employed	97.90	0.19	1.91
From	Unemployed	26.35	62.96	10.69
	OLF	3.30	4.05	92.65

Note: E denotes the employment rate, U the unemployment-to-population ratio, O the nonparticipation rate, $\overline{w}$ average wages, and $\overline{a}$ average asset holdings.

the unemployed who found no employment during the last period receive signals of lower quality than their thresholds, and decide to leave the labor force. Rather than incur the costs associated with job search activities, they decide to drop out of the labor force. This is quite consistent with the *discouraged worker effect*.[7]

For nonparticipants who find non-searching to be a better choice than searching, on the other hand, if they lose some of their assets they will respond to a signal quality of sufficiently high value, because nonsearching is no longer a better choice. Given a signal of such quality, they will decide to search and find a job with that degree of probability.

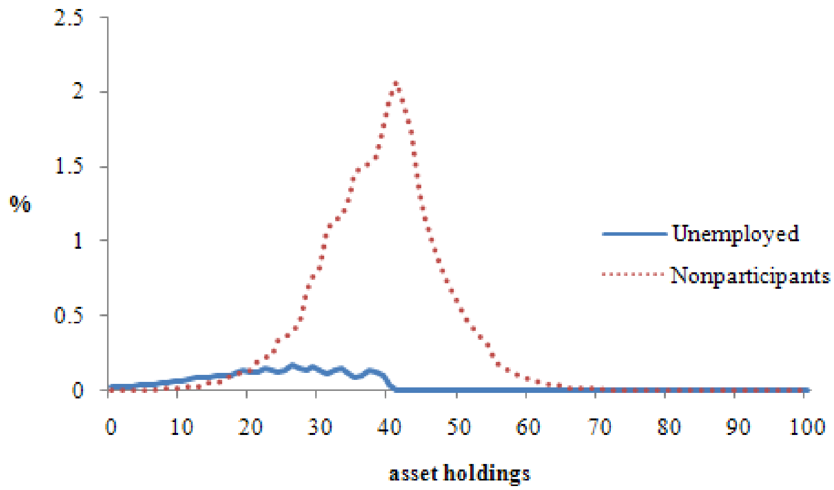
The U.S. data given in Table 1 shows the transition rate from unemployment to employment, denoted by $tr(UE)$, and the transition rate from unemployment to unemployment, $tr(UU)$, to be 26.4 percent and 63.0 percent, respectively. On the other hand, the transition rate from OLF to employment, $tr(OE)$, and the transition rate from OLF to unemployment, $tr(OU)$, are 2.8 percent and 2.3 percent, respectively. The relationship can be written as follows:

$$\frac{tr\,(UE)}{tr\,(UU)} < 1 < \frac{tr\,(OE)}{tr\,(OU)} \tag{26}$$

The above inequality (26) shows that the average probability with which the unemployed find a job is much less than the average probability with which those out of the labor force

[7]The discouraged worker effect is associated with the business cycle, and leads the labor force participation rate to a relationship with the business cycle. While we do not consider business cycles in this paper, we can easily find large flows from unemployment to OLF in the data.

Figure 2: Steady State Distribution from Model of Signal Quality



find a job conditional on deciding to search.

The model underpredicts $tr(OE)$ and overpredicts $tr(OU)$: $tr(OE)$ is 3.3 percent in the model but 2.8 percent in the data, and $tr(OU)$ 4.1 percent in the model but 2.3 percent in the data. The model, nevertheless, has the same *qualitative* implication:

$$\frac{tr\,(UE)}{tr\,(UU)} < \frac{tr\,(OE)}{tr\,(OU)} \tag{27}$$

The ratio between $tr(UE)$ and $tr(UU)$ is $.42 (= 26.35/62.96)$, and the ratio between $tr(OE)$ and $tr(OU)$ is $.81 (= 3.30/4.05)$. This is one of the important contributions made in this paper. Note that the unemployed have a relatively low threshold signal quality while nonparticipants have a relatively high threshold signal quality. Suppose workers who were classified as unemployed in the last period decide to search. We can guess that their average job-finding probability will be low, because they are willing to search even if they receive a low signal quality. This leads to the low rate of transition from unemployment to employment, and the high rate from unemployment to unemployment. In contrast, suppose workers who were classified as OLF in the last period decide to search. In this case we can guess that the average job-finding probability will be relatively high, because they respond only to high signal quality. The rate of transition from OLF to employment is therefore not much less than that of transition from OLF to unemployment.

Table 6: Effects of Firing Costs

	none	20%	40%	60%	80%	100%
E	61.70	61.42	61.07	60.52	59.81	59.34
U	4.06	4.13	4.24	4.33	4.49	4.66
O	34.23	34.45	34.70	35.15	35.70	36.00
$U/(E+U)$	6.18	6.30	6.49	6.68	6.99	7.28
EU	0.19	0.19	0.19	0.18	0.18	0.17
EO	1.91	1.88	1.86	1.81	1.74	1.69
UE	26.35	25.92	25.68	25.20	24.54	23.62
UO	10.69	10.88	10.75	10.83	11.02	10.99
OE	3.30	3.20	3.05	2.84	2.59	2.43
OU	4.05	4.07	4.12	4.13	4.17	4.20
wages	1.04	1.04	1.03	1.03	1.03	1.03
assets	35.76	36.21	36.74	37.61	38.74	39.33
V/S	1.69	1.51	1.33	1.17	1.02	0.91

4.3 Effects of Firing Costs

This subsection discusses the effects of introducing firing costs, as a type of firing tax, to the model economy. In the search and matching model, firing costs cannot be much greater than job posting costs; otherwise, no firm will post its vacancy. For that reason, firing taxes that the government levies are introduced as a fraction of the steady-state job posting cost. It is also assumed that firing taxes are not rebated to agents, and neither workers nor firms receive payments from the government.

Table 6 shows the effects of firing costs on the labor market variables. First, firing costs have a negative effect on the layoff rate. Figure 3 shows that firing costs lower threshold productivity. Once firing costs are introduced, firms continue their matches at a productivity level at which they would not when there are no firing restrictions. As a consequence, the existence of firing costs reduces separations.

Second, firing costs have a negative effect on the job-finding probability. Firing costs reduce the firm's expected value from a match, and in turn reduce the number of vacancies posted. The equilibrium vacancy-to-searcher ratio, denoted by V/S, decreases. A decrease in the vacancy-to-searcher ratio leads to a decrease in the job-finding probability as well as in the UE and OE transition rates. In the model, the effect of a decrease in the job-finding probability is much greater than the effect of a decrease in the layoff rate, and this results in an increase in the unemployment-to-population ratio.

Figure 3: Threshold Productivity

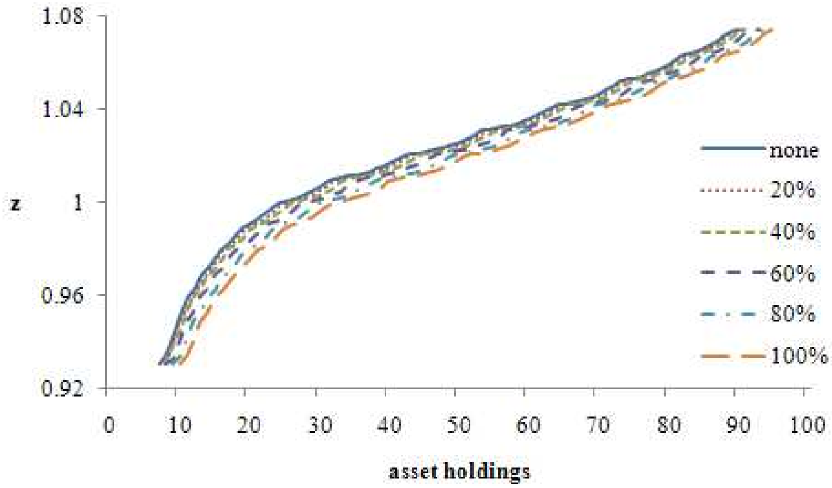


Figure 4: Distribution of Unemployment

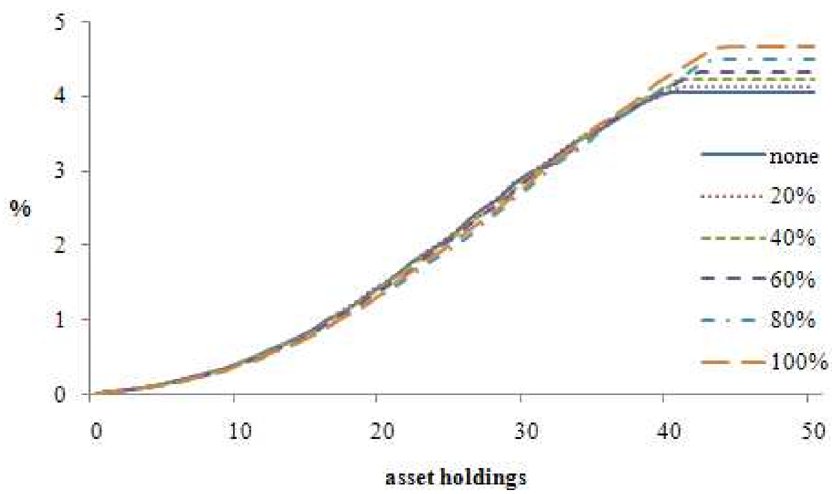
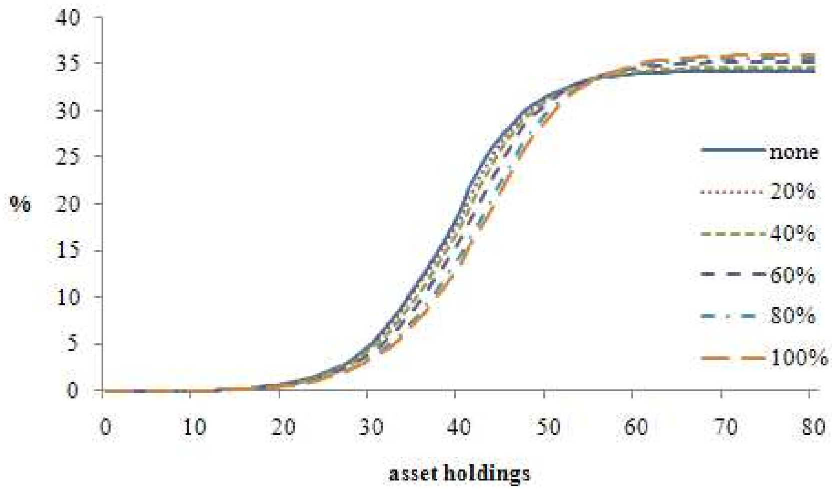


Figure 5: Distribution of OLF



Finally, firing costs have a negative effect on the participation rate. A decrease in the layoff rate due to firing costs makes individuals' job tenures longer and skew the asset distribution to the right as in Figure 4 and 5. The number of workers who are located outside the participation margin increases, and the participation rate decreases. Therefore, an increase in the unemployment rate follows.

5 Conclusion

In this paper, I construct a matching model in which workers are risk-averse and can be employed, unemployed or out of the labor force. The job-finding process has two steps: it the first step, each worker receives a piece of information on possible employment opportunities, and based on how promising the piece of information is each decides whether to search or not. In the second step, those who decide to search make search efforts and take costly actions. As nonparticipation is brought into the model, the distinction between unemployment and OLF is made in a way consistent with the classification of the Current Population Survey.

A calibrated version of the model shows that the U.S. labor market, especially the gross labor-force transition rates between employment, unemployment and OLF, is accounted for. In particular, the transition between employment and OLF, and the transition between unemployment and OLF can be explained without assuming nonparticipants have employment opportunities or adjusting the time period of the model.

Once firing costs are introduced as a firing tax, numerical experiments show that firing costs have a negative effect on the layoff rate and the job-finding probability. The effect of a decrease in the job-finding probability is greater than the effect of a decrease in the layoff rate, and this results in an increase in the unemployment-to-population ratio. Firing costs also have a negative effect on the participation rate. A decrease in the layoff rate makes individuals' job tenures longer and skew the asset distribution to the right. The number of workers who are located outside the participation margin increases, and the participation rate decreases.

A Appendix

A.1 Model of Search Intensity

The individual worker's problem is formulated recursively. Let $W(a, z)$ denote the value function for a worker who decides to work, $U(a)$ the value function for a worker who decides to search actively, and $O(a)$ the value function for a worker who decides to search inactively, where a denotes asset holdings and z idiosyncratic match-specific productivity.

A worker who does not have employment opportunities decides whether to search actively or inactively. The unmatched workers solve the following decision problem:

$$N(a) = \max\Big\{U(a), O(a)\Big\} \tag{A-1}$$

The worker's value of an active search is

$$\begin{aligned} U(a) \;=\; \max_{c_u, a'_u}\Big\{ & \ln c_u + B^u + \beta\left(1 - s^h p\right) N(a'_u) \\ & + \beta s^h p E\Big[\max\Big\{W(a'_u, \overline{z}), N(a'_u)\Big\}\Big]\Big\} \end{aligned} \tag{A-2}$$

subject to

$$\begin{aligned} c_u + a'_u &= (1+r)a + h \\ a'_u &\geq 0 \end{aligned}$$

where s^h denotes high search intensity and p the equilibrium job-finding probability.

The worker's value of an inactive search is

$$
\begin{aligned}
O(a) &= \max_{c_o, a'_o} \Big\{ \ln c_o + B^o + \beta \left(1 - s^l p\right) N(a'_o) \\
&\qquad + \beta s^l p E\Big[\max\Big\{W(a'_o, \bar{z}), N(a'_o)\Big\}\Big]\Big\}
\end{aligned} \tag{A-3}
$$

subject to

$$
\begin{aligned}
c_o + a'_o &= (1+r)a + h \\
a'_o &\geq 0
\end{aligned}
$$

where s^l denotes low search intensity.

A worker who has an employment opportunity decides whether to work or not after (s)he observes the idiosyncratic match-specific productivity shock. The matched workers solve the following decision problem:

$$
\max\Big\{W(a,z), N(a)\Big\} \tag{A-4}
$$

The worker's value of working is

$$
\begin{aligned}
W(a,z) &= \max_{c_w, a'_w} \Big\{ \ln c_w + \beta \lambda N(a'_w) \\
&\qquad + \beta (1-\lambda) E\Big[\max\Big\{W(a'_w, z'), N(a'_w)\Big\} | z\Big]\Big\}
\end{aligned} \tag{A-5}
$$

subject to

$$
\begin{aligned}
c_w + a'_w &= (1+r)a + w(a,z) \\
a'_w &\geq 0
\end{aligned}
$$

The value function to a firm matched with a worker is given by equation (14). The equilibrium number of job vacancies is however determined by the following free-entry condition, which states that vacancies earn zero profits:

$$\begin{aligned} k &= \frac{1}{1+r} q f^h \sum_a \max\Big\{ J\left(a_u'\left(a\right), \overline{z}\right), V \Big\} \frac{\mu^u\left(a\right)}{u} \\ &\quad + \frac{1}{1+r} q f^l \sum_a \max\Big\{ J\left(a_o'\left(a\right), \overline{z}\right), V \Big\} \frac{\mu^o\left(a\right)}{o} \end{aligned} \tag{A-6}$$

where k is the job posting cost, $q\left(\theta\right)$ the firm's matching probability, $a_u'\left(a\right)$ and $a_u'\left(a\right)$ the active searchers' and inactive searchers' optimal saving functions, respectively, μ^u and μ^o the active searchers' and inactive searchers' measures, respectively, and u and o the total numbers of active searchers and of inactive searchers, respectively. In addition, f^h and f^l represent the relative search intensities of job-searchers defined as:

$$f^h = \frac{s^h u}{s^h u + s^l o} \tag{A-7}$$

$$f^l = \frac{s^l o}{s^h u + s^l o} \tag{A-8}$$

Similar to equation (17), the wage is determined by generalized Nash bargaining. The difference from (17) is that the worker's threat point is given by $N(a)$:

$$w\left(a, z\right) = \arg\max \Big(W\left(a, z\right) - N\left(a\right) \Big)^{\gamma} \Big(J\left(a, z\right) - V + \chi \Big)^{1-\gamma} \tag{A-9}$$

Let $\mu^e\left(a, z\right)$, $\mu^u\left(a\right)$ and $\mu^o\left(a\right)$ denote the time-invariant measures of workers who are employed, unemployed (searching actively) and out of the labor force (searching inactively), respectively. For all $\left(a', z'\right)$, the next-period number of employed workers, $\mu^e\left(a', z'\right)$, satisfies

$$\begin{aligned} \mu^e\left(a', z'\right) &= \sum_{\Omega^w} I^w\left(a', z'\right) \pi\left(z'|z\right) \left(1-\lambda\right) \mu^e\left(a, z\right) \\ &\quad + 1\left\{z' = \overline{z}\right\} \sum_{\Omega^u} I^w\left(a', z'\right) s^h p \mu^u\left(a\right) \\ &\quad + 1\left\{z' = \overline{z}\right\} \sum_{\Omega^o} I^w\left(a', z'\right) s^l p \mu^o\left(a\right), \end{aligned} \tag{A-10}$$

and for all $\left(a'\right)$, the next-period number of unemployed workers (or active job-searchers), $\mu^u\left(a'\right)$, and the next-period number of nonparticipants (or inactive job-searchers), $\mu^o\left(a'\right)$, satisfy

$$\mu^u(a') = I^s(a')\left\{\sum_{z'}\sum_{\Omega^w}\left[1-I^w(a',z')\right]\pi(z'|z)(1-\lambda)\mu^e(a,z)\right.$$
$$\left.+\sum_{\Omega^w}\lambda\mu^e(a,z)+\sum_{\Omega^u}\left(1-s^h p\right)\mu^u(a)+\sum_{\Omega^o}\left(1-s^l p\right)\mu^o(a)\right\}, \quad \text{(A-11)}$$
$$\mu^o(a') = \left[1-I^s(a')\right]\left\{\sum_{z'}\sum_{\Omega^w}\left[1-I^w(a',z')\right]\pi(z'|z)(1-\lambda)\mu^e(a,z)\right.$$
$$\left.+\sum_{\Omega^w}\lambda\mu^e(a,z)+\sum_{\Omega^u}\left(1-s^h p\right)\mu^u(a)+\sum_{\Omega^o}\left(1-s^l p\right)\mu^o(a)\right\} \quad \text{(A-12)}$$

where $\Omega^w = \{(a,z)\,|a' = a'_w(a,z)\}$, $\Omega^u = \{a|a' = a'_u(a)\}$ and $\Omega^o = \{a|a' = a'_o(a)\}$.

The unemployed are defined as those who look for work actively and nonparticipants as those who look for work inactively. The aggregate employment rate, unemployment-to-population ratio and nonparticipation rate are given by

$$E = \sum_{a,z}\mu^e(a,z) \quad \text{(A-13)}$$
$$U = \sum_{a}\mu^u(a) \quad \text{(A-14)}$$
$$O = \sum_{a}\mu^o(a) \quad \text{(A-15)}$$

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