

AN EQUILIBRIUM MODEL OF SEARCH WITH BELATED INFORMATION

DONG HEON KIM*

In this paper I develop a simple equilibrium model of search with belated information in which a nondegenerate wage offer distribution is endogenously determined. The main results of the model are that an increase in search costs leads to a decrease in the equilibrium unemployment rate and quit rates, if the hazard function of the productivity distribution is monotonically increasing.

I. INTRODUCTION

There are several equilibrium search models in the literature that generate a nondegenerate wage offer distribution. Typically, job quits are not permitted in the models [see, e.g., Albrecht and Axell (1984)] or on-the-job search is assumed to generate voluntary quits [see Burdett (1990) and Mortensen (1990)].

An equilibrium model of turnover with belated information was first developed by Berninghaus, Lippman and McCall (1986). They analyze both the quit behavior of workers and the firing behavior of firms. However, in their model the wage offer distribution is exogenously given.

Unlike previous studies, in this paper we allow for the possibility of quits by assuming that, if the job turns out to be uncongenial, the worker quits into unemployment and searches anew. This paper is the first attempt to develop an equilibrium model of quits with belated information in which a nondegenerate wage offer distribution is endogenously determined.

The model provides a search-theoretic explanation for industry wage differentials as equilibrium phenomena and several stylized facts about industry wage differentials. The model predicts that workers in more profitable (or capital-intensive) firms will obtain higher wages. It is well-known in empirical labor economics that industry wage differentials are positively correlated with profitability and the capital-labor ratio (Groshen 1991, Montgomery 1991). In the model, as labor for-

* Korea Labor Education Institute. I am grateful to David S. Sibley for encouragement and advice. I thank Stephen G. Bronars, Jonathan L. Burke, Wayne Hickenbottom, Jongryn Mo, Gerald Oettinger, and two anonymous referees for helpful comments and suggestions.

ce size is increasing in the wage offered, large firms pay more for homogeneous workers than do small firms. This is called the employer size-wage effect in the literature. Brown and Medoff (1989) show that the employer size-wage effect is significant and that quit rates decline with employer size. In addition, the model predicts that quit rates are negatively associated with wages across industries. All these implications seem to be consistent with recent evidence on industry wage differentials.

The paper is organized as follows. Section 2 develops a basic framework for the analysis that generates two-wage dispersion and labor turnover in equilibrium. I show the existence of equilibrium and, once equilibrium is characterized, the effects of a change in search costs are examined. An increase in search costs leads to a decrease in the equilibrium unemployment rate, if the productivity distribution possesses a monotonically increasing hazard rate property. In this simple equilibrium model of quits, I show that the quit rate falls as the cost of search rises. This result seems to be important in that the comparative statics exercise is performed taking account of the induced change in the wage offer distribution. The model is generalized in section 3 to generate discrete equilibrium wage dispersion. Section 4 contrasts the results and implications of the general model with those of the BM (Burdett-Mortensen) model. The BM model gives rise to a closed-form solution for the equilibrium wage (offer) distribution, and the wage (offer) distribution has a strictly increasing density. This peculiar property has been criticized by Van den Berg and Ridder (1993) and other authors. The model in section 3 is flexible in predicting the form of the wage offer distribution so that the wage offer density need not be strictly increasing, but the hazard rate of the wage offer distribution is monotonically increasing, as the simulation results show in the next section. In section 5 I perform some simulation experiments to show that for a broad range of parameter values in the model there exist nondegenerate wage offer distributions. Section 6 discusses the contributions and limitations of the study, and suggests future research directions based upon this study.

II. THE BASIC MODEL

Workers are homogeneous. The total number of workers in the market is L . There exists a constant death probability of δ per period ($0 < \delta < 1$). Thus $1 - \delta$ is the survival probability each period. There is a flow of δL workers into and out of the market per period to maintain a "continual flow of ignorance." Denote the wage offer by the random variable W and the value of the nonwage characteristic by the random variable Y . Y is called the congeniality of a job. Thus, a job offer is composed of a pair (w, y) , where w is the wage rate and y the congeniality which becomes known to the worker exactly one period after he or she has accepted the job. Workers are risk neutral. I term the sum of the wage rate and congeniality of a job the reward rate: $u = w + y$. To keep the

analysis simple, assume that $E(Y) = \text{Cov}(W, Y) = 0$ and $\text{Prob}(Y = \alpha) = \text{Prob}(Y = -\alpha) = 1/2$, where α is a positive number. In words, the expected value of the nonwage characteristic from a random job match is zero and W and Y are uncorrelated. If $Y = \alpha$, then the job is said to be congenial. If $Y = -\alpha$, the job is said to be uncongenial. The worker obtains one offer per period at a constant search cost c . Search costs are incurred at the beginning of the period and offers are received at the end of the period. If the worker accepts the job, he or she starts working immediately and the total value of u is revealed after one period. If the total value of u is unacceptable, a quit into unemployment occurs and search resumes. The worker keeps the job for the duration of his or her lifetime if the total value of u is acceptable. The worker seeks to maximize the expected present value of rewards, net of search costs.

Under the assumptions it can be shown that there are two reservation wages, w_l and w_h [see, e.g., Lippman and McCall (1981)]. The lower reservation wage, w_l , is the wage at which the value of employment is equal to the value of continued search. The higher reservation wage, w_h , is the smallest wage at which no quit occurs after acceptance.

With only two reservation wages, there can be at most two equilibrium wage offers [see Mortensen (1990) for a formal proof]. In this model only two wages are offered in equilibrium. The low wage is equal to the lower reservation wage and the high wage is equal to the higher reservation wage. Let γ denote the fraction of firms offering the low wage ($0 < \gamma < 1$). Then all workers draw a wage of w_l with probability γ and a wage of w_h with probability $1 - \gamma$. Thus, (w_l, w_h, γ) characterizes an equilibrium distribution.

To summarize, the worker's decision process is as follows. When the worker enters the market at the beginning of period 0, the worker is randomly matched to a firm. If the firm is a high-wage firm, the worker starts working immediately and keeps the job for the duration of his or her lifetime. If the firm is a low-wage firm, the worker survives with probability $1 - \delta$ to evaluate the congeniality of the job at the end of period 0. If it is congenial, i.e. $Y = \alpha$ with probability $1/2$, the worker keeps the job for the duration of his or her lifetime. If it is uncongenial, i.e. $Y = -\alpha$ with probability $1/2$, the worker quits the job at the end of period 0. At the beginning of period 1, the worker incurs search costs c to draw a wage at random from the wage offer distribution. While unemployed, the worker enjoys the value of non-market time b . With probability $1 - \delta$ the worker survives to receive an offer at the end of period 1. Thus, if a new worker is initially employed by a low-wage firm, it takes one period to evaluate the nonwage characteristic of the job, and with probability $1/2$ the surviving worker quits into the unemployment pool and searches anew for one period. In this framework it takes exactly two periods for *unfortunate* workers to change jobs.

We are now in a position to characterize the equilibrium conditions for w_l ,

and w_h . Let $V(w_i)$ be the maximum expected rewards when an unemployed worker has just received an offer of w_i . Denote the value of continued search by S and the value of accepting w_i by $M(w_i)$. Then

$$V(w_i) = \max\{S, M(w_i)\} \quad (1)$$

where

$$M(w_i) \equiv E(w_i + Y) + (1 - \delta)E \max \left(S, \frac{w_i + Y}{\delta} \right) \quad (2)$$

and

$$S = b - c + (1 - \delta) \left[(1 - \gamma) \frac{w_h}{\delta} + \gamma S \right]. \quad (3)$$

Then the following equilibrium conditions for w_i and w_h are easily derived:¹⁾

$$w_i = b - c + \frac{\alpha}{\delta} \left[\frac{1 - \delta}{1 + \delta} \right] [1 - \delta(1 + \delta)] \quad (4)$$

$$w_h = b - c + \left[\frac{1 - \gamma(1 - \delta)}{\delta} \right] \alpha. \quad (5)$$

$$\text{Note that } w_h - w_i = \left(\frac{2}{1 + \delta} \right) \alpha \text{ or } w_h = w_i + \alpha + \left(\frac{1 - \delta}{1 + \delta} \right) \alpha. \quad (6)$$

To close the model we specify the behavior of firms in the market. The total number of firms in the market is M . Firms are assumed to live forever. Each firm has the following linear production technology:

$$Q = \lambda l,$$

where Q is output, λ is a productivity index, and l is the number of workers. Following Albrecht and Axell (1984) and Eckstein and Wolpin (1990), we allow for heterogeneity among firms. Firms are heterogeneous in terms of productive efficiency. Specifically, the productivity λ is distributed across firms according to the distribution function $\Phi(\lambda)$ and let $\phi(\lambda)$ denote the corresponding differentiable density function. As a normalization, take the support of λ to be $[0, 1]$. Then the profit of a firm with productivity index λ is $\Pi(w; \lambda) = (\lambda - w)l(w)$, where $l(w)$ is the labor force of a firm that sets its wage at w . Firms with $\lambda \leq w_i$ will not op-

¹ All derivations are provided in Kim (1994) and available upon request.

erate, thus a fraction $1 - \Phi(w_l)$ of all firms is active. Let λ^* be defined by $\Pi(w_l; \lambda^*) = \Pi(w_h; \lambda^*)$. That is, λ^* is the critical value of λ which makes a firm indifferent between offering w_l and w_h .²⁾ Firms with $w_l < \lambda \leq \lambda^*$ will offer w_l , while firms with $\lambda^* < \lambda \leq 1$ will offer w_h . Then we get the following equilibrium condition for γ :

$$\gamma = \frac{\Phi(\lambda^*) - \Phi(w_l)}{1 - \Phi(w_l)} \quad (7)$$

where

$$\lambda^* = \frac{w_h l(w_h) - w_l l(w_l)}{l(w_h) - l(w_l)} \quad (8)$$

It can be easily shown that $l(w_l) = \frac{1+\delta}{2} \left[\frac{1}{1 - \frac{1}{2}\gamma(1-\delta)^2} \mu \right]$ and

$l(w_h) = \frac{1}{1 - \frac{1}{2}\gamma(1-\delta)^2} \mu$, where $\mu = \frac{L}{M[1 - \Phi(w_l)]}$ is the ratio of workers

to active firms. Note that

$$l(w_h) - l(w_l) = \frac{1-\delta}{2} l(w_h) \text{ or } \frac{l(w_l)}{l(w_h)} = \frac{1+\delta}{2}. \quad (9)$$

Then λ^* can be simplified as follows:

$$\begin{aligned} \lambda^* &= \frac{w_h l(w_h) - w_l l(w_l)}{l(w_h) - l(w_l)} = w_h + \frac{(w_h - w_l) l(w_l)}{l(w_h) - l(w_l)} \\ &= b - c - \frac{\alpha}{\delta}(1-\delta)\gamma + \frac{\alpha(1+\delta)}{\delta(1-\delta)}, \end{aligned} \quad (10)$$

where we used (5), (6) and (9).

It can be shown that the equilibrium unemployment rate is

$$u = \frac{\gamma\delta(1-\delta)}{2 - \gamma(1-\delta)^2}. \quad (11)$$

Note that the equilibrium unemployment rate is increasing in γ (the fraction of

² For the following analysis I implicitly assume that $0 < \lambda^* < 1$. Simulation work in section 5 shows that this assumption is satisfied for a broad range of parameter values in the model.

firms offering the low wage). In this model only workers matched to low-wage firms are allowed to quit into the unemployment pool depending on the congeniality of the job. Thus, it is intuitive that an increase in the fraction of firms offering the low wage leads to an increase in the equilibrium unemployment rate.

We are now in a position to analyze the effects of a change in the cost of search on the equilibrium unemployment rate and the equilibrium wage dispersion. From (4), (5), (7) and (10) we have

$$\frac{dw_l}{dc} = -1 - \frac{\alpha}{\delta}(1-\delta)\frac{d\gamma}{dc}, \quad (12)$$

$$\frac{dw_h}{dc} = -1 - \frac{\alpha}{\delta}(1-\delta)\frac{d\gamma}{dc}, \quad (13)$$

$$\frac{d\lambda^*}{dc} = -1 - \frac{\alpha}{\delta}(1-\delta)\frac{d\gamma}{dc}, \quad (14)$$

and

$$\phi(\lambda^*)\frac{d\lambda^*}{dc} - \phi(w_l)\frac{dw_l}{dc} - \frac{d\gamma}{dc} [1 - \Phi(w_l)] + \gamma \phi(w_l) \frac{dw_l}{dc} = 0. \quad (15)$$

I state and prove the main propositions in this model and then discuss the implications of the results.

Proposition 1. An increase in search costs leads to a decrease in the equilibrium unemployment rate, if the hazard function of the productivity distribution is monotonically increasing.

Proof. Substituting (12) and (14) into (15) yields

$$\frac{d\gamma}{dc} = \frac{(1-\gamma)\phi(w_l) - \phi(\lambda^*)}{[\phi(\lambda^*) - (1-\gamma)\phi(w_l)]\frac{\alpha}{\delta}(1-\delta) + [1 - \Phi(w_l)]}.$$

Note that $\gamma = \frac{\Phi(\lambda^*) - \Phi(w_l)}{1 - \Phi(w_l)}$. It is easy to show that $[\phi(\lambda^*) - (1-\gamma)\phi(w_l)]$

is positive if the productivity distribution $\Phi(\lambda)$ possesses a monotonically increasing hazard rate property.³ This implies that $d\gamma/dc < 0$. Then from (11)

³ The hazard rate is defined by $h(\lambda) = \phi(\lambda) / [1 - \Phi(\lambda)]$.

The condition that $h(\lambda)$ is increasing in λ is called the monotone-hazard-rate condition.

$$\frac{du}{dc} = \frac{2\delta(1-\delta)}{[2-\gamma(1-\delta)^2]^2} \frac{d\gamma}{dc} < 0.$$

Proposition 2. $\frac{dw_l}{dc} = \frac{dw_h}{dc} = \frac{d\lambda^*}{dc} < 0$, if the productivity distribution possesses a monotonically increasing hazard rate property.

Proof.

$$\begin{aligned} \frac{dw_l}{dc} &= \frac{dw_h}{dc} = \frac{d\lambda^*}{dc} \\ &= -1 - \frac{\alpha}{\delta}(1-\delta) \left[\frac{(1-\gamma)\phi(w_l) - \phi(\lambda^*)}{[\phi(\lambda^*) - (1-\gamma)\phi(w_l)] - \frac{\alpha}{\delta}(1-\delta) + [1 - \Phi(w_l)]} \right] \\ &= -1 + \left[\frac{[\phi(\lambda^*) - (1-\gamma)\phi(w_l)] - \frac{\alpha}{\delta}(1-\delta)}{[\phi(\lambda^*) - (1-\gamma)\phi(w_l)] - \frac{\alpha}{\delta}(1-\delta) + [1 - \Phi(w_l)]} \right]. \end{aligned} \quad (16)$$

If the monotone-hazard-rate condition holds, the second term on the right-hand side of (16) is positive, but less than one.

Proposition 3. The expected probability of a quit falls as the cost of search rises, if the productivity distribution possesses a monotonically increasing hazard rate property.

Proof. The expected probability of a quit is $q = \frac{1}{2}\gamma$. From proposition 1, I showed that $\frac{d\gamma}{dc} < 0$ if the monotone-hazard-rate condition holds. Then, $\frac{dq}{dc} = \frac{1}{2} \frac{d\gamma}{dc} < 0$.

Proposition 2 shows that a change in search costs has the same quantitative effect on the two reservation wages. As the cost of search rises, workers reduce their reservation wages. This has two effects on the number of firms offering the low wage. Some firms become active since they are now capable of earning positive profits in the market. However, some firms originally offering the low wage switch and offer the high wage since the higher reservation wage has been reduced. The analysis shows that the direction of the net effect depends on the shape of the productivity distribution. Specifically, the monotone-hazard-rate condition ensures that the fraction of firms offering the low wage (γ) decreases in

equilibrium. Note that in this model only workers matched to low-wage firms are allowed to quit into the unemployment pool depending on the congeniality of the job. Thus, a decrease in the fraction of firms offering the low wage leads to a decrease in the equilibrium unemployment rate (proposition 1) and a decrease in the expected probability of a quit (proposition 3).

III. THE GENERAL MODEL

In the previous section I assumed that the random variable Y can take only two values to simplify the analysis. The outcome of the assumption is that the model generates two-wage dispersion in equilibrium. In this section I relax the assumption and allow for more than two outcomes for Y to generate discrete equilibrium wage dispersion.

Suppose that Y takes n values. Without loss of generality I assume that each value is equally likely and that the expected value of Y is zero. That is,

$$\text{Prob} \left(Y = \frac{n-1-2j}{n-1} \alpha \right) = \frac{1}{n},$$

where $n \geq 2$, $j = 0, 1, 2, \dots, n-1$, and α is a positive number.

Let $V(w_0)$ be the maximum expected rewards when an unemployed worker has just received an offer of w_0 , where w_0 is the lowest reservation wage. Denote the value of continued search by S and the value of accepting w_0 by $M(w_0)$. Then

$$V(w_0) = \max \{ S, M(w_0) \}, \quad (17)$$

where

$$\begin{aligned} M(w_0) &= E(w_0 + Y) + (1 - \delta) E \max \left(S, \frac{w_0 + Y}{\delta} \right) \\ &= w_0 + \frac{1 - \delta}{n} \left[\sum_{j=0}^{n-1} \max \left(S, \frac{w_0 + \left[\frac{n-1-2j}{n-1} \right] \alpha}{\delta} \right) \right]. \end{aligned} \quad (18)$$

In a similar way we did in the previous section it is easy to show that

$$w_0 = \delta S - \left[\frac{1 - \delta}{1 + (n-1)\delta} \right] \alpha \quad (19a)$$

and

$$w_j = \delta S - \left[\frac{n-1-2j}{(n-1)} \right] \alpha, \quad (19b)$$

where $j = 1, 2, \dots, n-1$.

In equilibrium the set of wage offers is equal to the set of reservation wages.⁴ Wages are in discrete levels such that $w_{j-1} < w_j < w_{j+1}$ and workers sample w_j with probability γ_j , $j = 0, 1, 2, \dots, n-1$. The value of search is therefore

$$S = b - c + (1 - \delta) \left[\gamma_0 S + \sum_{j=1}^{n-1} \gamma_j M(w_j) \right], \quad (20a)$$

where

$$M(w_j) = \frac{w_j}{\delta} + \frac{1-\delta}{n} \left[\frac{(n-j)\{n-(j+1)\}}{n-1} \right] \frac{\alpha}{\delta} \quad (20b)$$

From equations (19) and (20) we can get the equilibrium conditions for the n reservation wages.

Let λ_j be defined by $\Pi(w_{j-1}; \lambda_j) = \Pi(w_j; \lambda_j)$, $j = 1, 2, \dots, n-1$. That is, λ_j is the critical value of λ which makes a firm indifferent between offering w_{j-1} and w_j . Firms with λ between λ_j and λ_{j+1} offer a wage w_j . Denote the lowest productivity index associated with an active firm by λ_0 . Then by definition $\lambda_0 = w_0$ (the lowest wage). Then we get the following equilibrium condition for γ_j :

$$\gamma_j = \frac{\Phi(\lambda_{j+1}) - \Phi(\lambda_j)}{1 - \Phi(\lambda_0)}, \text{ for } j = 0, 1, 2, \dots, n-2 \quad (21a)$$

where

$$\lambda_j = \frac{w_j l(w_j) - w_{j-1} l(w_{j-1})}{l(w_j) - l(w_{j-1})}, \text{ for } j = 1, 2, \dots, n-1 \quad (21b)$$

$$\text{and } \sum_{j=0}^{n-1} \gamma_j = 1. \quad (21c)$$

Thus, (w_j, γ_j) , $j = 0, 1, 2, \dots, n-1$, characterizes an equilibrium wage offer distribution. In principle the equilibrium variables of the model can be obtained from the equations (19), (20), and (21).

⁴ When n is large, δ should be sufficiently close to zero to ensure exactly n reservation wages.

To perform comparative statics I consider the case of $n = 3$, which is analytically tractable. Assume that $\text{Prob}(Y = \alpha) = \text{Prob}(Y = 0) = \text{Prob}(Y = -\alpha) = 1/3$. In this case there are three reservation wages, w_l , w_m , and w_h . In equilibrium only three wages are offered. Let γ_j denote the fraction of firms offering the j wage ($0 < \gamma_j < 1$). Then all workers draw a wage of w_j with probability γ_j , where $j = l, m, h$ and $\gamma_h = 1 - \gamma_l - \gamma_m$. The lower reservation wage, w_l , is the smallest acceptable wage at which a quit occurs with probability $2/3$ after acceptance. The medium reservation wage, w_m , is the smallest wage at which a quit occurs with probability $1/3$ after acceptance. The higher reservation wage, w_h , is the smallest wage at which no quit occurs after acceptance. Then it can be shown that

$$w_l = b - c + \left[\frac{\gamma_m(1-\delta)^2}{3} \right] \frac{\alpha}{\delta} + (1-\delta)(1-\gamma_l-\gamma_m) \frac{\alpha}{\delta} - \left[\frac{1-\delta}{1+2\delta} \right] \alpha, \quad (22)$$

$$w_m = b - c + \left[\frac{\gamma_m(1-\delta)^2}{3} \right] \frac{\alpha}{\delta} + (1-\delta)(1-\gamma_l-\gamma_m) \frac{\alpha}{\delta}, \quad (23)$$

$$w_h = b - c + \left[\frac{\gamma_m(1-\delta)^2}{3} \right] \frac{\alpha}{\delta} + (1-\delta)(1-\gamma_l-\gamma_m) \frac{\alpha}{\delta} + \alpha, \quad (24)$$

$$l(w_l) = \frac{1+2\delta}{3} \left[\frac{\mu}{1 - \left[\frac{2}{3}\gamma_l + \frac{1}{3}\gamma_m \right] (1-\delta)^2} \right], \quad (25)$$

$$l(w_m) = \frac{2+\delta}{3} \left[\frac{\mu}{1 - \left[\frac{2}{3}\gamma_l + \frac{1}{3}\gamma_m \right] (1-\delta)^2} \right], \quad (26)$$

$$l(w_h) = \left[\frac{\mu}{1 - \left[\frac{2}{3}\gamma_l + \frac{1}{3}\gamma_m \right] (1-\delta)^2} \right], \quad (27)$$

$$\lambda_1 = b - c + \left[\frac{\gamma_m(1-\delta)^2}{3} \right] \frac{\alpha}{\delta} + (1-\delta)(1-\gamma_l-\gamma_m) \frac{\alpha}{\delta} + \alpha, \quad (28)$$

$$\lambda_2 = b - c + \left[\frac{\gamma_m(1-\delta)^2}{3} \right] \frac{\alpha}{\delta} + (1-\delta)(1-\gamma_l-\gamma_m) \frac{\alpha}{\delta} + \frac{3}{1-\delta} \alpha, \quad (29)$$

$$\gamma_l = \frac{\Phi(\lambda_1) - \Phi(w_l)}{1 - \Phi(w_l)}, \quad (30)$$

$$\gamma_m = \frac{\Phi(\lambda_2) - \Phi(\lambda_1)}{1 - \Phi(w_l)} , \quad (31)$$

and

$$u = \frac{\delta(1-\delta)(2\gamma_l + \gamma_m)}{3 - (2\gamma_l + \gamma_m)(1-\delta)^2} . \quad (32)$$

With the above equations we can analyze the effects of a change in the cost of search on the equilibrium unemployment rate and the equilibrium wage dispersion. The results are the same as those we derived in the previous section. That is, an increase in search costs leads to a decrease in the equilibrium unemployment rate and quit rates, if the productivity distribution $\Phi(\lambda)$ possesses a monotonically increasing hazard rate property.

IV. DISCUSSION

In this section I contrast the results and implications of the model with those of the BM model, and discuss the theoretical importance of the results found in this paper. As noted before, in the BM model the wage (offer) density is strictly increasing. According to Van den Berg and Ridder (1993), the simple BM model makes “embarrassingly precise predictions of the form of the wage offer and wage distributions, which are clearly at odds with our knowledge of these distributions” (p.244). There is not much *a priori* intuition on the shape of the wage offer distribution. But, concerning the wage distribution, it is plausible that it resembles the observed earnings distribution. Thus we expect its density to be decreasing on most of its support, to be skewed to the right. As criticized by Van den Berg and Ridder (1993), the wage offer and wage distributions in the BM model violate all of these features. This need not be the case in the model in this paper, as the simulation results show in the next section.

As Pissarides (1993) points out, the implication of the increasing wage density is that large firms pay more than small firms. Burdett and Mortensen (1989) mention that the critical feature of their model is the positive relationship between employer (labor force) size and wages. Indeed it is generally found that large firms pay more for observationally equivalent workers than do small firms. There are several explanations for the positive relationship between employer size and wages. Brown and Medoff (1989) mention six explanations: large firms (1) hire higher quality workers; (2) offer inferior working conditions; (3) make more use of high wages to thwart unionization; (4) have more ability to pay high wages; (5) face smaller pools of applicants relative to vacancies; (6) are less able to monitor their workers. Interestingly, none of these explanations can be used to ex-

plain the positive relationship between employer size and wages suggested by the BM model. In the BM model high-wage firms have become big by paying high wages, and so attracting more labor. This does not seem to be a convincing story. Without allowing for heterogeneity among firms it is not easy to explain why some firms pay more for similar workers than do others. The model in this paper also suggests the positive relationship between employer size and wages simply because labor force size is increasing in the wage offered. However, the model's implications for such relationship are strikingly different from those of the BM model. In the model firms are heterogeneous in terms of productive efficiency and each firm earns different profits depending on its productive efficiency. Thus, the model implied that wages are higher in firms that are more profitable (or capital-intensive). Dickens and Kats (1987) and Krueger and Summers (1988) find that industries with high capital-labor ratios tend to pay higher wages. Most studies reviewed in Groshen (1991) find a positive relationship between industry wages and profit rates.

Compared with the theory of on-the-job search, the theory of search with belated information has been tangentially treated in labor economics. Furthermore, most of the important relationships, such as the relationship between search costs and turnover, are known to be ambiguous even in a partial equilibrium framework (Wilde 1979). In this paper I have developed an equilibrium model of job search with belated information, and have shown that the quit rate falls as the cost of search rises under a fairly general restriction on the productivity distribution. The analysis shows that we can make *positive* predictions regarding the relationship between search costs and turnover in an equilibrium search model.

V. SIMULATION

Throughout the comparative statics analysis in section 3, I implicitly assumed that $0 < \lambda_1 < \lambda_2 < 1$. That is, the equilibrium λ s are in the interior of the support $[0, 1]$ to guarantee that the equilibrium wage offer distribution is nondegenerate. The purpose of this simulation exercise is to show that this is indeed the case for a broad range of selected parameter values in the model. To simplify the numerical analysis, I assume that $b = 0$ and $\Phi(\lambda) = \lambda$, $0 \leq \lambda \leq 1$.⁵ There are eight equilibrium variables and eight equilibrium equations. The parameters to be specified in the model are α , δ , and c . Tables 1 and 2 present the equilibrium variables as functions of the level of search costs for selected parameter values of α and δ . Specifically, starting with $c = 0$, I compute the equilibrium values of the endogenous variables in the model for increments of 0.05 in c up to $c = 0.4$.

⁵ The uniform distribution is particularly simple and legitimate to use for our purpose since it satisfies the monotone-hazard-rate condition.

[Table 1] [$\alpha = .05$ and $\delta = .05$]

c	0	.05	.10	.15	.20	.25	.30	.35	.40
w_l	.552	.524	.494	.462	.429	.395	.359	.323	.285
w_m	.596	.567	.537	.505	.472	.438	.403	.366	.328
w_h	.646	.617	.587	.555	.522	.488	.453	.416	.378
λ_1	.646	.617	.587	.555	.522	.488	.453	.416	.378
λ_2	.754	.725	.695	.663	.630	.596	.560	.524	.486
γ_l	.208	.196	.184	.173	.163	.154	.145	.138	.130
γ_m	.241	.227	.213	.201	.189	.178	.168	.159	.151
u	.013	.012	.011	.010	.010	.009	.008	.008	.007

[Table 2] [$\alpha = .15$ and $\delta = .1$]

c	0	.05	.10	.15	.20	.25	.30	.35	.40
w_l	.283	.261	.238	.215	.191	.166	.140	.114	.087
w_m	.395	.373	.351	.327	.303	.279	.253	.227	.200
w_h	.545	.523	.501	.477	.453	.429	.403	.377	.350
λ_1	.545	.523	.501	.477	.453	.429	.403	.377	.350
λ_2	.895	.873	.851	.827	.803	.779	.753	.727	.700
γ_l	.366	.355	.345	.334	.324	.315	.305	.296	.288
γ_m	.488	.473	.459	.446	.433	.420	.407	.395	.383
u	.055	.052	.050	.048	.046	.044	.042	.040	.039

This simulation confirms the comparative-static results. As the level of search costs rises, the equilibrium variables in the model fall monotonically and they are in the interior of the interval $[0, 1]$ for a wide range of selected parameter values. Table 2 provides an interesting example. In the table the fraction of firms offering the medium wage (γ_m) is greater than the fraction of firms offering the low wage (γ_l). However, the fraction of firms offering the high wage ($1 - \gamma_l - \gamma_m$) is even smaller than the fraction of firms offering the low wage (γ_l) for the low levels of search costs (up to .30 in this particular example). This is different from the BM model in which the equilibrium wage (offer) density is strictly increasing. This example shows that the equilibrium wage density need not be strictly increasing, but it is still possible that the wage offer distribution satisfies the monotone-hazard-rate condition.

VI. CONCLUDING REMARKS

The theory of search with belated information has been tangentially treated in labor economics. It has been well-known that the theory could be applied to other markets, such as product and marriage markets. However, seminal work has provided few, if any, unambiguous predictions even in a partial equilibrium framework. For example, Wide (1979) suggested that there is no systematic relationship between search costs and quit rates. Moreover, equilibrium search models have not been fully developed in this literature.

My analysis consistently shows that in this type of search models it is sufficient to impose a mild restriction (the monotone-hazard-rate condition) on the forms of the underlying distributions describing the degree of heterogeneity in the market to get unambiguous comparative-static predictions. Indeed, it is rather unfortunate that we need a restriction on either the wage offer distribution (Kim 1995) or the productivity distribution (Kim 1994) to get unambiguous results. However, we note that the monotone-hazard-rate condition is satisfied by many familiar distributions in economics and generally assumed by economists in their theoretical models.

As a referee points out, this model does not explain observed equilibrium search behavior. That is, only a single search is required in equilibrium (Reinganum 1979). The model could be further developed by allowing for heterogeneity among workers in terms of either search costs or productive skills. It is an interesting question that we could get a fairly general wage offer distribution in an equilibrium model of quits with belated information in which a *continuous* wage offer distribution is endogenously determined.

REFERENCES

- Albrecht, J. W. and B. Axell (1984). "An Equilibrium Model of Search Unemployment." *Journal of Political Economy* 92, 824-840.
- Berninghaus, S., S. A. Lippman, and J. J. McCall (1986). "An Equilibrium Model of Turnover with Belated Information." *Information Economics and Policy* 2, 221-239.
- Brown, C. and J. Medoff (1989). "The Employer Size-Wage Effect." *Journal of Political Economy* 97, 1027-1059.
- Burdett, K. (1990). "Empirical Wage Distributions: A New Framework for Labor Market Policy Analysis." In J. Hartog, G. Ridder, and J. Theeuwes (eds.), *Panel Data and Labor Market Studies*. North-Holland, Amsterdam, pp. 297-312.
- Burdett, K. and D. T. Mortensen (1989). "Equilibrium Wage Differentials and Employer Size." Mimeo, Cornell University, October.
- Dickens, W. T. and L. F. Katz (1987). "Inter-Industry Wage Differences and Industry Characteristics." In K. Lang and J. S. Leonard (eds.), *Unemployment and the Structure of Labor Markets*. Basil Blackwell, Oxford.
- Eckstein, Z. and K. I. Wolpin (1990). "Estimating a Market Equilibrium Search Model from Panel Data on Individuals." *Econometrica* 58, 783-808.
- Groshen, E. L. (1991). "Five Reasons Why Wages Vary among Employers." *Industrial Relations* 30, 350-381.
- Kim, D. H. (1994). "Equilibrium Wage Dispersion and Turnover." Unpublished paper, University of Texas at Austin.
- Kim, D. H. (1995). "Search Costs and the Quit Rate." *Economics Letters* 49, 85-90.
- Krueger, A. B. and L. H. Summers (1988). "Efficiency Wages and the Inter-Industry Wage Structure." *Econometrica* 56, 259-293.
- Lippman, S. A. and J. J. McCall (1981). "The Economics of Belated Information." *International Economic Review* 22, 135-146.
- Montgomery, J. D. (1991). "Equilibrium Wage Dispersion and Interindustry Wage Differentials." *Quarterly Journal of Economics* 106, 163-179.
- Mortensen, D. T. (1990). "Equilibrium Wage Distributions: A Synthesis." In J. Hartog, G. Ridder, and J. Theeuwes (eds.), *Panel Data and Labor Market Studies*. North-Holland, Amsterdam, pp. 279-296.
- Pissarides, C. A. (1993). "Comments on 'On the Estimation of Equilibrium Search Models from Panel Data' by G. J. van den Berg and G. Ridder." In J. C. van Ours, G. A. Pfann, and G. Ridder (eds.), *Labor Demand and Equilibrium Wage Formation*. North-Holland, Amsterdam, pp. 246-247.
- Reinganum, J. T. (1979). "A Simple Model of Equilibrium Price Dispersion." *Journal of Political Economy* 87, 851-858.

- Van den Berg, G. J. and G. Ridder (1993). "On the Estimation of Equilibrium Search Models from Panel Data." In J. C. van Ours, G. A. Pfann, and G. Ridder (eds.), *Labor Demand and Equilibrium Wage Formation*. North-Holland, Amsterdam, pp. 227-245.
- Wilde, L. L. (1979). "An Information-Theoretic Approach to Job Quits." In S. A. Lippman and J. J. McCall(eds.), *Studies in the Economics of Search*. North-Holland, New York, pp. 35-52.