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QUIT BEHAVIOR UNDER IMPERFECT INFORMATION: SEARCHING, MOVING, LEARNING

by

Bertil Holmlund and Harald Lang

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1 Introduction

The application of search theory to labor market issues has yielded important new insights regarding individual behavior under unemployment. A model frequently cited portrays the behavior of an unemployed worker in an environment characterized by (i) constant search costs, (ii) a known wage offer distribution, (iii) an exogenous job offer probability, and (iv) an infinite time horizon. It can be shown that a strategy that maximizes expected life-time income implies the selection of a reservation wage, constant over time when the horizon is infinite. The worker leaves the unemployment pool when he receives an offer above the reservation wage and stays with the particular firm for quite a long time; in fact, the employment contracts lasts for ever.

The basic search model has, however, some obvious limitations. It is, for example, not without problems to use this model as a vehicle for understanding turnover in the labor market. A typical feature of job mobility is job-to-job changes without intervenient unemployment. Mattila (1974) has estimated that the major fraction of voluntary job changes in the United States occur without interim unemployment and Holmlund (1983) indicates that quits into the unemployment pool are even more rare in the Swedish labor market. An obvious inference from these observations is that <u>on-the-job-search</u> appears to be of some empirical importance. The superior search efficiency sometimes attributed to the unemployment state is not very convincing given the magnitude of job mobility without intervenient unemployment.

Another aspect of mobility behavior is its *repetitive* nature; workers with recent job changes are often those who are most likely to quit. Various empirical studies demonstrate that quit-probabilities are declining as job tenure increases. One suggested explanation is that workers accumulate firm-specific capital, which - by definition - is non-transferable across firms. The amount of firm-specific capital will increase as tenure increases and the worker's current wage will grow in relation to his market alternatives; hence, quit probabilities will decrease.(See, for example, Parsons, 1972.)

It is questionable, however, if this story can explain the apparently *rapid* decline in quit rates that occurs as tenure increases. Hedberg (1967) estimates that separation rates run between 15-20 percent in the first months of employment; after one year the separation frequencies are between 2 and 5 percent. It is unlikely that this pattern of rapidly declining (conditional) quit-probabilities can be attributed to accumulation of firm-specific human capital.

Several empirical studies have shown that non-wage job attributes are important determinants of quit rates. (See, for example, Viscusi, 1979 and Bartel, 1982.) This, of course, makes good economic sense; workers who are interested in utility-improving job changes will take account of all aspects of current and prospective jobs, including non-pecuniary components.

Many non-wage job attributes are not easily discovered by job searchers before acceptance decisions are made. Workers may have to *learn* about them by actually working on the job. This aspect of the job matching process has often been stressed in literature on labor mobility: "Voluntary mobility is essential a form of job-shopping by workers ..... workers have great difficulty in judging the attractiveness of a job by talking it over in the company's employment office. The only way to judge it accurately is to work on it for a while. After a few weeks or months of work, one can tell whether the job is worth keeping. This explains why quits are most frequent during the first few months of service and diminish rapidly after that point." (Reynolds, 1951.)

In this paper we attempt to incorporate uncertainty about non-wage job attributes in the basic search-theoretic framework. We know of two earlier such attempts. Borjas and Goldberg (1978) show that the reservation wage rule holds even when the non-wage attribute is revealed <u>after</u> the acceptance decision is made. They show how the (unemployed) worker's reservation wage is affected by uncertainty about the non-pecuniary component but attempt no analysis of quit behavior. The other study is by Wilde (1979). He considers a decision process where the worker is allowed to quit when the non-wage attribute of the job is observed. On-the-job-search is ruled out (by assumption) and the worker therefore always quits into unemployment. Wilde shows that quit probabilities are positive but provides no information of how conditional quit probabilities change as tenure increases.

Our analysis focuses on the employed worker's search and quit behavior in a setting where the non-wage characteristic is revealed (immediately) after the acceptance decision is made. It is shown that quit probabilities decline as tenure increases, consistent with observed empirical regularities. We also prove that the (risk-neutral) worker is prepared to accept a wage offer that falls <u>below</u> his current full wage (in the absence of moving costs). The difference between the current full wage and the acceptance wage represents the worker's willingness to pay for participating in the "job change lottery".

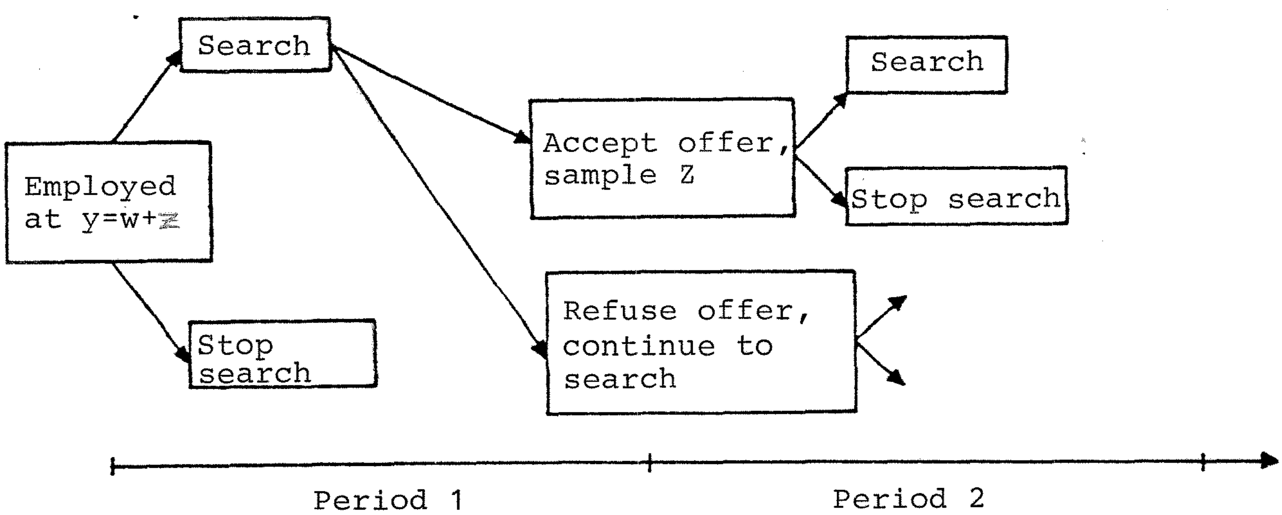
2 The Basic Model

Consider a worker who is employed at a particular money wage $W=w$. The job is also associated with a particular non-pecuniary attribute, $Z=z$, measured in the same units as W. The worker's full wage is accordingly $y=w+z$.

A worker contemplating search is facing a known wage offer distribution, $f(w)$ and a conditional distribution of non-wage attributes, $g(z;w)$. We assume that $E(Z)=0$ for all w. An offer is associated with an observable component, the money wage, as well as an unobservable part, the non-wage characteristic of the job.[1] The worker may choose to accept an offer or to refuse it; in the latter case the offer expires immediately. In case the worker accepts the offer and starts to work, the non-wage attribute is immediately revealed. The realized value of the full wage may well be such that continued search is considered.

The decision process is illustrated in Figure 1.

Figure 1



The worker's objective is to maximize his discounted life-time income, net of search and moving costs. Let V(y) denote the value of pursuing an optimal policy for the employed worker,

$$V(y) = \max\left\{ \frac{y(1+r)}{r} \; ; \; y-c+ \frac{1}{1+r} \int_0^\infty \max\left\{V(y); \; - C_M + \int_{-\infty}^{\infty} V(w+z)g(z;w)dz \right\} f(w)dw \right\} \tag{1}$$

where c is the marginal search cost, C_M is the moving cost and r is the discount rate. For simplicity, it is assumed that the range of Z is such that quits into search unemployment never will be considered. Note that the term y(1+r)/r is the present value of keeping the current job (and thereby receiving y forever).

The first claim establishes that (1) has a solution.

<u>Proposition 1</u>:

(a) There exists a unique continuous solution to the functional equation (1).

(b) V(y) is convex and increasing in y.

The proof is shown in the Appendix.

The optimal decision process involves two critical wage rates. First, there is a critical "search reservation wage", k. When the full wage falls below this level, i.e. y < k, the worker is induced to search. The critical search wage is given as the solution to

$$\frac{k(1+r)}{r} = k - c + \frac{1}{1+r} \int_0^{\infty} \max \left\{ V(k); \; - C_M + \int_{-\infty}^{\infty} V(w+z)g(z;w)dz \right\} f(w)dw \tag{2}$$

Clearly, at the full wage y=k the worker is indifferent between searching and keeping his current job. Eq.(2) expresses this equality condition.

The next problem is to show that k is unique.

<u>Proposition 2</u>:
There exists a unique solution to (2).

The proof is given in the Appendix.

The searching worker has to decide on a reservation wage that separates acceptable offers from unacceptable ones. Wage offers for which $w>w^*$ hold are acceptable, w^* being the "acceptance reservation wage". The latter is given as the solution to

$$V(y) = - C_M + \int_{-\infty}^{\infty} V(w^*+z)g(z;w^*)dz \tag{3}$$

where $w^*=w^*(y)$. The next claim gives a sufficient condition for a unique w^*.

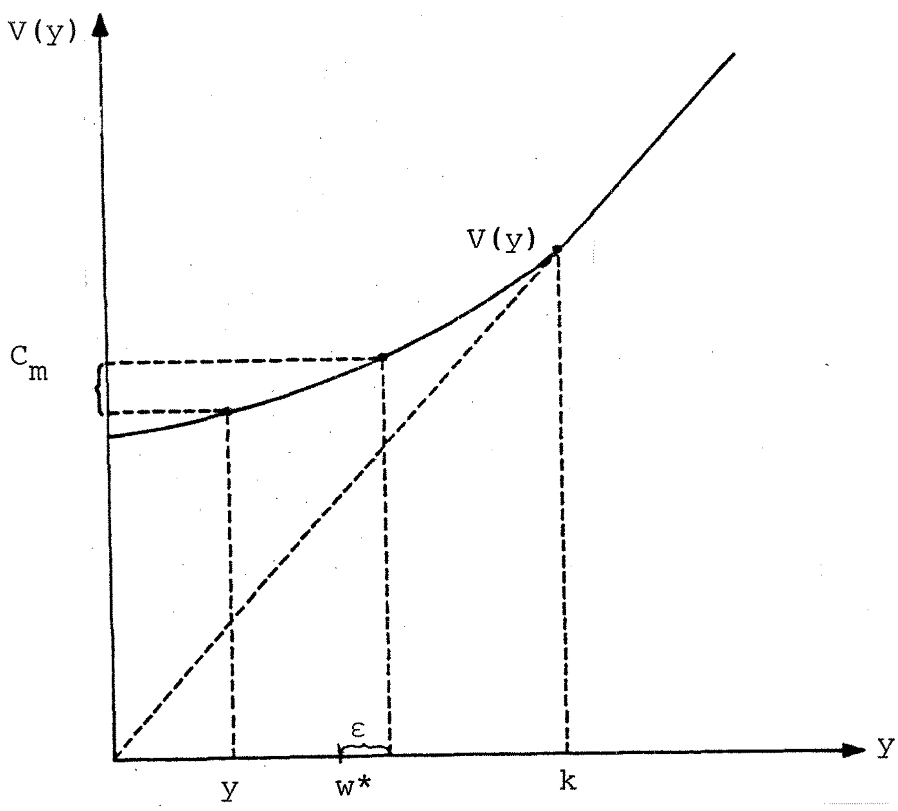
<u>Proposition 3</u>:
If W and Z are independent, (3) has a unique solution.

If $g(z;w)=g(z)$ is independent of w, the RHS of (3) is increasing in w^* since $V(\cdot)$ is increasing. Of course, uniqueness of w^* holds true also under less restrictive assumptions.

We have now established the existence of an optimal search strategy for the decision process illustrated in Figure 1. This strategy involves a unique "search reservation wage" as well as a unique "acceptance reservation wage".

Some properties of the problem may be illustrated by means of Figure 2. The ray from the origin has slope $(1+r)/r$. The vertical distance between the ray and the horizontal axis represents the value of remaining in the current job forever (for each y). When $y<k$ it holds that $V(y) > y(1+r)/r$; hence, the worker will engage in job search. The vertical distance between the $V(\cdot)$ function and the ray from the origin expresses the expected increase in life-time income implied by an optimal search strategy. For $y > k$ there is no payoff to search; hence, the ray and the $V(\cdot)$ function coincide in that interval.

Figure 2



Recall that $V(\cdot)$ is an increasing and convex function. Thus, by (3) and Jensen's inequality we have

$$V(y) = - C_M + V(w^*+\varepsilon) \tag{4}$$

where ε is a positive number. If $V(\cdot)$ were affine or Z had zero variance, we would have $\varepsilon = 0$. The size of ε is determined by the degree of convexity of $V(\cdot)$ and the variance of Z.

Consider the case when there are no moving costs (i.e., $C_M = 0$). It is obvious from (4) that the acceptance wage then falls <u>below</u> the worker's current full wage (i.e., $w^* < y$). The difference between the full wage and the acceptance wage (ε) may be interpreted of the maximum "price" the worker is willing to pay for participation in the "job change lottery".

A worker who accepts an offer $W = w^*$ expects a discounted life-time income of

$$\int_{-\infty}^{\infty} V(w^*+z)g(z;w^*)dz$$

before Z is observed. Suppose that he draws the expected value of Z, i.e. $Z = 0$. In that case his expected life-time income falls! This follows from the inequality

$$\int_{-\infty}^{\infty} V(w^*+z)g(z;w^*)dz \geqslant V(w^*) \tag{5}$$

which holds by an application of Jensen's inequality. (Recall that $V(\cdot)$ is a convex function.) If the worker who accepts $W = w^*$ draws $Z = \varepsilon$, the realized full wage will be $y = w^* + \varepsilon$; hence, his expected life-time income will not change.

3 The Quit Rate

Consider now a worker who just has been hired at the wage $W = w$ but not yet observed Z. His probability (ex ante) of quitting in period $n + 1$, conditional on employment in n periods, is given by

$$\Pr(Q|n,w) = \frac{\int_{-\infty}^{k-w} \left[F(w^*(w+z))\right]^n \left[1-F(w^*(w+z))\right] g(z;w)dz}{\int_{k-w}^{\infty} g(z;w)dz + \int_{-\infty}^{k-w} \left[F(w^*(w+z))\right]^n g(z;w)dz} \tag{6}$$

where $F(\cdot)$ is the c.d.f. of W. Expression (6) may require some explanations. The numerator, first, has essentially three components. One of them is the probability of searching; search continues if the worker observes a value of Z such that the full wage falls below the search reservation wage, i.e., $w + z < k$. The probability of remaining as searcher in n periods is $\left[F(w^*)\right]^n$ and the probability of accepting an offer in period $n + 1$ is $1 - F(w^*)$. The denominator, next, is the sum of two terms, the first being the probability of observing a value of Z such that the search process is terminated (i.e., $w + z > k$). The second term is the probability of remaining as searcher in n periods.

Inspection of (6) allows us to make the following claims:

Proposition 4:

(a) If there are no non-wage attributes (i.e., $Z = 0$ with probability one), then the quit-probability is independent of n, $Pr(Q|n,w) = 1 - F(w^*)$.

(b) If there is a distribution of non-wage attributes, then, in general, the quit-probability is decreasing in n, $\frac{\partial Pr(Q|n,w)}{\partial n} < 0$

(c) The quit probability in the presence of non-wage attributes is in general approaching zero as n increases $\lim_{n \to \infty} Pr(Q|n,w) = 0$

Claims (a) and (c) are obvious; the proof of claim (b) is given in the Appendix.

The negative relationship between quit rates and tenure has a straightforward intuitive interpretation. Workers who sample very low values of Z will set low acceptance wages and therefore have high quit rates. Workers with higher values of Z will select higher acceptance wages and therefore quit at a slower pace. Those observed as having long tenure will be those who have drawn high values of Z; hence their acceptance wages will be higher and their quit rates lower.

The distribution of workers by tenure reflects an underlying distribution of full wages. Non-wage attributes, however, are in general only partially observed and tenure may be used as a proxy for the unobserved characteristics.

4 Comparative Statics

Expression (6) provides information about the worker's "quit-tenure profile". In what follows we will focus on how quit-probabilities are affected by changes in the current money wage (w), the marginal search cost (c), the moving cost (C_M), the discount rate (r) and the variance of the distribution of non-wage attributes (σ_z^2).

Consider, first, the quit-response to a higher money wage.The derivative $\partial \Pr(Q|n,w)/\partial w$ in (6) is not easily signed for arbitrary values of n. However, for n=0 we have

$$\Pr(Q|0,w) = \int_{-\infty}^{k-w} \left[1-F\left(w^*(w+z)\right)\right] g(z;w)dz \tag{7}$$

which is decreasing in w. Hence, an increase in the current money wage unambiguously decreases the first-period quit probability.

Next, consider the effect of an increase in the marginal search cost. We obtain[2]

$$\frac{\partial P}{\partial c} = \frac{\partial P}{\partial k} \cdot \frac{\partial k}{\partial c} + \frac{\partial P}{\partial w^*} \cdot \frac{\partial w^*}{\partial c} \tag{8}$$

where $P = \Pr(Q\ |n,w)$.

It is obvious from (6) that $\partial P/\partial k > 0$. If c increases, $V(\bullet)$ decreases (see Appendix) and inspection of Figure 2 reveals that k decreases as well, i.e. $\partial k/\partial c < 0$. Hence, an increase in the marginal search cost makes the worker less inclined to search, as reflected in the negative first term of (8); this result does hardly offend intuition.

Expression (8) cannot be signed in the general case (since $\partial P/\partial w^*$ is ambiguous). Note, however, that a higher c will have negligible impact on w* unless C_M is very large relative to $V(\cdot)$ (Figure 2). Thus, we may conclude that the quit response to an increase in the marginal search cost most likely will be negative.

Consider now the quit response to an increase in moving costs. We have

$$\frac{\partial P}{\partial C_M} = \frac{\partial P}{\partial k} \cdot \frac{\partial k}{\partial C_M} + \frac{\partial P}{\partial w^*} \cdot \frac{\partial w^*}{\partial C_M} \tag{9}$$

An increase in C_M implies a reduction in $V(\cdot)$ (see Appendix). By inspection of Figure 2 we conclude that a downward shift of the $V(\cdot)$ function implies a lower search reservation wage; hence $\partial k/\partial C_M < 0$. Since $\partial P/\partial k > 0$ it is clear that the first term in (9) is negative, i.e., an increase in moving costs implies a lower search probability.

From Figure 2 we can also infer that $\partial w^*/\partial C_M > 0$; when the cost of moving increases, the worker revises his acceptance wage upwards. Hence, the second term in (9) is negative for $n = 0$ (cf. Eq. (7)); the first-period quit probability unambiguously falls. For arbitrary values of n, however, the quit-effect of higher moving costs is indeterminate.

Suppose that the variance of the distribution of non-wage attributes increases. We have

$$\frac{uP}{\partial \sigma_z^2} = \frac{\partial P}{\partial k} \cdot \frac{\partial k}{\partial \sigma_z^2} + \frac{\partial P}{\partial w^*} \cdot \frac{\partial w^*}{\partial \sigma_z^2} \tag{10}$$

where σ_Z^2 is the variance of Z. An increase in σ_Z^2 implies a higher value of V(•) (see Appendix), which in turn implies $\partial k/\partial\sigma_Z^2 > 0$. A larger dispersion in the values of prospective job offers increases the returns to search; hence the search probability increases.

An increase in σ_Z^2 will also produce a larger ε in Figure 2; since the value of the "job lottery" has increased, the worker is willing to pay a higher price for participating in it. It follows that $\partial w^*/\partial\sigma_Z^2 < 0$ unless C_M is very large. Hence,an increase in the variance of the non-wage attributes will most likely increase the first-period quit probability.

Finally, it should be noted that an increase in the discount rate implies a reduction in life-time income associated with keeping the current job forever $(y(1+r)/r)$. However, there is also a downward shift of the V(•) function (Figure 2). The net effect on k and w* appears impossible to sign.

5 Concluding Remarks

Several different explanations have been suggested for observed empirical regularities between tenure and quit rates. One of them is the specific human capital hypothesis, according to which the gap between the worker's current wage and his market alternative increases with the length of the job.

Another story relies on unobserved heterogeneity among workers. Since those who are inherently most mobile are most likely to show up with short tenure, the "duration dependence" of quit rates may reflect heterogeneity in unobserved individual characteristics.

We have in this paper suggested another explanation, based on a search theoretic framework expanded to account for imperfect information about non-wage job attributes. Those attributes are often difficult to observe prior to acceptance decisions; hence jobs will be accepted (or refused) without full knowledge of the value of offers.

The introduction of non-wage attributes in a framework of optimal on-the-job search allows us to derive the worker's expected quit-tenure profile. Conditional quit probabilities, at given money wage rates, are decreasing as tenure increases. Workers who sample favorable non-wage attributes are less likely to quit and will therefore be disproportionately represented among those with long tenure.

A number of issues have not been dealt with in the paper. A fairly straightforward extension of the model would be to allow quits into search unemployment. Another, and more difficult, extension would be to model learning behavior among employees. An environment in which a worker makes a once-and-for-all discovery of the true qualities of his job is clearly not very realistic. Although the importance of learning behavior should be recognized, we suspect that an appropriate analysis of it may require contributions from other disciplines than economics.

APPENDIX

Let B be the Banach space of continuous functions on $[0,A]$, where A is chosen so large that W + Z will never exceed A. If $\Phi(V)$ = R.H.S. of (1), $V \in B$, then one verifies that Φ is a contraction mapping with "contraction constant" = $1/(1+r)$. Define $V_0 \equiv 0$ and inductively

$$V_n = \Phi(V_{n-1}) \ , \ n \geq 1.$$

By the "contraction mapping theorem"

$$\lim_{n\to\infty} V_n = V$$

exists and is the unique solution to (1). It is also easy to verify (by induction) that V_n is increasing, convex and has a rate of increase which is less than or equal to $(1+r)/r$. These qualities will be inherited by V, and this proves proposition 1 and also proposition 2 if we observe that the R.H.S. of (2) has a rate of increase which does not exceed $1 + [1/(1+r)][(1+r)/r] = (1+r)/r$, the rate of increase of the L.H.S. Thus, if (2) is satisfied for two distinct values of k, it will also be satisfied for all intermediate values of k. This proves that k is (essentially) unique. It follows also readily (by induction) that smaller c and/or C_M will give larger V_n's, i.e., larger V.

An increase of the variance σ_z^2 of Z will increase the value of the integral in (1), since the "Jensen effect" will be more pronounced. Thus, the same argument as above shows that V will increase by an increase of σ_z^2.

It remains to prove proposition 4b. In the integrals of (6) we make the change of variables $x = F(w^*(w+z))$ and introduce

$$C = \int_{k-w}^{\infty} g(z;w)dz \geq 0$$

Now

$$Pr(Q|n,w) = \frac{\int x^n(1-x)\tau(dx)}{c + \int x^n\tau(dx)}$$

where τ is some positive measure on $[0, 1]$. The condition $Pr(Q|n+1,w) \leq Pr(Q|n,w)$ is now seen to be equivalent to

$$\int x^{n+1} (1-x)\tau(dx) \cdot [c + \int x^n \tau(dx)] \leq$$

$$\leq \int x^n (1-x)\tau(dx) \cdot [c + \int x^{n+1} \tau(dx)].$$

Since $\int x^{n+1} (1-x)\tau(dx) \leq \int x^n (1-x)\tau(dx)$ it remains to prove that

$$\int x(1-x)\mu(dx) \cdot \int \mu(dx) \leq \int (1-x)\mu(dx) \cdot \int x\mu(dx)$$

where $\mu(dx) = x^n \tau(dx)$. Sine both sides are homogeneous of degree two in μ, we may without loss of generality, assume that μ is a probability measure, i.e. $\int \mu(dx) = 1$. The relation is now

$$\int x\mu(dx) - \int x^2\mu(dx) \leq \int x\mu(dx) - (\int x\mu(dx))^2$$

or

$$(\int x\mu(dx))^2 \leq \int x^2\mu(dx).$$

But this is a special case of Jensen's inequality. Q.E.D.

FOOTNOTES

[1] The money wage offer is interpreted as involving all observable aspects of the offer. To the extent that compensating wage differentials are present, those are captured by W.

[2] $\partial P/\partial w^*$ denotes the rate of increase of P due to variation of the function $w^*(y)$.

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