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The Impact of Optimal Search Models on the Modeling of Migration Behavior

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1. Introduction

For a long period of time perfect information has been a standard assumption in economic theory. Particularly in neoclassical micro-economic theory individuals by assumption know all prices and all characteristics of goods. Information about changes in the economic system is transferred immediately to all individuals, thus provoking instantaneous reactions, which stabilize the system and bring it to equilibrium. This implies that all information is completely costless, not only in monetary terms, but also in terms of time and effort necessary to aquire it. If he had to spend money or time to gather information, the neoclassical homo-oeconomicus would optimize the amount of resources invested into accumulation of information with respect to other activities. Consequently, to stay consistent within the neoclassical framework, information has to emerge somehow from within the individual and it has to do so in no time.

"That human endavors are constrained by our limited and uncertain knowledge of the world has always been recognized by leading economic thinkers. (...) But despite this long standing recognition, until relatively recently there was no rigorous foundation for the analysis of individual decision-making and market equilibrium under uncertainty" (Hirshleifer and Riley 1979, p.1375). Following the work of von Neumann and Morgenstern (1944), some important steps were undertaken by the theory of liquidity preference (Tobin 1958), portfolio (Markowitz 1959), and state preference theory (Hirshleifer 1966).

In labor market theory the strict information assumption of standard neoclassical theory was fist weakened by the invention of job search models (Stigler, 1961, 1962). Workers no longer are assumed to know "the wage" exactly, but to face a distribution of wages in the market. They draw from this distribution and since there are cost involved with each draw the individual faces a stopping problem. After each draw he has to decide whether to accept the offer drawn or to continue searching. To do so, in each step the individual has to compare the actual wage offer with the uncertain outcome of the continued search sequence net of search cost.

Numerous versions of the search model have been developed. They can be classified by criteria like limited or unlimited search, recall or no recall, the number of wage offers per period, etc. The most fundamental classification criterion is the assumption concerning the individual's knowledge about the wage offer distribution; whether he knows the distribution exactly or not. If he does, draws from the distribution do not tell the individual anything new about parameters and form of the distribution, while in the second case with each draw the individual improves his knowledge about the distribution. The following discussion about the regional implications of job-search models will be organized along this distinction.

Although the concept of search is well accepted in migration literature (see e.g. Clark 1983, Greenwood 1985), little emphasis has been put into the formal linking of migration and job search models (Schaeffer 1985). With a few exceptions (Weibull 1978, David 1974, Miron 1978, Rogerson 1982) the literature either uses just a verbal job search argumentation without strict formal considerations or departs considerably from the basic structure of economic job search models, focusing e.g. on the problem of matching applicants and vacancies in the labor market.

By no means it is our intention to disregard the importance of this body of literature. In some aspects it is more realistic than pure job search concepts and able to overcome some of the weaknesses of search models, particularly in relating labor supply and demand. Nevertheless, this situation is surprising from a theoretical as well as an empirical point of view, since there is a huge and fast growing literature on search processes in economics (see e.g. Rosenfield and Shapiro 1981, Burdett and

Malueg 1981, Benhabib and Bull 1983, Morgan 1985, Morgan and Manning 1985), and in regional science a lively interest in the analysis of individual decisions and most recently in the dynamics of individual decisions (Dunn and Wrigley 1985, Davies and Pickles 1985). Lerman and Mahmassani (1985) made an attempt to link search and discrete choice models and provided a framework for econometric estimation of search processes.

It is the aim of this paper to analyse the implications economic job search models have for migration. We restrict ourselves to the job search model predominant in the economic literature and its variants. Therefore we use the following assumptions throughout the paper, which are more or less standard in job search theory.

- The wage offer distribution is constant over time. So the individual always faces the same wage offer distribution while searching for a job.
- The individual is risk neutral and income is the only element in his utility function. Therefore the expected utility of some uncertain income is equal to the utility of the expected income and the individual's utility function can be ignored.
- Labor and jobs are homogenous within the submarket of the individual. With the exception of the wage there are no differences between jobs. They all offer the same working conditions and there is no risk of losing the job in the future. The productivity of all workers is the same.
- Search cost are known to the individual.

When more than one (regional) labor market has to be taken into account, we use two additional basic assumptions:

- Labor markets are disjoint and the assumptions mentioned above hold for all of them.

- Migration cost are known to the individual.

The paper generalizes some earlier work done by the author (Maier 1983, 1985a). So the models and results presented there will be discussed here only briefly.

2. Job-search models with perfect information about the wage offer distribution

2.1. The standard job search model

Additional to the assumptions mentioned above the standard version of the job-search model assumes unlimited search. Additionally let us assume in the first step that the individual can draw one wage offer per time period and that he doesn't discount opportunities. With this set of assumptions the individual's optimal strategy is myopic and has the reservation wage property (Lippman and McCall, 1976). He fixes a reservation wage and searches for the first wage offer to exceed it (Telser, 1973, Lippman, McCall, 1976, 1979, McCall, 1970). Let c be the cost for one random draw from the wage offer distribution, x a random variable denoting wage offers, and F(x) the cumulative density function of this random variable then the reservation wage (y^*) has to satisfy the following condition:

$$c = \int_{y^*}^{\infty} (x-y^*)\ dF(x) \qquad (1)$$

Since in each step the individual compares the actual wage offer with the expected return of continued unlimited search and chooses the larger one, the reservation wage is constant over time and equal to the expected return of search with search cost c, wage offer distribution F and an unlimited search horizon. Let us denote this expected return of search as V, leaving the dependence on c, F, and the search horizon implicit.

$$V = y^* = -c + \int_0^\infty \max(x,y^*)\ dF(x) \tag{2}$$

This strategy maximizes the individual's expected return of search. Deviations yield a lower expected return of search. They either lead to the acceptance of too low wage offers or to a search sequence longer and thus more expensive than optimal. All these results hold for both, the recall and no-recall strategy. This follows from the fact that the reservation wage doesn't change over time. Therefore the first offer exceeding the reservation wage is always the largest one in the whole sequence and will be chosen irrespective of the validity of recall.

This search model has the following well known properties:

- An increase in search cost leads to a decline in the reservation wage (= expected return of search) and therefore to a shorter expected period of search.
- A mean preserving increase in the riskiness of the wage offer distribution yields a higher reservation wage.

Lippman and McCall (1976) discuss some interesting variants of the standard search model. They all imply optimal search strategies with the general structure and results discusses above. They are myopic, and have a reservation wage, which is invariant over time. However, the reservation wages differ from (1) or (2). Discounting yields a lower reservation wage, which is lower for greater interest rates. Equation (2) becomes

$$y^* = (1+r)^{-1}\ (-c+\int_0^\infty \max(x,y^*)\,dF(x)) \tag{3}$$

when the search cost is incurred at the end of the time period, and

$$y^* = -c + (1+r)^{-1} \int_0^\infty \max(x,y^*)\ dF(x) \qquad (4)$$

when it is incurred at the beginning of the period. In both cases the wage offer is assumed to be received at the end of the period.

If the individual cannot draw one wage offer per period of time with certainty but only with some probability p, the reservation wage will be lower for lower probabilities. It results from

$$y^* = p\ (-c + \int_0^\infty \max(x,y^*) dF(x)) \qquad (5)$$

which is a general version of (2). An other interesting result of their work is the following: Search with a fixed number of available wage offers per period yields a higher expected return than search with a random number of wage offers with an expeced number of the same size.

This whole family of the job search models implies a very simple optimal migration behavior. For the discussion of these implications we will utilize the most simple version of the job search model as described by (1) and (2). Suppose there are N regions, each characterized by its own wage offer distribution and search cost.

$$F_i(x), \quad c_i \qquad i = 1,..,N$$

Assume further that the assumptions of the standard search model hold for all N regions and that the migration cost (m) between the regions are known to the individual and satisfy

$$m_{ij} \begin{cases} =0 & \text{for } i=j \\ >0 & \text{for } i \neq j \end{cases} \qquad (6)$$

With known wage offer distributions and search cost the individual can calculate reservation wages for all regions from (1) or (2). Let's denote them as

$$y_1^*,\ y_2^*,\ y_3^*,\ \ldots\ ,\ y_N^* \tag{7}$$

As noted above, they are equal to the expected return of search in these regions. Without loss of generality we can assume that the individual is currently located in region 1. Then the individual can calculate his expected return from migration to region j (Y^*_{1j}) as

$$Y^*_{1j} = y_j^* - m_{1j} \tag{8}$$

and choose the region giving the highest expected return net of search cost.

It is important to note that the migration decision based on (8) is not stochastic. Because of his perfect knowledge of the wage offer distribution the individual can calculate the expected returns for all regions exactly. His actual income in the chosen region, however, is a random variable.

This migration model has some interesting features:

- By assumption the individual knows all cost and all wage offer distributions. There is no strategy which can provide any additional information. If we make the reasonable assumption that search in a region is always more expensive when the individual does not live in this region, the individual will always migrate before he starts searching for a job (Maier 1986).

- Since the reservation wage doesn't change over time the expected returns from migration do not change either. Therefore the individual chooses the optimal region and will never have to revise this choice during the search process. Each individual will search for a job in only one region.

- Migration cost are the only element varying with distance. Therefore all the distance-sensibility of migration rates, which is observed in reality, has to be ascribed to this variable. In this respect nothing is gained from a job search approach as compared to the simple "full information" - model.

- The properties of the search model noted above lead directly to the conclusion that a region is more preferable when - other things equal - it has lower search cost or a more risky wage offer distribution. The second point is of particular importance. It implies that not only the mean but also higher moments of the wage offer distribution will influence migration behavior.

2.2. A job search model with limited search horizon

One reason for the simplicity of the migration model lies in the fact that we have assumed an unlimited search horizon. This assumption leads directly to the result of a time-invariant reservation wage. For the rest of this section we will discuss the changes in the search- and migration model following from a relaxation of this assumption.

Let us assume a search model differing from the standard version only in the respect that the individual faces a limited search sequence of n additional draws. Under this assumption the reservation wage does not remain constant over time and consequently the recall and no-recall options yield different results. In the economic job search literature it is usually argued that the limitation of the search sequence is the result of the life expectancy of the individual and/or his wealth, both of which diminish during the search process. In this interpretation n, the number of additional draws open to the individual, is a characteristic of the individual only and is unrelated to the (regional) labor market he searches. We will first discuss the model and its implications for migration and in section 2.3 reinterpret it in a more space-related way. Moreover, we will discuss the no-recall option only.

The expected return of search in a search model of this type (perfect knowledge about F, no recall, n additional draws permitted) is equal to

$$V^n = -c + \int_0^\infty \max(V^{n-1}, x)\ dF(x) \tag{9}$$

where the superscripts (n) and (n-1) indicate the length of the remaining search sequence. By assumption

$$V^0 = 0$$

and therefore

$$V^1 = -c + \int_0^\infty x\ dF(x) \tag{10}$$

So, when the individual is down to one additional draw, the only thing he can do is to pay the search cost and accept whatever he draws from the wage offer distribution.

As can be shown by a simple induction argument (Lippman and McCall 1976) the expected return of search is a nondecreasing function of n, with

$$\lim_{n\to\infty} V^n = y^* \tag{11}$$

Or, if viewed the other way around, when an individual starts with a long search horizon (large n) his reservation wage is only little below that of an unlimited search sequence. With each unacceptable draw the individual becomes less selective, i.e. his reservation wage decreases. It does so with increasing steps. In the last step (n = 1) the individual will be willing to accept every wage offer that comes up. Loosely speaking, more and more emphasis is shifted from the upper part of the wage offer distribution, which is determining the reservation wage of the unlimited search sequence, to the distribution as a whole.

The range of the possible values for V^n is determined by the spread of the wage offer distribution and search cost. The first influence results from the reaction of (2) to a mean preserving increase in the spread of the wage offer distrubition. The second one stems from the fact that

$$\partial y^*/\partial c = 1/(F(y^*)-1) \qquad \text{and} \qquad \partial V^1/\partial c = -1 \tag{12}$$

the marginal changes of (2) and (10) to changes in search cost. Note that the range between (10) and (2) decreases with increasing search cost and that it is zero for $F(y^*) = 0$, i.e. for search cost equal to the mean of the wage offer distributon, a value which makes the individual indifferent between search and no-search and reduces (2) and (9) to zero.

Let us turn to the migration behavior implied by this search model. Since the expected return of search for an individual varies over time, equation (8) changes to

$$Y^n_{1j} = V^n_j - m_{1j} \tag{13}$$

with V^n being the expected return of search in region j, given a search horizon of n. Still the individual chooses the region offering the highest expected return net of search cost, however, he has to make this decision for every value of n.

This has an important effect on the migration decision:

- In this model it can be an optimal strategy for the individual to start to search in one region and, if unsuccessful, to move to an other region. Because of the properties of the search model, as long as n decreases this move always has to be to a region with a less risky wage offer distribution with a higher mean. A move in the contrary direction will only be made by an individual, whose parameter n did increase, e.g. because of the accumulation of wealth.

If we assume n mainly to be determined by the age of the individual, this result implies that older people tend to prefer regions with less risky wage offer distributions. However, a region, which has a wage offer distribution with lower risk and lower mean than any other will not be chosen at all.

2.3. A spatial job search model

Up to now we have considered spatial aspects only at the level of the migration model. At the level of the job search model we have applied the concept of a spaceless point economy. The size of the regional labor market was assumed to be given exogenously. This structure is by no means realistic, and so we will turn to the discussion of a spatial version of the standard job search model, i.e. the model with perfect knowledge about the wage offer distribution. As it will turn out, the limitation of the search sequence is an implicit result of this model.

Suppose the individual is located at one point in space, labeled 1) and enterprises distributed somehow around this point at discrete locations. So, in an area with a specific radius around his location the individual finds a limited number of enterprises. Let's assume that all enterprises in this area apply the same wage offer distribution F(x) and that search cost for the individual increase with the distance from point 1.

The relation between search cost and distance can be interpreted in one of two ways: (1) as the influence of distance on the search cost per se; i.e. the effect of the longer way to obtain a wage offer, (2) as the influence mentioned in (1) plus the present value of commuting cost. The first case will establish only a weak relation between search cost and distance, while in the second case the individual's location within the labor market region has to be assumed fixed at point 1. For the sake of simplicity we will accept the second interpretation.

However, both versions allow the individual to label the enterprises in increasing order of search cost. We will use the index k for this sequence of firms. If the search cost increase strongly enough, there is a label K, for which

$$c_k >= \int_0^\infty x \, dF(x) \tag{14}$$

From this point on the expected return of a single draw from the wage offer distribution is zero or negative and so, the individual will never search beyond K, which on the one hand represents the cut off point in the sequence of firms, on the other the spatial boundary of the individual's regional labor market. So the individual faces a search problem with at most K firms to search.

As proved in the appendix it is optimal to search firms with lower search cost first. So, without any further assumptions the optimal strategy would be to search the firm with lowest search cost only. Since this is exactly the unlimited search problem discussed above, we will add the assumption that each firm can be searched only once. This assumption seems to be quite technical in this form. However, it can be modified either to hold only for a specific time period or that each firm can be searched a limited number of times.

With this extra assumption the individual's optimal strategy is to search the firms in increasing order of search cost. Therefore, the expected return of search at firm k is (note that k increases during search, while n in section 2.2 decreases)

$$V^k \doteq -c_k + \int_0^\infty \max(x, V^{k+1})\ dF(x) \qquad \text{for } k<K \qquad (15)$$

It decreases with increasing k because of (1) the increasing search cost and (2) the decreasing number of available opportunities. The two influences are connected, since the maximum search distance, as determined by (14), is a function of search cost.

In this version of the search model the spatial structure of the region plays a central role. Regions with firms concentrated around the location of the individual have a higher expected return of search than regions with a more disperse distribution of firms. The reason is that in the first case the individual will have many more chances for observing an acceptable wage offer at low cost than in the second. When all firms are lined up at the maximum search distance, the expected return of search is zero.

Table 1. The effect of ß on the expected Return of search

ß	V	ß	V
0.1	1.972	1.0	7.818
0.2	3.452	2.0	8.708
0.3	4.572	3.0	8.905
0.4	5.430	4.0	8.963
0.5	6.092	5.0	8.983
0.6	6.610	6.0	8.991
0.7	7.018	7.0	8.995
0.8	7.343	8.0	8.997
0.9	7.605	9.0	8.998

Table 1 illustrates this feature by the use of a simple numerical example. We use a uniform wage offer distribution between zero and ten and a linear relation between search cost and distance.

$$F(x) = x/10 \qquad 0 <= x <= 10 \qquad c_k = 0.05 + 0.05\ d_k$$

With this specification the maximum search distance is 99 and we fix the number of firms at 99 as well. The different values for the expected return of search in table 1 originate from the variation of a single parameter ß relating the index k to distance and thus describing the spatial distribution of firms in the region.

$$d_k = k^{\beta}\ 99^{(1-\beta)}$$

When compared to the model with limited search sequence discussed in section 2.2, the effect of the spatial distribution of opportunities is much stronger than that of the number of firms. This results from the fact that in the present model search cost increase with each draw. A major difference between the model with limited search sequence and the spatial model lies in the nature of the limitation. While N in the first model is a characteristic of the individual, K in the second is a characteristic of the region. So, when the individual migrates from one region to another, in the spatial model he can start the new search sequence from the beginning, i.e. from k = 1. This is not the case in the model with limited search sequence. Moreover, since search cost increase during the search sequence, the reaction of the expected return of search through time is stronger than in the model with limited search sequence.

All these have important effects on the level of the migration model. All other things equal regions are more preferable when

- they have a more risky wage offer distribution,
- a lower general level of search cost,
- there are more firms within the maximum search distance,
- they have a more concentrated spatial distribution of firms.

Since K is a characteristic of the region, search in one region does not reduce the expected return of search in other regions. So the result derived from the search model with limited search sequence that migration is directed towards regions with a less risky wage offer distribution does not hold in the spatial model.

On the other hand, the result of the standard search model that migration always occurs ahead of any search activity does not hold either. Since the expected return of search decreases with each unsuccessful draw, at each step the individual has to make a migration decision. If there is a region offering a higher expected return of search - net of migration cost - than his current one, the individual should migrate to this region. Because of the increasing search cost migration is more likely in this model than in the models discussed before.

3. Search models with imperfect information about the wage offer distribution

Until now we used the assumption that the individual has full knowledge about the wage offer distribution. It is not much weaker than the perfect information assumption of standard neoclassical theory. Only if information about the wage offer distribution is completely costless, an optimising individual would acquire full knowledge about the wage offer distribution, otherwise he would try to balance the cost of additional information with its marginal value, which again depends on the subject the information is used for.

A search model based on the assumption of full knowledge about the wage offer distribution completely ignores the process of learning and implies a rather neurotic behavior of the individual: he does not change his opinion about the wage offer distribution, even if he observes the lowest wage offer possible one hundred times in a row.

The reason for the popularity of this assumption lies in the fact that it simplifies the model structure and yields an optimal search strategy which has the reservation wage property. With this property at each step the set of possible wage offers can be split into two convex subsets, the acceptable and the not-acceptable wage offers, divided by the reservation wage. All wages larger - or equal - than the reservation wage are acceptable, all other unacceptable.

When assuming the individual has only incomplete knowledge of the wage offer distribution "the problem becomes more complex, and search strategies become less well behaved" (Rosenfield and Shapiro 1981, p.1). In this type of model wage offers are not only employment opportunities, they also provide information about the wage offer distribution. Besides deciding whether to accept the wage offer or not the individual has to incorporate this new information into his state of knowledge. We assume that this is done according to Bayes' rule. Because of this updating process models of this type do not generally have the reservation wage property. Consider for example the following situation (adapted from Rothschild 1974, p.701): "Suppose there are three wages, $1.00, $2.00, and $3.00, and that the cost of search is $0.01. Prior beliefs admit the possibility of only two distributions of wages. Either all wages are $1.00 or they are distributed between $2.00 and $3.00 in the proportions 1 to 99. A man with these beliefs should accept a wage of $1.00 (as this is a signal that no higher wages are to be had) and reject a quote of S $2.00 (which indicates that the likelihood is high that a much better wage will be obtained on another draw)." (Lippman and McCall 1976, p.174). Obviously there is no reservation wage in this situation. What makes this example work, of course, is the fact that the wage offer contains a large amount of information, since it allows the individual to distinguish between the two possible distributions.

For more reasonable situations, however, one can prove that the search problem has the reservation wage property. For a multinominal distribution of wage offers with a dirichlet prior this prove was worked out by Rothschild (1974). Rosenfield and Shapiro (1981) provide a general theorem for the existence of the reservation wage property and show that a normal wage offer distribution with unknown mean and an exponential wage offer distribution with exponential prior on the parameter both fulfill the conditions of the theorem.

Let F(x) be the subjective distribution of wage offers describing the individual's knowledge prior to any search. It is the result of information received from friends and relatives of general information transmitted by mass media etc. In addition to the wage offers observed up to a specific point in the search sequence this distribution describes the individual's state of knowledge. Let $\mathbf{p}$ be the vector of past wage offers and $F(x|\mathbf{p})$ the individual's subjective distribution of wage offers after observing the vector $\mathbf{p}$. $V(\mathbf{p})$ denotes the expected return of search, which now is a function of the vector of past offers.

In a search problem without recall and limited to n more draws the expected return of search is

$$V^n(\mathbf{p}) = -c + \int_0^\infty \max\{x, V^{n-1}(x,\mathbf{p})\} \, dF(x|\mathbf{p}) \tag{16}$$

If the reservation wage property holds the reservation wage results from solving for x

$$x = V^{n-1}(x,\mathbf{p}) \tag{17}$$

and is a function of n and $\mathbf{p}$.

- As in section 2 the expected return of search is a nondecreasing function of n. This results from the fact that an increase of n only adds additional options without changing the cost of search.

- The expected return of future search - the right hand side of (17) - depends on the value of the wage offer drawn, since this influences the individual's beliefs about the actual wage offer distribution.

- It is a non-decreasing function of x, and in the limiting case of full knowledge about the distribution and unlimited search it is constant.

- Since additional information contributes relatively more when the individual has only little knowledge the slope of the right hand side of (17) with respect to x is larger in this case.

The strategy discussed in section 2 was optimal in the sense that it yielded the highest expected return of search. It was based on the assumption of perfect knowledge about the wage offer distribution. The best strategy an individual with incomplete knowledge about the wage offer distribution can apply will deviate from this sequence of reservation wages, and therefore result in a lower expected return of search. Since deviations from the optimal full knowledge strategy are more likely when the individual has less precise information, the expected return of search increases - other things equal - with the precision of information and converges towards the return of full knowledge search.

The question arises how the reservation wage changes over time in a search problem with incomplete knowledge and the reservation wage property. There are three counteracting influences:

- The limitation of the search problem as indicated by the index n in (16) leads to a decrease in the reservation wage during search.

- The improvement in knowledge about the distribution the individual experiences during search increases the reservation wage.

- For search to continue to a specific point, all wage offers observed up to this point have to be unacceptable. So the individual gets more and more information about unacceptable wage offers, but no additional hints that there are any acceptable wage offers. At least in the long run this has to reduce the reservation wage.

The net effect of these three influences is unclear. Neither the relevant literature gives any clear results nor were we able to prove an increasing or decreasing reservation wage. Numerical tests, however, using a multinomial wage offer distribution always produced a sequence of decreasing reservation wages. Also intuitively this is the most appealing tendency.

With imperfect knowledge about the wage offer distribution accumulation of information is valuable for the individual. Its expected result is an increase in the individual's expected return of search by reducing the probability of large deviations from the full knowledge sequence of reservation wages. The main difference between search and the accumulation of information lies in the fact that observation of wage offers above the reservation wage stop the search strategy but do not stop the information strategy. Since with more and more accumulated knowledge the expected return of search converges towards the full knowledge value, the expected value of additional information decreases and converges towards zero. So, for an individual whose prior knowledge is vague but indicates the possibility of high wage offers the accumulation of additional information very likely is optimal.

In a migration context the assumption of imperfect knowledge about the wage offer distribution has some important implications:

- Migration cost is not any longer the only distance related element. The individual will also have less precise prior information about the wage offer distribution in more distant regions and information cost will be higher for those regions as well.

- General (newspapers, radio, TV, etc.) and individual specific information channels (friends, relatives, business contacts, etc.) have an important impact on migration behavior. They can improve the prior knowledge about the wage offer distribution in a specific region and also lower the information cost. Past migrants can have a similar influence and thus establish a beaten path phenomenon (see Maier 1985a for a discussion of more effects of this type).

- The migration decision depends on the prior knowledge an individual has about the wage offer distribution in a specific region. Therefore, from the point of view of the analyst the migration decision no longer is deterministic (as in section 2) but stochastic. This is very similar to the randomness of the utility in discrete choice models (see Hensher and Johnson 1981, Ben Akiva and Lerman 1985, Maier 1985b).

4. Summary and concluding remarks

The discussion of regional impacts of job search models was organized along the knowledge an individual is assumed to have about the wage offer distribution. Section 2 discusses job search models with perfect knowledge about the wage offer distribution and their implications for migration. Section 3 focuses on the more complicated but more realistic model with imperfect knowledge about the distribution.

In particular the standard job search model (with unlimited search horizon, section 2.1) was found to bring forth quite unsatisfactory results at the migration level. It implies that migration decisions are always made ahead of any search and the individual will search one region only. When turning to the job search model with limited search horizon (section 2.2) we found these results not to hold any longer. In this model unsuccessful search can be followed by migration, although it is rather unlikely since the limitation of the search horizon is determined by the characteristics of the individual, not by those of the region. In section 2.3 we discuss a spatial version of the standard job search model where search cost are a function of the distance between the locations of the individual and the firm. In this model the search sequence is implicitly limited by the maximum search distance, and firms are searched in increasing order of search cost. The spatial distribution of firms has an important impact on the expected return of search and consequently on the attractivity of regions at the migration level. A disperse spatial distribution of firms yields a much lower expected return of search than a spatial concentration of firms.

In section 3 we discuss search models with imperfect knowledge about the wage offer distribution. Offers drawn provide additional information about the wage offer distribution, which the individual incorporates into his state of knowledge. This model is more complicated than the model versions discussed in section 2 and does not always have the reservation wage property. For some reasonable assumptions about the wage offer distribution and the individual's state of knowledge, however, the reservation wage property can be shown to hold. Since less precise information about the wage offer distribution yields a lower reservation wage, in this model information and the way it is distributed over space have an important impact on migration. Friends and relatives, past migrants, mass media, etc. can lead to a situation where individuals have better knowledge about the wage offer distribution in a specific region and will therefore more likely migrate to this region.

It was the aim of this paper to investigate the regional implications of job search models. Although there are numerous versions of search models in economic literature, the assumptions made in section 1 are more or less common to all of them. When trying to evaluate the role job search models can play in regional theory, one has to be aware of the restrictive nature of these assumptions. Especially the neglect of all effects unsuccessful search and unemployment have on the behavior of the individual and on the wage offer distribution he faces is a severe weakness. It is related to the fact that employers are usually treated only as "random number generators" in job search models. They produce wage offers according to a specific probability function and are by no means interested in filling their vacancies or hiring the most productive applicant. So, job search models deal with just one side of the labor market and do not adequately represent the adjustment processes in the labor market. All attempts to overcome this deficit were successful only for very simplistic search models (see e.g. MacMinn, 1980).

Nevertheless, the concept of search is appealing and clearly superior to the old neoclassical full information approach. It seems to be a step in the right direction, although the goal of a consistent microeconomic theory based on limited information is still way ahead; not to mention a spatial theory of this type. From our point of view future efforts should be made in the following areas: In theory more attention should be paid to search models with imperfect knowledge about the wage offer distribution. Particularly from a regional point of view they seem much more promising than perfect knowledge search models. Secondly, the integration of supply and demand to search-based labor market models is urgently needed. In empirical research, on the other hand, more effort should be made in investigating the reality of search processes and testing the hypotheses brought about by various theoretical models. The recent interest of regional scientists, geographers and economists in the analysis of microdata and the rapid methodological progress in this area (see e.g. Wrigley 1985, Ben Akiva and Lerman 1985) should ease this task.

Appendix

Suppose there are two possible draws labeled k and l out of a search sequence of some length greater than both k and l. These two draws are characterized by search cost c_k and c_l.

The expected return of search from k and l onwards is independent of the sequence in which k and l are searched and is denoted by V. V_{kl} denotes the return of search where first k is searched and then l, V_{lk} denotes the return of the reverse sequence. V_k is the expected return where l has already been rejected and only k (plus all following draws) is left, V_l is the respective return for draw l.

Theorem:

$$\text{If } c_k < c_l \quad \text{then} \quad V_{kl} > V_{lk}$$

Proof:

$$V_{kl} = -c_k + \int_0^\infty \max(V_l, x)\, dF(x) \qquad V_{lk} = -c_l + \int_0^\infty \max(V_k, x)\, dF(x) \tag{A.1}$$

$$V_k = -c_k + \int_0^\infty \max(V, x)\, dF(x) \qquad V_l = -c_l + \int_0^\infty \max(V, x)\, dF(x) \tag{A.2}$$

From (A.2): $V_k - V_l = c_l - c_k$, from the condition: $V_k > V_l$ (A.3)

The conclusion of the theorem can be rewritten as:

$$V_{kl} - V_{lk} = -c_k + \int_0^\infty \max(V_l, x)\, dF(x) + c_l - \int_0^\infty \max(V_k, x)\, dF(x)$$

Using (A.3): $V_{kl} - V_{lk} = V_k - V_l + \int_0^{V_l} V_l\, dF(x) + \int_{V_l}^{V_k} x\, dF(x) - \int_0^{V_k} V_k\, dF(x)$

If we add and subtract $\int_{V_l}^{V_k} V_l \, dF(x)$ at the right hand side, some basic transformations yield:

$$V_{kl} - V_{lk} = (V_k - V_l)(1 - F(V_l)) + \int_{V_l}^{V_k} (x - V_l)\, dF(x) \tag{A.4}$$

Since both elements at the right hand side of (A.4) are positive, their sum has to be positive as well. This proves the theorem.

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