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MATCHING EMPLOYERS AND WORKERS: AN EMPIRICAL ANALYSIS ON THE EFFECTIVENESS OF SEARCH

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1. Introduction

THE SUCCESS of a search/recruitment channel depends on the speed at which potential contacts result in a match, and on the total number of job seekers and vacancies that use the channel.

Generally the effectiveness of search/recruitment channels is assessed in two different ways: first, by the number of job offers for workers and the pool of applicants for employers that are generated when these channels are used; second, by the time it takes to find a new job or a new employee. Contributions on the success of search methods have been made, for example, by Holzer (1987, 1988) and Blau and Robins (1990) for worker's search and by Roper (1988) for employer's search. In these contributions four different search or recruitment channels are distinguished: advertisements, employment office, informal search and other.

With regard to worker's search Holzer (1987, 1988) found informal search, using friends and relatives, to be the most productive in terms of the number of job offers and accepted jobs. This is confirmed by Blau and Robins (1990), who in addition established that employed job seekers have a higher probability of finding a job than unemployed job seekers. Blaschke (1987) using German data, also found the informal search channel to be the most productive, whereas Jones (1989) found no significant differences. Roper (1988), in his analysis for employer's search duration, concluded that informal search is also the most productive channel for firms (in terms of expected duration).

There are some drawbacks in these earlier studies. Firstly, they are partial in the sense that worker's search and employer's search are analysed separately. Secondly, the total number of workers and employers operating through a specific search or recruitment channel is ignored. It is obvious that if the number of workers on the market, searching through a specific channel, is relatively large compared to the number of vacancies, long 'search' durations for workers and short vacancy durations are to be expected. In general the effectiveness of a specific search or recruitment channel depends on the number of applicants and vacancies at market level.

We estimate a general model that allows for both sides of the labour market to interact, and takes into account their relative numbers. For each separate search/recruitment channel we specify a matching function. The number of matches per channel depends on the number of vacancies and the number of job seekers entering the market through that channel. The parameters of the matching function are technical parameters ('geometric weights'), indicating the relative importance of supply (job seekers) and demand (vacancies), and an efficiency parameter. The effectiveness of a specific search/recruitment channel can be assessed on the basis of the estimated parameters.

We explicitly allow the parameters to differ for employed and unemployed workers. This is done because it is as yet *a priori* not clear whether informal search will be as effective for unemployed workers as it is for employed workers. The unemployed may lose their informal contacts as time goes on.

From the matching functions defined at market level, we derive microeconomic duration models for employers and workers. In the specification of the hazard, the same parameters as those in the matching function appear. Successful jobsearch by a worker or the filling of a vacancy are two processes that are generated by the same matching function.

Our approach allows us to analyse microeconomic data on vacancy and job search duration simultaneously. To establish what effect the total number of vacancies and the total number of workers have on the effectiveness of the different search/recruitment channels, we combine the micro data with data at market level.

The analysis must be considered exploratory and descriptive. We focus on characteristics of labour markets rather than on optimising behaviour from an individual point of view. The latter would require a complete structural (equilibrium) model, in which success probabilities and the choice of search method are related. Instead we use a model in which the effectiveness of a specific search channel is assessed conditional on the choice of search method. The results of our analysis indicate large differences in the effectiveness of the search channels. For any given specific search channel large differences exist between employed and unemployed workers. Advertisements and informal search are most effective in matching employed workers and vacancies. At the same time the employment office is very ineffective in doing this. The employment office is on the other hand very effective in matching unemployed workers and vacancies. For them advertisements are very ineffective.

The plan of this paper is as follows. We present the model in Section 2. In Section 3 we discuss the data. In Section 4 we present the empirical specification and the results. Section 5 concludes.

2. The model

2.1. *Matching employers and workers*

Starting out from previous empirical work (e.g. Holzer, 1987, 1988), we distinguish four different search/recruitment channels that employers (vacancies) and workers (job seekers) use: advertisements, informal search, public employment office and other.[1] The number of matches (or the flow of filled job

[1] For workers (employers) informal search methods include checking friends/relatives (friends/relatives/own personnel) or inquiring for work at an employer (recruiting those who inquired). Other search methods are a collection of remaining categories (e.g. the use of temporary employment agencies).

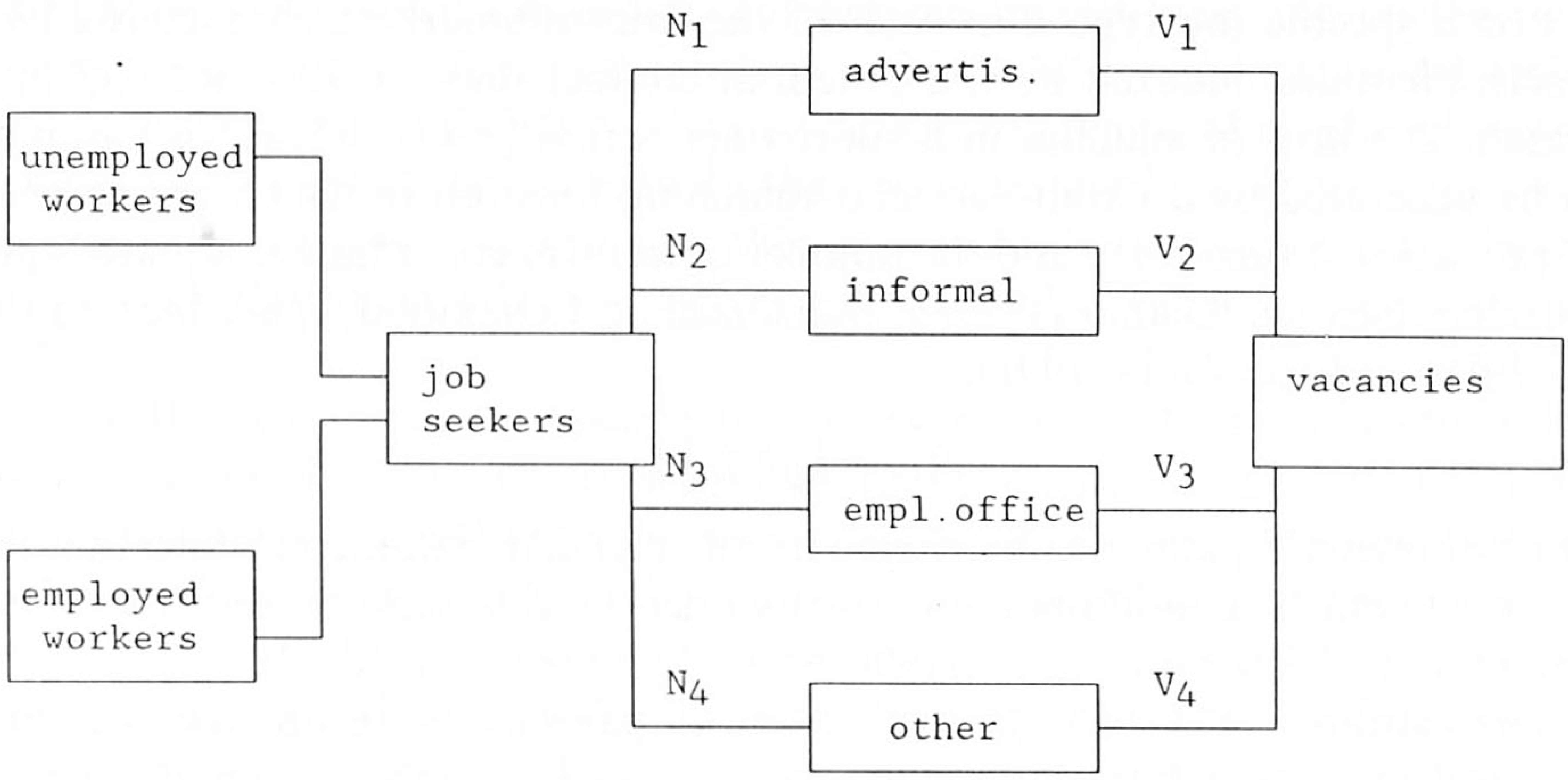

FIG. 1. Search of employees and workers

vacancies *c.q.* the flow of job seekers finding a job) through each channel depends on the number of job seekers and vacancies using the channel, as well as on the speed at which each potential contact between job seeker and vacancy is transposed into a formal match. In the literature speed is seen as a measure of the efficiency of a search channel. The total effect on the number of matches of the number of vacancies and job seekers combined with the efficiency of the search channel is referred to as the effectiveness of the channel.

Figure 1 gives a graphic illustration of our view of the market per job type. Job types, indexed by i, are distinguished according to occupation, education and region. The number of job seekers (N) and the number of vacancies (V) operating in each market is generated by the search process at the individual level. On the supply side of the market an individual of a specific job type, decides whether or not to search, and if so, which search method(s) to use. The same holds for the employer. Aggregation gives the pool of job seekers and vacancies at market level of job type i. For each specific job type, workers and employer may only meet if they use the same search channel (i.e., if they operate on the same submarket). Employers will use recruitment channels in different proportions for different job types (vacancies). An employer who wants to fill a vacancy requiring a high level of education might prefer advertisements to the public employment office. Different job seekers might also want to use different search channels. For example, construction workers may prefer informal search rather than advertisements.

So, the market is divided into different submarkets, stratified according to job type and search channels. In these submarkets employer and job seeker may make contact, and given a contact they may decide whether to form a match. Basically we will specify and estimate functions for the number of matches that are generated on each of the submarkets. The effectiveness of a specific search channel can be assessed on the basis of the estimated parameters of these matching functions. Below we will present the model more formally.

For a specific job type i, in each of the four submarkets characterised by search channels, indexed by j, a potential contact may or may not end in a match. The flow of matches in a short time period $[t, t + dt\rangle$, F_{ij}, is assumed to be generated by a Cobb–Douglas matching function in which the number of vacancies at time t, V_{ij}, and the number of job seekers at time t, N_{ij}, are input variables (see e.g., Diamond, 1982; Blanchard and Diamond, 1989, Jackman *et al.*, 1989; and van Ours, 1991).

$$F_{ij} = \lambda_{ij} N_{ij}^{\alpha_j} V_{ij}^{\beta_j} \qquad (1)$$

The parameter λ_{ij} may be interpreted as an efficiency parameter indicating the speed at which, conditional on the number of job seekers and vacancies, potential contacts result in a match.[2]

The parameters α_j and β_j are technical parameters (geometric weights) assigned to the number of job seekers (N_{ij}) and the number of vacancies (V_{ij}) in the market, indicating the relative importance of supply and demand. We assume that the effect of the total number of job seekers (α_j) and the total number of vacancies (β_j) is the same for all job categories. Following Diamond (1982) and Blanchard and Diamond (1989) we allow for the possibility of increasing returns to scale. As Blanchard and Diamond argue: 'Active "thick" markets may lead to easier matches, with or without more intensive search'. We will return to this point when we discuss the estimation results. Earlier studies used aggregate time series data to estimate a single matching function for the labour market. In our approach the total labour market is divided into submarkets stratified according to job type and search channel use. For each submarket we specify and estimate separate matching functions.

Estimation of (1) requires data at market level on the flow of filled vacancies, the number of job seekers and on the number of vacancies, each stratified according to type of job as well as to search channel (F_{ij}, N_{ij}, and V_{ij}). In the Netherlands, and presumably in most other countries, these stratified data are not available.

2.2. *Empirical implementation*

We develop an empirical model based on the matching function (1) and also show that micro data on vacancy and search durations can be combined with aggregated data on the total number of job seekers of type i (N_i) and the total number of vacancies of type i (V_i) to estimate the parameters of the matching function (1).

Data on V_i is available in the Netherlands. Data on the total number of job seekers can be constructed in the following way. There are data available on the

[2] In a steady state situation we may write the expected vacancy duration t_v as V/F and the expected search duration for job seekers t_s as N/F. Assume that $\alpha + \beta = 1$, then we have:

$$\lambda = 1/\{t_s^{\alpha} t_v^{1-\alpha}\}$$

This is the inverse geometric average of expected vacancy duration and expected job search duration.

number of unemployed job seekers categorized by job type, and on the total number of people employed on job type i. Of the latter we have to determine who is looking for a job. Micro data on search behaviour of employed people enables us to predict the probability that someone working in job type i will be searching for a job. Combining this probability with the total number of workers employed on job type i gives us the total number of employed job seekers.

Note that we implicitly assume that workers are looking for a job of the same type, and that employers are searching for a worker with characteristics identical to the specified job requirements. In reality there may be some overflow from other markets.[3] So N_i and V_i must be considered as proxies instead of actual numbers of job seekers and vacancies.

Given aggregated data on N_i and V_i, we have to determine which fraction is assigned to advertisement, informal search, employment office and other search methods. These are constructed as follows.

At a specific point in time, say t_0, we define q_{ij} as the probability that a randomly selected vacancy of type i is from search channel j, $j = 1, \ldots, 4$. Furthermore define p_{ij} as the probability that a randomly selected worker of type i is searching through channel j, $j = 1, \ldots, 4$. Then, if V_i is the total number of vacancies in the population at time t_0, we have $V_{ij} = q_{ij} \cdot V_i$. Analogously, given the total number of workers N_i at time t_0, we have $N_{ij} = p_{ij} \cdot N_i$. So the pool of vacancies and searchers per job type, using search channel j, can be obtained from aggregated data on V_i, N_i and the probabilities q_{ij} and p_{ij}.[4]

Furthermore, given the pool of vacancies V_{ij}, the flow of filled vacancies per time period $[t, t + dt\rangle$, can be obtained using the instantaneous exit rate. At each point in time V_{ij} can be interpreted as the set of vacancies that are at risk to turn into matches. Hence as a natural interpretation the hazard rate for the durations of vacancies (θ^v_{ij}) can be defined as a simple ratio of F_{ij} to V_{ij}. Analogously, the hazard rate for workers' search duration (θ^s_{ij}) follows from the definition of F_{ij} and the pool of searchers (risk set) N_{ij}.

So far we have the following relations:

$$F_{ij} = \lambda_{ij} N_{ij}^{\alpha j} V_{ij}^{\beta j} \tag{1'}$$

$$V_{ij} = q_{ij} V_i \tag{2}$$

$$N_{ij} = p_{ij} N_i \tag{3}$$

$$F_{ij} = \theta^v_{ij} V_{ij} \tag{4}$$

$$F_{ij} = \theta^s_{ij} N_{ij} \tag{5}$$

Using equation (4) we rewrite equation (1′) as:

$$\theta^v_{ij} = \lambda_{ij} N_{ij}^{\alpha j} V_{ij}^{\beta j - 1} \tag{6a}$$

[3] Van Ours and Ridder (1991) for example find that for 16% of the filled vacancies the required educational level was higher than the educational level of the actually hired worker.

[4] In the market workers (and employers) may use multiple search (recruitment) channels. Consequently, the sum of $N_{ij}(V_{ij})$ may very well exceed $N_i(V_i)$.

And using equation (5):

$$\theta^s_{ij} = \lambda_{ij} N_{ij}^{\alpha j-1} V_{ij}^{\beta j} \tag{6b}$$

Reformulating the macro matching function we derive a model in which the hazard rates for workers and vacancies of job type i are a function of N_{ij} and V_{ij}, and where λ_{ij}, α_j, and β_j are the parameters of interest. Even in the absence of macro data on N_{ij}, V_{ij} and F_{ij} the parameters of the macro matching function, equation (1), can be obtained using micro data from workers' and/or employers' surveys combined with aggregate data on N_i and V_i.

Our estimation procedure consists of two steps. First, from micro data on the use of search/recruitment methods we determine the probabilities q_{ij} and p_{ij} using simple probit analyses. In combination with aggregated data on N_i and V_i, we use the predicted probabilities to generate N_{ij} and V_{ij}, $j = 1, \ldots, 4$. In the second stage we use the hazard rate specifications (6a), (6b) and observed duration data on job seekers and vacancies to estimate the parameters of the matching function λ_{ij}, α_j, and β_j.

The probabilities q_{ij} and p_{ij} are determined from analyses on the use of search methods by employers and workers. This is an interesting intermediate result of our estimation procedure. Contributions to the use of search methods are not available in abundance. Exceptions are Holzer (1987, 1988), Blaschke (1987), Jones (1989), and Blau and Robins (1990) for workers' search, and Roper (1988), van Ours (1989) and van Ours and Ridder (1992) for employers' search. We briefly discuss the intermediate results on the use of search and recruitment channels in Section 3.3.

Our analysis is mainly exploratory and descriptive. We use a model in which the effectiveness of a specific search channel is assessed conditional on the choice of search method. Simultaneous relationships between the use of search or recruitment channels and the probability of success are ruled out.[5] To be consistent with this, the equations explaining the use of search channels (the probabilities q_{ij} and p_{ij}) must be interpreted as purely reduced form equations. Estimation of a complete structural model in which search method choice (of course based on the expected success of a search channel) and matching probabilities are mutually related is a challenging subject for future research.

3. Data

To estimate our model we need micro data on the use of search and recruitment channels, duration of search, vacancy duration, and aggregated data on the number of vacancies (V_i) and the number of workers (N_i). Aggregated data on N_i and V_i are obtained from the Manpower Survey 'Arbeidskrachtentelling' (AKT) and the Vacancy Survey of the Netherlands Central Bureau of Statistics (CBS). Micro data on the use of search and recruitment channels, vacancy

[5] Implementation of the estimated q_{ij} and p_{ij} in equation (6a) or (6b) would be troublesome if for example the probability of success is included in the set of regressors for q_{ij} or p_{ij}.

duration and the duration of search are obtained from two panel surveys conducted by the Organization for Labour Market Research (OSA).

3.1. *Data on vacancies: the OSA job vacancy survey*

In this survey the employer is asked whether he has vacancies for employees whom he wants to put to work immediately or as soon as possible. This implies that vacancies are not resricted to unoccupied jobs. The employers' sample is drawn from the database of the Dutch Chambers of Commerce, from which government and education as well as temporary help agencies are excluded. The sample is stratified according to firm size and industry. In the original sample 1,288 medium sized (> 10 employees) and 625 large (> 100 employees) employers were included.

The job vacancy survey was held in two stages. In the first wave, held in the period November 1986 to January 1987, firms were asked whether they had vacancies. 648 employers (out of 1,913) had vacancies; 580 firms agreed to participate in the panel survey. The employers were asked about the skills they required for their job vacancies, the sorts of jobs the vacancies referred to, their search methods and selection procedures, the number of applicants, the elapsed duration of the job vacancies, the characteristics of the hard-to-fill job vacancies and the chances long-term unemployed would have if they would apply. Employers were also asked whether they had single or multiple vacancies. The latter implies a job vacancy for which the employer is searching for more than one applicant with the same skills.

550 employers (out of 580) participated in the second wave, held approximately four months later. The employers were asked whether the job vacancies registered in the first wave had been filled, and if so, at what time. Also some characteristics of the new employee were registered.

Discarding incomplete and unreliable observations a sample of 1,189 job vacancies remained.

3.2. *Data on employed and unemployed job seekers: the OSA labour force panel survey*

We use data on individuals from the second and the third wave of the OSA labour force panel. The second wave held in October 1986, had 4,115 respondents aged between 15 and 61 years at the time of the first interview (April 1985), and who were not attending full time education. In the second wave we selected all employed and unemployed respondents and obtained information on elapsed job search durations and personal and labour market characteristics. Using information from the third wave (held in September 1988) we established information on subsequent job search duration.

After discarding incomplete and/or inconsistent observations 2,442 employed and 212 unemployed workers remained. Among the employed workers 335 were looking for a new job. A person was considered to be unemployed if he or she was not working and reported to be actively seeking, irrespective of registration at the public employment office.

3.3. *Constructing stratified data on* N_{ij} and V_{ij}

The Vacancy Survey of the Central Bureau of Statistics (1986) provided us with the total number of vacancies stratified by job type. From the Manpower Survey 1985 of the Central Bureau of Statistics we have aggregated data on the number of unemployed job seekers per job type and the number of employed per job type. In this section we have a closer look at the demand/supply ratio (V_i/N_i) over the search/recruitment channels. Table 1 gives a first impression of the use of search channels by employers and workers.

Advertisement appears to be the most frequently used search channel for both workers and employers. Employed workers use informal search channels and the employment office less frequently than advertisement. The average number of search channels used by employers and employed workers is about two; unemployed workers use approximately three different search channels.

Next, to obtain estimates on the 'weights' p_{ij} and q_{ij}, we perform probit analyses on the use of search methods by employers and workers. The estimation results for employers are given in Table A.1 of Appendix 2. We briefly report on some of the results.

We find that large firms (firms with more than 300 employees) use advertisement and the employment office as a search channel more frequently. In searching for construction and production workers the employment office is used more often. Highly educated and more experienced workers are mostly advertised for.

For the choice of search method by employed and unemployed workers we refer to Tables A.3 and A.4 of Appendix 2. For employed workers we also had to estimate a probit equation explaining the decision to search (see Section 2). Since the decision to seach may be correlated to the decision to use a specific search channel, we also estimated a bivariate probit. It appeared that the two processes were not correlated. The probit equation explaining the decision to search is given in Table A.2 of Appendix 2.

Given the predicted probabilities and aggregated data on N_i and V_i we can

TABLE 1
The use of search channels by employers and workers

	Employers	*Employed workers*	*Unemployed workers*
Advertisement	66%	85%	78%
Informal	63%	29%	50%
Employment office	44%	12%	52%
Others	33%	33%	27%
Average number of channels	2.1	1.8	2.8

Source: OSA labour force panel survey and OSA job vacancy survey.

TABLE 2
Job seekers/vacancy ratios (N_{ij}/V_{ij}) for different categories

	Advertisement	*Informal*	*Employment office*
Administrative-lower vocational	11.1	3.8	12.1
Administrative-secondary	7.3	3.0	13.6
Administrative-higher/ac.	5.1	3.2	7.2
Construction-lower vocational	2.6	1.7	1.7

predict N_{ij} and V_{ij}. In Table 2 we report some of the predicted job seekers/vacancy ratios (N_{ij}/V_{ij}) for different types of workers.

From Table 2 we see that there are strong differences in the job seekers/vacancy ratios per channel. There are differences between both search channels and types of workers. Lower vocational administrative workers, for example, experience a job seekers/vacancy ratio of 12.1 for the employment agency, whereas this ratio equals only 1.7 for lower vocational construction workers. The high job seekers/vacancy ratio for lower vocational administrative workers using the employment agency, contrast also with the relatively small ratio of 3.8 for informal channels. It appears that for job seekers the supply and demand ratio (N_{ij}/V_{ij}) of the informal channel is most favourable.

4. Likelihood, empirical specification, and results

4.1. *The likelihood and the empirical specification*

Each individual in our sample (employer and worker) can be searching in either of the four categories: advertisement, employment office, informal search and other search. In the theoretical model, discussed in Section 2, we noted two important factors: the total numbers of vacancies and job seekers that use the channel and the efficiency of the channel. We specify the efficiency parameter λ_{ij} as $\exp(X_i' \gamma_j)$. The vector X_i consists of market characteristics (job types). A job type is characterised by occupation, education and region.

Denote the waiting time associated with worker's search in a specific search channel j by T_j. The waiting time associated with employer's search in this specific recruitment channel is denoted by S_j. We assume T_j and S_j to be independently distributed from the waiting times T_i and S_i, for every i, $i \neq j$, and furthermore $T_j \perp S_j$. The hazards corresponding to T_j and S_j are denoted by θ_j^s and θ_j^v.

Both the employers' and workers' data are stock samples implying that in general the duration density functions of the sample will be different from the population density functions. However, in case of exponentially distributed waiting times (absence of duration dependence in the hazards) and a constant inflow rate, elapsed search duration (search duration as measured at the date of selection) and the residual duration (search durations after the selection date) are independently and identically exponentially distributed (Salant, 1977; Ridder, 1984).

Since elapsed and residual durations of search channels i and j are independently distributed, we have that an uncensored observation for channel i can be treated as an independently censored observation for channel j, $j \neq i$. The likelihood function splits neatly into separate parts for each of the search channels. Let f_j be a generic symbol for the density function of the workers' search duration and let g_j be a generic symbol for the density function of the employers' search duration. For a worker with elapsed search duration p, using all four channels and finding a job through channel 1 after t units of time, we simply write the following contribution to the likelihood (omitting the index i):

$$f_1(p)\cdot f_1(t)\prod_{j=2}^{4}\{f_j(p)\cdot(1-F_j(t))\} \tag{7}$$

The functions $F_j(.)$ are the cumulative distribution functions corresponding to $f_j(.)$. And for example for an employer with elapsed search duration $\tilde{p}$, using only channel 1 and finding an employee after $\tilde{t}$ units of time we depict the following contribution to the likelihood function:

$$g_1(\tilde{p})\cdot g_1(\tilde{t}) \tag{7'}$$

The likelihood consists of parts like (7) and (7′). It must be stressed that for each search channel both sources of information, the employers' survey and the workers' survey, contribute to the estimation of the parameters α_j, β_j, and γ_j.

Some comments are in order. As can be seen in (6a) and (6b) the hazards θ_j^v and θ_j^s have the same set of parameters α_j, β_j, and γ_j. So consistent estimates of the parameters can be obtained with either the employers' search or workers' search. However, combining both sources, as we do, is more efficient.

The second point concerns the interpretation of the channel: other search methods. This is a collection of remaining categories which may differ for employers and workers. Combining workers' and employers' information may give misleading results in this case. We therefore restrict ourselves to presenting the results of the remaining channels.

The assumption of exponentially distributed durations may be restrictive, but convenient. With this assumption no numerical integrations in the construction of the likelihood were required, and the likelihood remains simple. It is, however, well known that in the presence of unobserved heterogeneity a restrictive baseline hazard may seriously bias the parameter estimates (Ridder, 1987). In the next subsection we distinguish different markets for unemployed and employed workers, introducing a large amount of flexibility, that will capture some of the unobserved heterogeneity.

4.2. *Unemployed versus employed job seekers*

The parameter λ_{ij} is specified as a function of observed job (market) characteristics X_i. The vector includes occupation, education and region. So far, the model does not distinguish between employed and unemployed workers. However, the matching process of an employed worker may differ from the matching process of an unemployed worker. For that reason we specify separate matching functions for unemployed and employed job seekers, which differ in their efficiency parameter λ and the parameters α and β.

Differences in the efficiency parameter λ for employed workers and unemployed workers may be due to differences in the matching probability. This may be a result of differences in search behaviour of employed workers and unemployed workers, or differences in the recruitment behaviour of employers with respect to employed and unemployed workers. Unfortunately we cannot identify whether these differences are due to workers' or employers' decisions. In the specification of the efficiency parameter λ we will allow for a constant shift (this corresponds with the incorporation of a dummy). Differences between α^u and α^e (and β^u and β^e) allow for differences in the relative importance of N_j and V_j.

So we write for unemployed job seekers and employed job seekers, respectively:

$$F^u = \lambda^u N^{\alpha^u} V^{\beta^u} \tag{8}$$

$$F^e = \lambda^e N^{\alpha^e} V^{\beta^e} \tag{9}$$

And we adjust the notation in (4) and (5) to:

$$\theta_j^{su} = F_j^u / N_j \tag{10}$$

$$\theta_j^{se} = F_j^e / N_j \tag{11}$$

$$\theta_j^{vu} = F_j^u / V_j \tag{12}$$

$$\theta_j^{ve} = F_j^e / V_j \tag{13}$$

Note that $\theta_j^s = \theta_j^{su} + \theta_j^{se}$ and $\theta_j^v = \theta_j^{vu} + \theta_j^{ve}$. From the demand side of the labour market this means that we deal with a competing risk model, i.e. a vacancy can be filled by either an unemployed or an employed worker. For the supply side of the market our setup implies competition between employed and unemployed job seekers for the same vacancies. For each different search/recruitment channel four subhazards are estimated (θ_j^{su}, θ_j^{se}, θ_j^{vu}, and θ_j^{ve}), resulting in the estimation of twelve different subhazards.[6]

[6] Distinguishing between other subgroups that search for the same type of job would (e.g. within the group of unemployed those who receive benefits) require an even more extended model. Moreover in order to identify such a model properly, we would need this information also from the vacancy duration data set (this information should be available from the personal characteristics of the hired worker). The information is limited and not always reliable.

4.3. *Results*

Using information on search durations from both workers and employers, we estimated the α's, β's, and the parameters of λ's. Both employers and workers have the same efficiency parameter. The efficiency parameter depends on occupation variables (with 'managers' as reference group), education variables (reference group: primary education) and regional variables (the western part of the Netherlands—the economic centre—as the reference group). These variables describe the stratification in job types. Furthermore, λ differs by a constant for employed workers and unemployed workers. The (geometric) 'weights' α and β, indicating the relative importance of N and V, are allowed to differ for employed and unemployed workers.

Since market data stratified according to job type and search channel use are not available, we have to use estimated values of supply ($\hat{N}_{ij} = \hat{p}_{ij} \cdot N_i$) and demand ($\hat{V}_{ij} = \hat{q}_{ij} \cdot V_i$) in our empirical model. As a result of this procedure unobserved heterogeneity is introduced into the model. As is well known, this may have some influence on our parameter estimates. We discuss this in Appendix 3, where we also present a relatively simple test which indicates that no large effect on the parameter estimates may be expected. We may therefore safely turn to the results, reported in Table 3.

4.3.1. *Results on the efficiency parameter λ*

For advertisements there are significantly positive effects for administrative workers and for virtually all the education variables. Significant negative effects are found for vacancies and job seekers in the eastern part of the Netherlands and for unemployed workers. Ignoring the number of job seekers (N_{ij}) and the number of vacancies (V_{ij}), unemployed workers have a smaller probability of finding a job than employed workers.

The small and insignificant coefficient for the unemployed worker dummy in the informal channel case shows that there are no differences in the efficiency parameter of employed and unemployed workers. Compared to the other search channels, the efficiency parameter for the employment office is very low. Furthermore, for the public employment office, the efficiency parameter appears to be much higher for unemployed workers. This large positive coefficient for unemployed workers may seem strange at first sight. However, at least in the Netherlands, the public employment office is primarily designed for unemployed job seekers. The sample of employed searchers using the employment office as a search channel may be a negative selection of the total sample of employed workers.

Comparing the efficiency parameters over the search channels, we see that for unemployed workers advertisements are the least efficient, whereas the same channel is most efficient for employed workers. For employed workers the employment office is the least efficient search channel.

So far, the results presented are conditional on the number of job seekers

TABLE 3
*Estimation results**

	A *Advertisements*	*B* *Employment office*	*C* *Informal search*
Constant	−3.33 (17.8)	−6.58 (6.6)	−3.96 (6.0)
Occupation			
Services	−0.23 (1.5)	−0.08 (0.3)	−0.16 (0.7)
Administrative	0.20 (2.1)	0.39 (2.5)	0.19 (1.7)
Production	−0.20 (2.0)	0.08 (0.5)	−0.02 (0.1)
Construction	−0.26 (1.2)	0.15 (0.6)	0.04 (0.2)
Education			
Ext. primary	0.49 (3.2)	0.49 (2.4)	0.16 (0.9)
Secondary	0.29 (1.8)	0.39 (1.6)	0.16 (0.7)
Low vocational	0.42 (2.9)	0.42 (2.1)	0.10 (0.5)
Sec. vocational	0.58 (3.7)	0.53 (2.1)	0.32 (1.5)
Higher/academic	0.27 (1.8)	0.33 (1.6)	−0.17 (0.9)
Region			
North	−0.09 (0.5)	0.10 (0.5)	0.04 (0.2)
East	−0.31 (4.3)	−0.09 (0.7)	−0.09 (1.0)
South	−0.04 (0.5)	0.23 (2.2)	0.27 (3.2)
Unemployed	−1.96 (3.8)	2.73 (2.8)	−0.17 (0.3)
α (unemployed)	0.34 (3.1)	0.00 —	0.00 —
β (unemployed)	0.68† (9.2)	0.89 (3.1)	0.92 (10.9)
α (employed)	0.00 —	0.33 (4.4)	0.10 (0.5)
β (employed)	1.02 (19.8)	1.07 (5.5)	0.98 (11.1)
−log·lik	5,774.48	3,007.39	5,003.96

	−*log likelihood values*		
Restricted model versions	*A*	*B*	*C*
$\alpha^e + \beta^e = 1,\ \alpha^u + \beta^u = 1$	5,774.59	3,009.24	5,004.38
$\alpha^u = \alpha^e$	5,777.70	3,007.73	5,004.14
$\alpha^u = \alpha^e,\ \beta^u = \beta^e$	5,784.60	3,009.46	5,004.41

* Absolute *t*-values in parentheses.
† Significantly different from 1.

and the number of vacancies. For the effect of the number of job seekers and the number of vacancies on the hazard (or equivalently on the flow of filled vacancies), we turn to the estimates of the parameters α and β.

4.3.2. *Results on the parameters α and β: the relevance of N_{ij} and V_{ij}*

We start with the results for the advertisements. For the flow of vacancies filled by unemployed workers (F^u) both the number of job seekers and the number of vacancies are important, whereas for the flow of vacancies filled by employed workers (F^e) only the number of vacancies is of importance.[7] Estimation of restricted model versions i.e. $\alpha^u = \alpha^e$ and $\alpha^e = \alpha^u$, $\beta^e = \beta^u$ (see bottom rows of Table 3) establishes that the restrictions cannot be imposed.[8]

An increase in V_{ij} (an economic upswing) increases F^e and F^u, hence the hazard for employed and unemployed searchers will rise. The change in F^u is, however, smaller than the change in F^e (since $\beta^u < \beta^e$). The relatively small change in F^u is translated into a relatively small increase in the hazard θ^{su} (the hazard for an unemployed worker). Hence increasing V_{ij} is less advantageous for unemployed workers.

Increasing N_{ij} only affects F^u (since $\alpha^u > \alpha^e = 0$). Increasing N_{ij} will definitely decrease the hazards for both employed and unemployed job seekers. Since the number of filled vacancies by employed workers (F^e) remains constant, the decrease in the hazard θ^{se} will be larger than the decrease in the hazard θ^{su}. Hence employed workers are worse off if the number of job seekers increases. A possible explanation might be that with a fixed number of vacancies, an increase in N_{ij} is effectively a decrease in the number of offers per searcher. In response to this decrease in the 'offer arrival rate', unemployed and employed workers' reactions with respect to reservation wage and search intensity may differ.

For the public employment office we see that this does not happen. An increase in the number of job seekers has a stronger negative effect for unemployed than for employed workers. However the restrictions $\alpha^e = \alpha^u$ and $\alpha^e = \alpha^u$, $\beta^e = \beta^u$ are not rejected (see the bottom rows of Table 3). In the restricted model ($\alpha^e = \alpha^u$ and $\beta^e = \beta^u$) the coefficient α equals 0.02 whereas β equals 0.96. Since α is insignificantly different from zero, and β is insignificantly different from one, we may equally well write the matching function as a function of the number of vacancies alone. The number of matches is solely determined by the number of vacancies in the market (of course conditional on the efficiency parameter λ). A similar picture arises for informal search channels. The restrictions $\alpha^e = \alpha^u$ and $\alpha^e = \alpha^u$, $\beta^e = \beta^u$ are not rejected. Moreover, since in this restricted model $\alpha = 0$ and $\beta \neq 0$, only the number of vacancies are of importance. For each of the search channels we also tested whether the restriction $\alpha + \beta = 1$ (constant returns to scale of the matching function) could be imposed. In Table 3 we report the likelihood values of the restricted model. As in Blanchard and Diamond (1989) we cannot reject the hypothesis of constant returns to scale.

4.4. *Testing for differences in the matching process of employed and unemployed workers*

The results obtained so far indicate marked differences between employed and unemployed workers. In order to see whether these differences also hold statistically, we have to test the 'single-risk' model (the model in which no

[7] The parameter α for employed workers attained the lower bound of zero. If we re-estimate the model with no lower bound, we obtained a very small negative insignificant estimate.

[8] The likelihood ratio statistic for the restriction $\alpha^u = \alpha^e$ equals 6.4, which exceeds the chi-square(1) value (5.0). Imposing the additional restriction $\beta^u = \beta^e$ we see that the likelihood value drops another 7 points. Both hypotheses $\alpha^u = \alpha^e$, $\beta^u = \beta^e$, as well as $\alpha^u = \alpha^e$ are rejected.

distinction is made between employed and unemployed workers (equations (4)–(6b)) against the augmented model (equations (8)–(13)). We consider two alternative procedures to test for differences between employed and unemployed workers in the augmented model.

A first route is to derive a modified likelihood ratio test. The test appears to be similar to the one proposed by Narendranathan and Stewart (1991) and Lindeboom and Theeuwes (1991). In this specific case, however, the test depends on all the individual observations in the sample, which makes it a little more difficult to perform.

A second simple testing procedure is based on a conditional argument. One may test whether in the restricted augmented model, $\alpha^e = \alpha^u$ and $\beta^e = \beta^u$, the (single) dummy variable for unemployed is significantly different from zero. Next conditional on significance of this coefficient, in the setting of a nested model, differences between α and β can be tested. Note that this procedure gives a sufficient condition for differences between employed and unemployed workers. Differences between employed workers and unemployed workers are not ruled out by an insignificant coefficient for the dummy variable in the augmented model.

We only performed the second (conditional) test. The test indicates that for each search channel a distinction between employed and unemployed workers is meaningful.[9]

In the discussion of the results, we separately examined the influence of the parameters contained in λ, and α and β. Assessing the effectiveness of the different search channels requires a joint examination of the effects of λ, α, and β. To this end we will perform a small simulation analysis which will give us more insight into the effectiveness of different search channels.

4.5. *Simulations*

Table 4 below illustrates the estimation results of Table 3. The top part of the table reports the probability that a worker finds a new job within six months, whereas in the bottom part of Table 4 the probability that an employer finds a new worker within three months is shown. We calculated these probabilities for different types of labour, each categorised by employed and unemployed job seekers.

The differences for employed and unemployed job seekers are substantial. A first glance at the top part of the table reveals that for neither employed workers nor for unemployed workers could a specific search channel be pointed out as being the best. For employed job seekers advertising or informal search may be very effective whereas the use of employment offices may be very ineffective.

[9] According to the second procedure we have the following results (t-values in parentheses):

	dummy unemployed
Advertisements	−1.02 (10.2)
Employment office	1.02 (2.7)
Informal search	−0.47 (3.0)

TABLE 4
*Success probabilities**

Job seekers: percentage probabilities to find a new job within six months			
	Advertising	*Employment office*	*Informal*
Administrative/low vocational			
employed worker	10.3	1.8	16.4
unemployed worker	3.9	6.9	12.0
Administrative/secondary			
employed worker	15.5	2.1	16.5
unemployed worker	4.9	9.6	12.8
Administrative/Higher/Academic			
employed worker	13.6	0.9	10.9
unemployed worker	4.5	5.3	7.3
Construction/low vocational			
employed worker	23.5	9.5	30.6
unemployed worker	6.0	28.4	21.6

Vacancies: percentage probabilities for an employer to find a new worker within three months			
	Advertising	*Employment office*	*Informal*
Administrative/low vocational			
employed worker is hired	58.6	13.2	35.4
unemployed worker is hired	27.5	43.3	26.9
Administrative/secondary			
employed worker is hired	54.0	11.0	36.2
unemployed worker is hired	20.8	42.7	29.0
Administrative/Higher/Academic			
employed worker is hired	53.9	8.9	29.6
unemployed worker is hired	21.6	44.2	20.7
Construction/low vocational			
employed worker is hired	43.3	10.6	31.2
unemployed worker is hired	12.3	31.1	22.0

* Vacancy and job seeker are located in the eastern part of the Netherlands.

The probability of success for an employed administrative worker with secondary education using advertisements as a search channel is approximately seven times larger than the probability if the employment office is used (15.5% *versus* 2.1%). For employed higher/academic administrative workers the odds are even more favourable (13.6% *versus* 0.9%). The supply (N_{ij}) and demand (V_{ij}) ratio for the employment office are very unfavourable resulting in an extremely low success probability of only 0.9% for employed administrative/higher/academic workers. Although it may be clear that the employment office is the least effective for employed workers, it is not apparent which of the remaining search channels is the most effective. This is due to differences in the N_{ij} and V_{ij} ratio over different types of labour, resulting in an unclear overall (ranking) picture.

For unemployed workers an almost opposite picture emerges. Advertisement is definitely the least effective search channel for unemployed workers. For almost all categories informal search is the most effective. The efficiency parameter of the public employment office and of the informal search is approximately the same for unemployed workers, but since employers use the informal search channel more often than the employment office (relatively large V_{ij}), more matches result.

The relative success of the employment office in matching unemployed workers and vacancies as compared to employed job seekers and vacancies can be explained as follows. Firstly, from Table A.3 in Appendix 2 it can be seen that the probability that an employed worker uses the employment office is small (see also Table A.1 for the probability that an unemployed worker uses the employment office). Hence, the competition between the job seekers searching through this specific search channel, is primarily among unemployed workers. In the other search channels employed workers compete more prominently for the same type of job. Secondly, given the number of job seekers and the number of vacancies, employed workers using the employment office may become stigmatised.

Averaged over the search channels, we see that employed workers have a higher probability of success than unemployed workers.

The lower half of Table 4 concerns the success probabilities of employers looking for a new worker. The employers' success probabilities are on average much higher than those for job seekers. This is clearly a result of the relatively small number of vacancies (as compared to the number of job seekers). Consequently vacancy durations will on average be much shorter than search durations of employed or unemployed workers. As expected, averaged over the different recruitment channels the probability that an employed worker is hired is higher than the probability that an unemployed worker is hired. Furthermore, the hiring of an employed worker is most effective using advertisements or informal search. Again, the employment office is very effective in matching unemployed workers and vacancies. It is very ineffective for employed workers.

5. Conclusions

The main objective was to analyse the effectiveness of different search or recruitment channels used by workers and employers. In the empirical analyses we distinguish three different search or recruitment channels; advertisements, public employment office and informal search. Our approach to assess the effectiveness of the different search or recruitment channels differs from that in the literature. For each search/recruitment channel we specify a Cobb–Douglas matching function. The number of matches per channel depends on the number of vacancies and the number of job seekers coming through that channel. The parameters of the matching function consist of scale parameters (or 'geometric weights') α and β indicating the relative importance of N and V, and an efficiency parameter λ. The efficiency parameter indicates the speed at which, conditional on the number of workers and vacancies, a contact between an employer and a worker is transposed into a match. We explicitly allow the parameters α, β, and λ to differ for employed and unemployed workers.

From the matching functions defined at market level, we derive microeconomic duration models for employers and workers. In the specification of the hazard, the same parameters α, β, and λ appear. We estimated the model, using both microeconomic data from an employers' survey and a workers' survey. Estimation also requires data on the number of searchers and vacancies at market level for which we use Manpower Survey Data.

The results indicate clear differences between the effectiveness of the different search channels. This is caused not only by differences in efficiency (λ), but also by differences in the supply (N) and demand (V) ratio. Within a specific search channel large differences exist between employed workers and unemployed workers. The large differences are a result of the compounded effect of differences in the parameters λ, α, and β. Averaged over the search/recruitment channels we see that employed workers have a higher probability of success than unemployed workers. Advertisements and informal search channels are very effective in matching employed workers and vacancies. The employment office and informal search are very effective in matching unemployed workers and vacancies.

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APPENDIX 1

Definition of the variables

1. *OSA job vacancy survey and OSA labour force panel survey*

Occupation:

Services:	Services (nurses included)
Administrative:	Administrative workers
Production:	Production workers (metal, electrotechnic, others)
Construction:	Construction workers
Managerial workers, policy makers, scientific:	reference group

Education:

Primary (reference group)
Extended primary
Secondary
Low vocational
Secondary vocational
Higher or academic

Region:
North: Provinces Groningen, Friesland, Drenthe
East: Provinces Overijssel, Gelderland, Flevoland
South: Provinces Noord-Braband, Limburg
West: Reference group (Economic Centre of The Netherlands) District Utrecht, Noord-Holland, Zuid-Holland

2. *Additional variables in the OSA job vacancy survey* (*see Table A.1*)

Firm size:
10– 50 employees (reference group)
50–100 employees
100–200 employees
200–300 employees
>300 employees

Work experience required:
0–1 year (reference group)
1–3 years
>3 years

Single vacancy:
Dummy variable which equals one if only one employee is needed (reference group: multiple employees are needed)

3. *Additional variables in the OSA labour force panel survey*
(see Tables A.2, A.3, A.4)

Age:	Age in years
Gender:	Dummy 1 if female
Experience:	Number of years on the labour market
Number of unemployment spells in 1980–5:	Number of unemployment spells in years 1980–5
Part-time job:	Dummy 1 if number of hours worked <33
Strenuous work:	Dummy 1 for strenuous work (subjective)
Irregular work:	Dummy 1 for irregular work (subjective)
Temporary work:	Dummy 1 for provisional or temporary work
Civilian worker:	Dummy 1 for civilian workers
Satisfied with wage:	Dummy 1 if respondent is satisfied with wage (subjective)

APPENDIX 2

The use of search methods by employers and workers

TABLE A.1
The use of search methods by employers

	Advertisement	*Informal*	*Employment office*	*Others*
Constant	−0.06 (0.2)	1.00 (4.4)	−0.55 (2.4)	0.13 (0.5)
Size of firm				
50–100	0.31 (2.3)	−0.23 (1.7)	−0.03 (0.2)	−0.04 (0.3)
100–200	0.26 (2.2)	−0.15 (1.2)	0.12 (1.0)	0.05 (0.3)
200–300	0.23 (1.6)	−0.05 (0.3)	−0.08 (0.5)	−0.06 (0.4)
>300	0.32 (2.8)	−0.53 (4.5)	0.49 (4.2)	−0.35 (3.0)

TABLE A.1 (*continued*)

	Advertisement	*Informal*	*Employment office*	*Others*
Occupation				
Services	0.36 (2.0)	0.05 (0.2)	0.34 (2.0)	−0.01 (0.0)
Administrative	−0.06 (0.5)	−0.01 (0.1)	0.23 (1.9)	−0.09 (0.7)
Production	0.11 (0.7)	−0.08 (0.5)	0.53 (4.0)	−0.19 (1.3)
Construction	−0.30 (1.0)	−0.12 (0.3)	1.10 (3.4)	−1.10 (3.2)
Education				
Ext. primary	−0.19 (0.9)	−0.41 (1.9)	0.17 (0.8)	0.36 (1.7)
Secondary	0.09 (0.4)	−0.26 (1.2)	0.21 (0.9)	−0.31 (1.4)
Low vocational	−0.16 (0.9)	0.06 (0.3)	0.41 (2.3)	0.31 (1.7)
Secondary voc.	0.28 (1.5)	−0.10 (0.5)	0.08 (0.4)	−0.03 (0.1)
Higher/academic	0.40 (1.9)	−0.32 (1.5)	0.17 (0.8)	−0.11 (0.5)
Region				
North	−0.20 (1.1)	−0.16 (0.8)	0.72 (3.9)	−0.34 (1.7)
East	0.17 (1.5)	0.10 (0.8)	−0.17 (1.4)	−0.12 (1.0)
South	0.16 (1.6)	−0.00 (0.0)	−0.04 (0.4)	−0.06 (0.5)
Experience (years)				
1–3	0.16 (1.7)	0.12 (1.2)	0.06 (0.6)	−0.20 (2.0)
>3	0.30 (2.7)	0.21 (1.9)	−0.25 (2.3)	−0.21 (1.9)
Single vacancy	−0.22 (2.4)	−0.49 (5.2)	−0.31 (3.4)	−0.28 (3.1)

Absolute t-values in parentheses.

TABLE A.2

The search decision by employed workers

Constant	0.59 (0.9)
Age (log)	−0.34 (1.6)
Gender	−0.19 (2.2)
Education	
Ext. primary	0.11 (0.8)
Secondary	−0.07 (0.3)
Low voc.	0.10 (0.8)
Secondary voc.	0.10 (0.7)
Higher/ac.	0.21 (2.1)
Region	
North	−0.03 (0.2)
East	−0.15 (1.6)
South	−0.15 (1.8)
Experience	−0.29 (4.1)
Number of unemployment spells in 1980–5	0.06 (1.0)
Part-time job	−0.13 (1.2)
Strenuous work	−0.65 (0.8)
Irregular work	−0.14 (1.5)
Temporary work	0.62 (5.5)
Civilian worker	−0.06 (0.9)
Satisfied with wage	−0.42 (5.9)

Absolute t-values in parentheses.

TABLE A.3
The use of search methods by employed workers

	Advertisement	*Informal*	*Employment office*	*Others*
Constant	0.43 (0.2)	1.59 (0.9)	−2.71 (1.4)	−2.78 (1.8)
Age (log)	0.47 (0.8)	−0.79 (1.5)	0.06 (0.1)	0.79 (1.6)
Gender	0.02 (0.1)	−0.20 (1.1)	0.38 (1.7)	−0.03 (0.2)
Education				
Ext. primary	−1.06 (2.0)	0.04 (0.1)	0.71 (1.3)	−0.04 (0.1)
Secondary	3.99 (0.0)	0.30 (0.6)	1.46 (2.2)	−0.29 (0.6)
Low voc.	−0.83 (1.7)	0.07 (0.2)	1.04 (2.0)	0.10 (0.3)
Secondary voc.	−0.77 (1.6)	0.03 (0.1)	0.65 (1.2)	0.10 (0.3)
Higher/ac.	−0.63 (1.2)	0.40 (1.2)	0.14 (0.3)	−0.32 (1.0)
Occupation				
Services	0.02 (0.1)	−0.14 (0.6)	0.78 (1.6)	−0.25 (1.0)
Administrative	0.07 (0.2)	−0.02 (0.1)	0.55 (1.1)	−0.04 (0.2)
Production	−0.11 (0.4)	0.10 (0.4)	0.45 (0.9)	−0.09 (0.4)
Construction	−0.51 (0.9)	1.14 (2.2)	0.87 (1.3)	−0.98 (1.6)
Region				
North	0.53 (1.5)	−0.23 (0.9)	0.35 (1.3)	−0.59 (2.2)
East	0.43 (1.6)	0.30 (1.4)	−0.21 (0.7)	−0.16 (0.7)
South	0.04 (0.2)	−0.04 (0.2)	0.02 (0.1)	−0.01 (0.0)
Experience	−0.31 (1.4)	0.37 (2.0)	0.13 (0.6)	−0.05 (0.3)

Absolute t-values in parentheses.

TABLE A.4
The use of search methods by unemployed workers

	Advertisement	*Informal*	*Employment office*	*Others*
Constant	0.59 (0.4)	1.80 (1.2)	3.15 (2.1)	−2.05 (1.3)
Age (years)	−0.07 (0.1)	−0.63 (1.4)	−1.00 (2.2)	0.56 (1.2)
Gender	0.08 (0.3)	−0.15 (0.7)	−0.13 (0.6)	0.06 (0.3)
Education				
Ext. primary	0.28 (0.7)	−0.06 (0.2)	−0.07 (0.2)	0.22 (0.6)
Secondary	−0.10 (0.2)	0.06 (0.1)	0.55 (1.0)	0.02 (0.0)
Low voc.	−0.14 (0.4)	−0.34 (1.1)	−0.42 (1.3)	0.64 (1.8)
Secondary voc.	0.22 (0.6)	−0.21 (0.6)	−0.43 (1.2)	0.06 (0.2)
Higher/ac.	0.17 (0.4)	0.04 (0.1)	−0.72 (2.0)	0.19 (0.5)
Occupation				
Services	0.01 (0.0)	0.17 (0.5)	0.05 (0.1)	−0.27 (0.7)
Administrative	0.07 (0.1)	0.35 (0.8)	−0.24 (0.5)	−0.28 (0.6)
Production	0.14 (0.3)	0.07 (0.2)	−0.09 (0.2)	−0.33 (0.8)
Construction	−0.04 (0.0)	0.43 (0.5)	−0.01 (0.0)	—
Region				
North	0.51 (1.6)	0.13 (0.5)	0.34 (1.2)	−0.62 (2.0)
East	0.52 (1.9)	0.44 (1.9)	0.48 (2.0)	−0.72 (2.8)
South	0.10 (0.4)	0.61 (2.5)	0.83 (3.2)	−0.40 (1.5)
Experience	0.33 (0.2)	0.12 (0.7)	0.33 (1.9)	−0.11 (0.6)

Absolute t-values in parentheses.

APPENDIX 3

Comments on the estimation procedure

Estimation of the theoretical model (see Section 2, equation (3)) required data on the flow of filled vacancies, the number of job seekers and the number of vacancies, each stratified according to the type of job as well as to search channels used. Since market data stratified according to search channels used is not available, we had to use estimated values in the empirical model (equations (4), (5), (8), and (9)). True values of N_{ij} and V_{ij} are replaced by estimated values $\hat{p}_{ij}N_i$ and $\hat{q}_{ij}V_i$. To see what the consequence of these estimated values would have been, we write for one of our hazard specifications (omitting the indices):

$$\begin{aligned}\theta^s(X;\alpha,\beta,\gamma) &= \exp[X'\gamma + (\alpha-1)\log(\hat{N}) + \beta\log(\hat{V}) + (\alpha-1)\{\log(N)-\log(\hat{N})\} \\ &\quad + \beta\{\log(V)-\log(\hat{V})\}] \\ &= \exp[X'\gamma + (\alpha-1)\log(\hat{N}) + \beta\log(\hat{V})]\cdot\varepsilon_1^{\alpha-1}\cdot\varepsilon_2^{\beta}\end{aligned}$$

For the hazard of a vacancy we have an analogous expression in which the error terms ε_1 and ε_2 also arise. As a result unobserved heterogeneity is introduced. Because of the specific form of the unobserved heterogeneity, θ^v and θ^s will be correlated over the search channels. Moreover, since p_{ij} is the product of two marginal probabilities a common error term is introduced into each of the hazards. As a consequence all hazards may be correlated.

It is well known that ignoring unobserved heterogeneity in duration models may lead to biased parameter estimates (see for example Lancaster and Nickell, 1980). A way to solve this problem is to specify for each search channel a distribution for ε_1 and ε_2, and integrate these (correlated) terms out of the total likelihood. Estimation of the likelihood function will become rather cumbersome since it does not factorise and, in general, no closed form analytical expressions of the likelihood contributions will exist.

Instead of actually solving the problem of unobserved heterogeneity, one can also examine to what extent the obtained estimated results are sensitive to 'random' variations in the predictions of N and V. We therefore performed a very simple sensitivity analysis. We generated the error terms ε_1 and ε_2 and reestimated the likelihood function for each drawing of ε_1 and ε_2. We used ten different drawings. The results on these drawings are given in Table A.5 below. The parameters estimates appear to be quite robust.

TABLE A.5

*Some results on the sensitivity of the parameter estimates**

	Dummy unemployed	α^u	β^u	α^e	β^e
Advertisement	−1.02	0.26	0.71	0.12	1.02
	(0.27)	(0.04)	(0.13)	(0.04)	(0.02)
Employment office	2.70	0.01	1.08	0.34	0.88
	(0.17)	(0.00)	(0.02)	(0.03)	(0.01)
Informal search	0.24	0.01	0.90	0.14	0.97
	(0.09)	(0.00)	(0.01)	(0.02)	(0.01)

Standard errors in parentheses.