A STRUCTURAL DYNAMIC ANALYSIS OF JOB TURNOVER AND THE COSTS ASSOCIATED WITH MOVING TO ANOTHER JOB

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ABSTRACT.

This paper provides an empirical analysis of the labour market behaviour of employed individuals, using a structural on-the-job search model. The costs associated with moving to another job are allowed to be nonzero and may depend on the wage level. It is shown that under certain conditions the optimal strategy has the reservation wage property. The model is estimated using data on job durations and subjective responses concerning the search strategy. The results reveal some strong sources of inflexibility of the labour market.

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JEL classification: 810, 210

1. INTRODUCTION.

In this paper we analyze the labour market behaviour of employedindividuals using a structural on-the-job search model. The model allows for nonzero costs associated with moving to another job. Using a data set which provides abundant information on the labour market environment of employed individuals we are able to estimate the structural parameters of interest.

During the last decades the use of job search models for the analysis of unemployment durations has become widespread. The reduced form approach, in which only the hazard of the duration distribution is estimated, seems to be replaced gradually by a structural approach in which the search-theoretical framework is used explicitly in empirical analysis (some examples of the latter approach are Yoon (1981), Lancaster & Chesher (1983), Narendranathan & Nickell (1985), Ridder & Gorter (1986), Wolpin (1987) and van den Berg (1990). Structural empirical inference allows one to estimate the underlying parameters of the search process, to formally test the adequacy of the theory and to make detailed policy recommendations.

Burdett (1978) was one of the first to model labour market behaviour of employed individuals in a job search context, to account for the fact that most job-to-job transitions occur without an intervening spell of unemployment. In these so-called on-the-job search models individuals search for jobs which are better than their present ones. By now there is an extensive theoretical literature on on-the-job search (see e.g. Hey & McKenna (1979), Holmlund (1984), Mortensen (1985), Albrecht, Holmlund & Lang (1986)). However, up to now there haven't been published any attempts to confront the on-the-job search model with empirical data. In light of the popularity of search theory as a tool for explaining job mobility it should be interesting to make such a confrontation. Moreover, emperical inference on labour market behaviour of employed individuals may help in understanding the behaviour of unemployed individuals. It is well-known that from a theoretical point of view the possibility of search on the job influences the optimal strategy of unemployed individuals (see e.g. Mortensen (1986)). Van den Berg (1989) provides some empirical evidence: it is shown that the estimation results for a structural search model for the unemployed are very sensitive to the extent of wage increases during employment (e.g., due to search on the job).

In this paper we estimate a structural on-the-job search model using micro data on individuals who were employed in 1985. When specifying the model we pay particular attention to factors that may reduce flexibility of the labour market. This is partly because of a growing policy interest in obstacles discouraging individuals to change jobs. Note that using a reduced form analysis of job durations one cannot distinguish between the costs of moving to another job and other factors that influence duration.

In addition to data on job durations we will use subjective responses of working individuals on a question about the level of their reservation wage in order to estimate the model. To our knowledge this is the first use of 'reservation wage data' of employed individuals. (As for unemployed individuals, in a number of papers reservation wage data were used for empirical inference, see Lancaster & Chesher (1983), Lynch (1983), Ridder & Gorter (1986), Main & Shelly (1988), van den Berg (1990)).

The outline of the paper is as follows. In section 2 the on-the-job search model specification is discussed. We examine in some detail the assumptions under which the optimal strategy of an employed individual can be characterized by the reservation wage property. Section 3 contains a description of the data and the empirical implementation of the model. We develop an estimation method that identifies the parameters of interest without having to make assumptions about the class of wage offer distributions. Section 4 presents the main results. In addition to the parameter estimates we present sample averages of the main characteristics of the search process. Furthermore we pay special attention to the effects of changes in the level of the costs of moving to another job and of the job offer arrival rate on the reservation wage and the duration of a job. In section 5 we examine the robustness of the model with respect to various sources of misspecification. Also it is discussed how the results relate to competing theories of labour market behaviour of the employed. Section 6 concludes.

2. THE MODEL.

2.1. On-the-job search theory and model specification.

The theory of on-the-job search tries to explain the behaviour of employed individuals who search for a better job (for a survey, see Mortensen (1986)). In the basic version of the theory search and job turnover are costless so in principle everybody is engaged in search. Suppose an individual works at a wage w. Offers of new jobs arrive according to a Poisson process with arrival rate λ. Such job offers are random drawings (without recall) from a wage offer distribution $F(x)$. For the moment we assume that a job is characterized by its wage level and that jobs can be held forever. Every time a job offer arrives the decision has to be made whether to accept it or to reject it. Individuals aim at maximization of their expected discounted lifetime income (over an infinite horizon). They are assumed to know λ and $F(x)$.

Most papers on on-the-job search assume that the model is stationary (see e.g. Hey & McKenna (1979), Holmlund (1984), Mortensen (1985), Albrecht, Holmlund & Lang (1986), Burgess (1988)). This means that w, λ and $F(x)$ are assumed to be independent of the duration of being in the present job and independent of all events during the stay in the present job. Further, λ and $F(x)$ are not allowed to depend on w. Obviously these assumptions are not very realistic. The motivation for adopting stationarity is that in a nonstationary setting the model equations become intractable. Also, most empirical studies using structural job search models for the unemployed assume stationarity of the models for computational reasons. Therefore it seems to be a good strategy to start an empirical analysis of on-the-job search with a stationary model. If w, λ and $F(x)$ are approximately constant within jobs and if λ and $F(x)$ do not depend heavily on w then the results will hold approximately. In section 5 a test for the stationarity assumption is presented.

The model does not allow for transitions into unemployment. From a conceptual point of view such an extension can be made easily. However, our main interest is in factors influencing job-to-job transitions. Inclusion of transitions into unemployment would make the model equations more complicated and would require more data than presently used to estimate the model. In section 5 it is examined in what way the estimation results may be affected by the omission of possible transitions into unemployment.

It can be argued that modeling the search process in terms of job offers is not very realistic. Sometimes one knows the wage rate associated with a job opening before the job is actually offered. Narendranathan & Nickell (1985) constructed a search model in which vacancies arrive according to a Poisson process. A vacancy is characterized by a random drawing from the distribution of wages associated with the flow of vacancies, so the decision whether to apply or not is made with knowledge of the wage corresponding to the vacancy. In van den Berg (1989) it is shown that such a model can be rewritten as the model described in this section with a different interpretation of λ and $F(x)$.

In section 3 we show that both model versions generate the same empirical specification.

The optimal strategy of an employed individual in the environment sketched above can be characterized by a very simple rule: accept a job offer if and only if its wage exceeds the wage presently earned. The transition rate from the present job to other jobs θ can be written as the product of the job offer arrival rate and the conditional probability of accepting a job offer.

(1) $\theta = \lambda\bar{F}(w) \qquad \bar{F} = 1-F$

One of our main interests is in factors causing inflexibility of the labour market, that is, factors that prevent employed individuals from accepting a job offer they would have accepted in the absence of those factors. It is likely that the transaction costs associated with moving to another job are among the most important of these factors. There are numerous kinds of costs associated with moving and they may add up to a considerable amount. Moving to another job usually involves moving to another town which implies that one has to search for a new house, possibly sell the old house, make costs in order to transport furniture (though this sometimes is paid by the new employer) and redecorate the new house. Moving to another job may also be costly if other members of the household have a job too: it may be that the choice is between other members giving up their job in order to move together or splitting up the household which may incur considerable psychic costs. The loss of non-transferable pension claims is a commonly recognized transaction cost that may have a large impact on labour mobility between jobs. People who have built up large claims will be reluctant to move especially when the number of years until retirement is small. Psychic costs associated with moving may also be considerable. The family has to integrate in the new social environment while the worker has to familiarize with a new working environment. Further, he may have to learn new skills during the first period in the new job. Also, a change of the educational environment may not be beneficial for children in the household. Special financial benefits (in addition to the wage) in the present job, like fringe benefits, may prevent an individual from moving to another job if a new job does not offer benefits or offers these only after having worked for a certain length of time in that job. We extend the basic on-the-job search model by introducing transaction costs c. Specifically, every time one moves from one job to another an amount of money c has to be paid (it is assumed that non-material (psychic) costs have a monetary equivalent). Some papers have been published that analyze on-the-job search models with transaction costs (Hey & McKenna (1979), Holmlund (1984), Holmlund & Lang (1985), Burgess (1988)). Hey & McKenna (1979) and Burgess (1988) give a thorough theoretical analysis of the influence of c on labour mobility, including comparative statics results.

In all papers mentioned above c does not depend on the present wage w. However, there are various reasons to assume that c in fact does depend on w. In particular, the amount of pension claims that may be lost is strongly correlated with the present wage. Also, individuals who earn a high wage may have spent more money on their house and their children's education. If the costs associated with changing houses and education are correlated with the value of the old house and the money already spent on education then c will be larger for individuals who earn a high wage.

In order to maintain stationarity we assume that c as a function of w does not depend on the time spent in the present job nor on events during the stay in the present job. In combination with the infinite horizon assumption stationarity of the model implies that the employed individual's perception of the future is independent of the time spent in the present job. Consequently, the optimal strategy is constant during the present job.

Allowing c to be a non-constant function of w has important consequences for the properties of the optimal strategy of an employed individual. The qualitative comparative statics results derived for the model with constant c do not necessarily hold anymore. Indeed, the set of acceptable wage offers may not be connected. In that case the optimal strategy does not have the reservation wage property, that is, there is no number such that a job offer is acceptable if an only if its wage exceeds that number. In subsection 2.2 we derive conditions on λ, $F(x)$, c and the subjective rate of discount ρ which ensure that the optimal strategy does have the reservation wage property.

Analogous to Hey & McKenna (1979) we do not incorporate per-period search costs in the model. This is because in our opinion actual search (noticing advertisements when reading newspapers, contacting potential employers, making an expenses-paid visit to them etc.) is relatively costless for the individuals in the dataset. Also, allowing for nonzero search costs would generate computational problems when estimating the model because non-zero search costs make it optimal for some individuals not to search on the job (see e.g. Burdett (1978)). As we shall see in section 3 the data suggest that in some sense all employed individuals are engaged in search.

2.2. The optimal strategy of employed individuals.

Let R(w) denote the expected present value of income if the present wage equals w, when following the optimal strategy. Because of the stationarity assumption R(w) does not depend on the elapsed duration of the present job so R(w) is constant during the present job. R(w) is written recursively as a function of R(x), in which x is interpreted as the wage offer associated with the next job offer. The waiting time t until the next offer has an exponential distribution with parameter λ. At t the individual has to choose between acceptance of the offer (present value R(x)−c(w)) and rejection (present value R(w)). This gives

$$(2) \qquad R(w) = \int_0^\infty \left[\int_0^t w e^{-\rho s} ds + e^{-\rho t}. E_x(\max(R(x)-c(w), R(w))) \right] \lambda e^{-\lambda t} dt$$

$$= \frac{1}{\rho+\lambda} .(w+\lambda E_x(\max(R(x)-c(w), R(w)))).$$

A wage offer x is acceptable if $R(x)-c(w)>R(w)$ while it is not if $R(x)-c(w)<R(w)$. If $R(x)-c(w)=R(w)$ then the individual is indifferent with respect to accepting the offer or not.

Suppose that c(w) is constant except for a large discrete upward jump at say w_0, e.g. $c(w)=0$ for $w<w_0$, c(w) is 'large' for $w \geq w_0$. An individual earning $w_0-\varepsilon$ will accept a wage offer $w_0-½\varepsilon$. However, it is conceivable that he will reject an offer w_0 because the wage increase ε does not offset the increase of c that has to be paid for another transition. So in such a case the optimal strategy does not have the reservation wage property. Moreover, there always are sufficiently high wage offers that do offset the increase of c so the set of acceptable offers is not connected. This example shows that contrary to virtually all search models for labour market behaviour our model does not guarantee the reservation wage property to hold. We now present some propositions regarding existence, uniqueness and properties of R(w) as given in (2) and regarding the characterization of the optimal strategy, given conditions on the structural parameters λ, F(x), c(w) and ρ. First these conditions are given.

1. $0<\lambda<\infty$, $0<\rho<\infty$.
2. F(x) is a strictly increasing differentiable function on $[0,\bar{w}]$ with $0<\bar{w}<\infty$. For $x \leq 0$ $F(x)=0$, for $x \geq \bar{w}$ $F(x)=1$. Further, $0 \leq w \leq \bar{w}$.

3a. $c(w)$ is a continuous function on $[0,\bar{w}]$.

3b. $c(w)$ is a continuously differentiable function on $[0,\bar{w}]$.

4a. $\forall\ 0 \leq w < w^* \leq \bar{w}\ \ c(w^*) < c(w) + \frac{1}{\lambda}(w^* - w)$

4b. $\forall\ 0 \leq w \leq \bar{w}\ \ c'(w) < \frac{1}{\lambda}$

$c'(w)$ being the derivative of $c(w)$. Conditions 1, 2 and 3a are fairly general. Choosing zero to be the lower bound of the domain of $F(x)$ is a matter of convenience, we might as well choose another number. Likewise, $\bar{w}$ can be thought of as being a very large number. Conditions 4a and 4b assure that $c(w)$ does not increase too fast, in order to avoid the kind of problems related to the reservation wage property that were discussed before. Note that λ can be interpreted as an upper bound on the rate at which payment of transaction costs occurs. Consequently, the quantity $(w-\lambda c(w)).dt$ can be interpreted as the wage earned in a small time interval with length dt minus an upper bound on the expected amount of transaction costs to be paid in that small time interval, if the wage rate equals w. Conditions 4a and 4b state that this quantity must be increasing in w. Whether these are strong conditions cannot be said a priori but, as we shall see, it will turn up empirically. Note that condition 4b is sensible only if condition 3b also holds. Conditions 3b and 4b make it possible to give a characterization of the optimal strategy in terms of a differential equation. Condition 3b is not very strong since a differentiable function can approximate discontinuities well.

The proofs of the propositions are given in appendix 1.

Proposition 1.

Let conditions 1,2 *and* 3a *be satisfied. Then* $R(w)$ *exists and it is the unique continuous function on* $[0,\bar{w}]$ *that solves equation* (2).

Proposition 2.

If in addition condition 4a *is satisfied then* $R(w)$ *is strictly increasing on* $[0,\bar{w}]$.

This means that if c does not increase too fast as a function of w in the sense that condition 4a is satisfied, then a high wage rate associated with a job implies a large (expected present) value of that job. From now on it is assumed that conditions 1,2,3a and 4a hold. If $R(0)<R(w)+c(w)<R(\bar{w})$ then, because R is strictly increasing on $[0,\bar{w}]$ there exists a unique $\xi(w)$ such that

$$(3) \qquad R(\xi(w)) = R(w)+c(w)$$

while $R(x) \gtrless R(w)+c(w)$ if $x \gtrless \xi(w)$. Consequently, the optimal strategy for an individual earning a wage w then can be rewritten as follows: accept a wage offer x if $x>\xi(w)$ and reject it if $x<\xi(w)$. $\xi(w)$ is the reservation wage, which of course depends on all explanatory variables in the model. If $R(0) \geq R(w)+c(w)$ then any offer is acceptable for an individual earning w, so $\xi(w)$ may be anything ≤ 0; in that case we define $\xi(w)=0$. Similarly, for $R(w)+c(w) \geq R(\overline{w})$ we define $\xi(w)=\overline{w}$. Note that whether $\xi(w)=0$ or $\xi(w)=\overline{w}$ occurs for the range of w in the dataset is an empirical matter. However, as we shall see, F(x) is not identified for our data and therefore neither is $\overline{w}$. We may assume that $\overline{w}$ is so large that for every relevant case (every individual in the dataset) $R(\overline{w})>R(w)+c(w)$.

Because R is strictly increasing and continuous in its argument on $[0,\overline{w}]$, it follows that the inverse of R exists and in continuous in its argument on $[R(0),R(\overline{w})]$. Therefore $\xi(w)$ as defined above is continuous on $[0,\overline{w}]$.In summary, the optimal strategy satisfies the reservation wage property and the reservation wage ξ is a continuous function of w on $[0,\overline{w}]$. If condition 4a is weakened by replacing the strict inequality by a weak inequality then we can only prove that R(w) is non-decreasing on $[0,\overline{w}]$. In that case there may be an interval $[\xi_1,\xi_2]$ with $0 \leq \xi_1<\xi_2 \leq \overline{w}$ such that an individual is indifferent between acceptance and rejection of wage offers from that interval. Because there is a positive probability that wage offers $x \in [\xi_1,\xi_2]$ arrive, this arbitrariness would raise problems in any analysis of models in which such cases are allowed.

By strenghtening conditions 3a and 4a it is possible to derive expressions for the derivatives of R(w) and $\xi(w)$ with respect to w.

Proposition 3.

If conditions 1,2,3b and 4a are satisfied then R(w) is continuously differentiable on $[0,\overline{w}]$ and for every $0 \leq w \leq \overline{w}$ there holds that

$$(4) \qquad R'(w) = \frac{1-c'(w)\lambda\overline{F}(\xi(w))}{\rho+\lambda\overline{F}(\xi(w))}$$

Proposition 4.

If conditions 1,2,3b and 4b are satisfied then $R'(w)>0$ on $[0,\overline{w}]$ and $\xi(w)$ is a *continuously differentiable function of* w *for the wage intervals on* $[0,\overline{w}]$ *on which* $0<\xi(w)<\overline{w}$. *For those* w

$$(5)\qquad \xi'(w) = \frac{1+\rho\,.\,c'(w)}{1-\lambda\overline{F}(\xi(\xi(w)))\,.\,c'(\xi(w))}\;.\;\frac{\rho+\lambda\overline{F}(\xi(\xi(w)))}{\rho+\lambda\overline{F}(\xi(w))}$$

Equation (5) can be rewritten by noting that the exit rate out of the present job equals

$$(6)\qquad \theta(w) = \lambda\overline{F}(\xi(w))$$

so

$$\xi'(w) = \frac{1+\rho\,.\,c'(w)}{1-\theta(\xi(w))\,.\,c'(\xi(w))}\;.\;\frac{\rho+\theta(\xi(w))}{\rho+\theta(w)}\,.$$

From the results so far the following corollary can be obtained.

Corollary.

Let conditions 1.2.3b *and* 4b *be satisfied. Further, let* $\xi(w)\in\langle 0,\overline{w}\rangle$. *Then*

(*i*) $\xi(w)\gtrless w \Leftrightarrow c(w)\gtrless 0$

(*ii*) $\xi'(w)\gtrless 0 \Leftrightarrow c'(w)\gtrless -\frac{1}{\rho} \Leftrightarrow R'(w)\lessgtr\frac{1}{\rho} \Leftrightarrow \theta'(w)\lessgtr 0$

(*iii*) *if* $c'(w)=0$ *then* $\xi'(w)<1 \Leftrightarrow c(w)>0$

The results in (i) and (ii) make sense. If job changing costs are positive then one is more reluctant to move to another job than when such costs are absent. If c as a function of the wage level decreases very fast at w then the job offers that are not acceptable at w become acceptable for wages larger than w. Note that the model is not incompatible with an exit rate increasing with the present wage. The case $c'(w)=0$ for every w, $c>0$ has been analyzed extensively by Hey & McKenna (1979). In that case, if $\xi(w)<\overline{w}$ then $\xi(w)>w+\rho.c$ and the gap between $\xi(w)$ and w is a decreasing function of w. This can be understood by the following argument. Individuals take into account that they may change jobs more than once in the future. Therefore, the reservation wage has to exceed the sum of the present wage and the long-run compensation of the transaction costs that have to be paid for the first move. The more job changes one expects, the larger the gap between $\xi(w)$ and w because one does not want to pay too much transaction costs in order to reach a high wage level. Because the number of job changes one expects is relatively large for individuals who have a relatively small wage, this implies that the gap between $\xi(w)$ and w is decreasing in w.

In order to be able to use the model for structural empirical analysis the reservation wage has to be solvable for given w, c(w), λ, F(x) and ρ. It is clear that the differential equation (5) cannot be solved analytically. Also, numerical methods may generate severe computational problems due to the lack of simple boundary values and the restricted interval $(0<\xi(w)<\bar{w})$ on which the equation holds. Therefore, a different route is taken in order to be able to calculate $\xi(w)$ as predicted by the model. Specifically, $\xi(w)$ is approximated by the first terms of a Taylor series expansion of $\xi(w)$ around c(w)=0, keeping w constant in the expansion.

Proposition 5.

Let conditions 1,2,3b *and* 4b *be satisfied. Further, let* c(w) *be dependent on a parameter* η *such that* $c(w)-\eta$ *does not depend on* η *and* η *does not depend on* w *(*η *is an additive parameter of* c(w)*). Then for every* $w \in <0,\bar{w}>$

$$(7) \qquad \xi(w) = w + \frac{\rho+\theta(w)}{1-c'(w)\theta(w)} \cdot c(w) + o(c(w)).$$

The proof is in the appendix. The reservation wage is expanded as a function of the parameter η around $\eta=-(c(w)-\eta)$. For instance, if c(w) is a linear function of w, say $c(w)=c(0)+\alpha w$, then $\xi(w)$ is expanded around $c(0)=-\alpha w$. Note that ξ is expanded in terms of η only, with w being treated as an arbitrary constant. The resulting equation (7) suppresses the dependence of ξ on η and highlights the dependence of ξ on w. Several alternative expansions can be proposed, but these alternatives all have disadvantages. An expansion of $\xi(w)$ as a function of w around a specific value of w is impossible because we cannot calculate ξ for that value of w. Also, the expansion resulting in equation (7) is less stringent and has probably a better quality than an expansion of $\xi(w)$ as a function of all parameters of c(w) around the parameter values that correspond to c(w)=0 for every w. (In the example this would amount to expanding $\xi(w)$ around $c(0)=\alpha=0$ which is obviously more stringent than $c(0)=-\alpha w$). In the latter case the remainder generally is not o(c(w)).

From now on it is assumed that conditions 1,2,3b and 4b are satisfied.

Further, attention is restricted to cases in which $0<w<\bar{w}$ and $0<\xi(w)<\bar{w}$. The approximate $\xi(w)$ that is obtained by deleting the $o(c(w))$ term in equation (7) preserves many of the properties of the exact $\xi(w)$. (Note that $\xi(w)$ appears on both sides of equation (7) because θ depends on ξ. It can be shown that the implicit equation for the approximate $\xi(w)$ always has a solution). For instance, if $c(w)>0$ then $\xi(w)>w$, if $c(w)=0$ then $\xi(w)=w$ and if $c(w)<0$ then $\xi(w)<w$. Further, if $c'(w)=-1/\rho$ then $\xi'(w)=0$, while if $c'(w)=0$ then there holds that $\xi'(w)\leq 1$ if and only if $c(w)\geq 0$. If for every $w \in [0,\bar{w}]$ $c'(w)=-1/\rho$ then the approximate and the exact reservation wage functions coincide. In summary, the approximation is good for values of $c(w)$ which are not too large and it preserves many of the properties of the exact $\xi(w)$. Though it would be interesting to know whether there is a systematic relationship between the explanatory variables in the model and the approximation error it is not possible to investigate this since in general the exact $\xi(w)$ cannot be solved. However, for very specific choices of $F(x)$ and $c(w)$ the exact $\xi(w)$ can be solved and the relationship between w and the approximation error can be derived. Details are in the appendix. It appears that for values of $F(x)$, $c(w)$, λ and ρ that seem to be reasonable (as far as that is possible given that the exact $\xi(w)$ has to be solvable), and for a wide range of w, the relative approximation error in $\xi(w)$ is less than 0.4%.

The equation for the approximate $\xi(w)$ has intuitive appeal. Suppose $c'(w)=0$. In that case $\xi(w)$ is approximated by $w+(\rho+\theta(w)).c(w)$. As explained before, if $c(w)$ is constant and positive then $\xi(w)$ exceeds $w+\rho c(w)$ because one takes into account that one may have to pay transaction costs more than once in the future. Further, the more job changes one expects and the higher the transaction costs, the larger the gap between ξ and $w+\rho c(w)$. The term $\theta(w).c(w)$ in the approximation takes account of this. Now suppose $c'(w)$ and $c(w)$ are positive. Then in (7) $\xi(w)$ exceeds the $\xi(w)$ that would have prevailed if $c'(w)$ were zero. This effect is more pronounced if $\theta(w)$ is large. Again this is plausible: if transaction costs increase with wages and if one is still at the bottom of the wage distribution then $\xi(w)$ must be large to prevent that one has to pay too much transaction costs in order to reach a high wage level.

2.3. Job durations.

As shown before, the exit rate out of the present job $\theta(w)$ equals $\lambda\bar{F}(\xi(w))$ and therefore depends on all structural parameters λ, F(x), c(w), w and ρ. However, because of the stationary assumption $\theta(w)$ does not depend on the elapsed duration in the present job. Consequently, the job duration has an exponential distribution with parameter $\theta(w)$. In section 5 the validity of the stationarity assumption will be tested.

3. THE DATA.

3.1. The data set.

The data set used is constructed from the Labour Market Research Panel, a survey conducted by the Netherlands Organization for Strategic Labour Market Research (OSA). As of April 1985 a sample of about 4000 individuals living in the Netherlands is interviewed every one and a half year. The sample includes only individuals aged between 15 and 61 and it over-represents individuals who are in certain labour market states at the date of the first interview (notably employment and unemployment) but it is supposed to be random in all other respects. For our study only the first wave of the panel is available. Respondents are asked to recall their labour market history from January, 1980 until the date of the interview. Further, they were asked to provide information on their income at the date of the interview. The data set contains a wide range of job characteristics and information on the social and working environment of individuals who are employed in April, 1985. This makes the data set particularly useful for explaining individual differences in job durations. Another distinguishing feature of the data set is that individuals who were employed at the date of the interview were asked for their lowest acceptable net wage offer. Responses on this question are interpreted as the observed counterpart of the reservation $\xi(w)$.

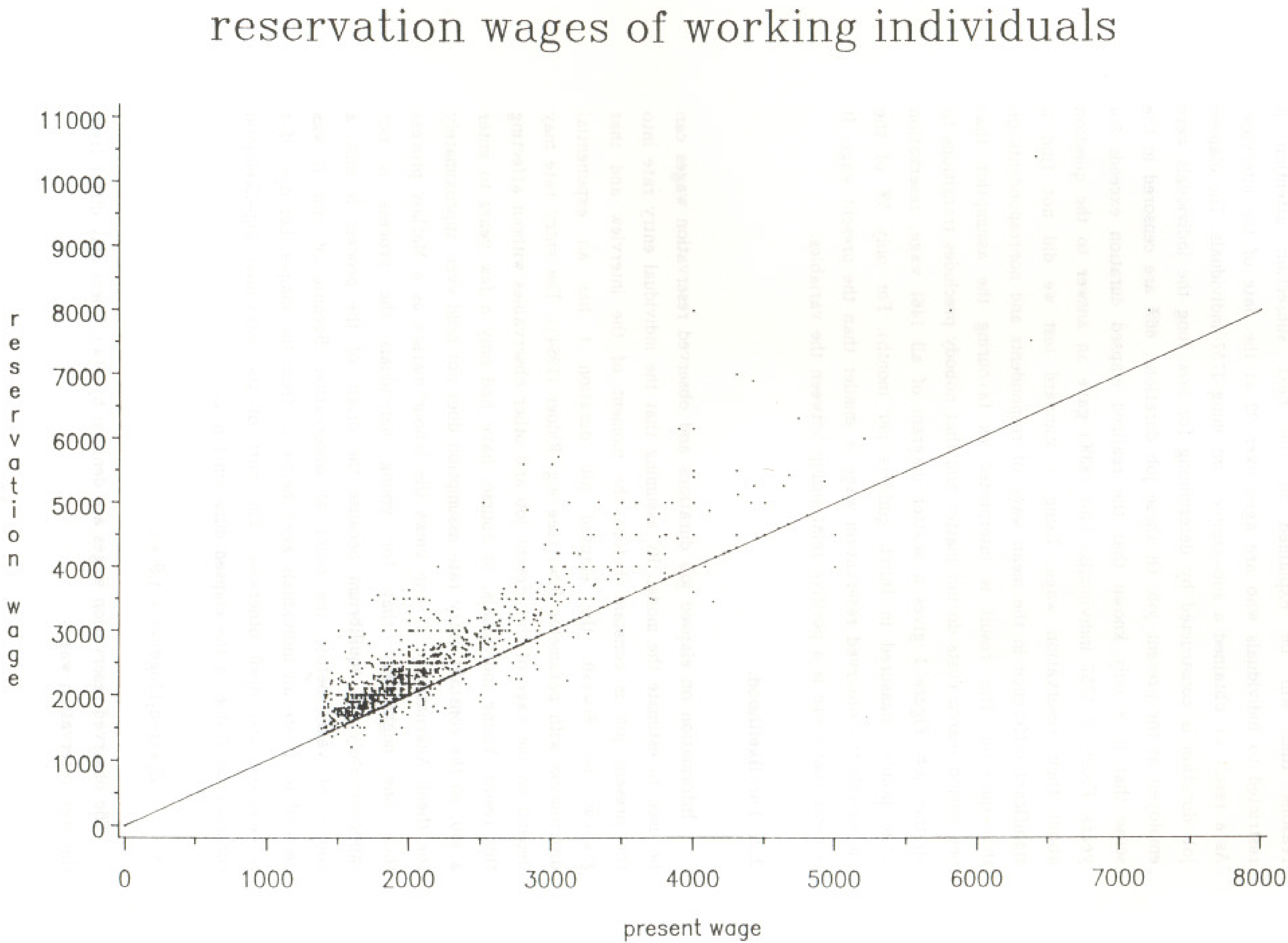
For our estimation purposes we selected individuals who were employed in a paid job at the date of the interview. Since we do not know the income, the working environment and the job characteristics associated with previous jobs, we cannot use job spells that ended before April 1985 for the empirical analysis. Self-employed individuals are deleted because their labour market behaviour may deviate substantially from the behaviour of employees. For reasons that will be explained in the next subsection attention is restricted to individuals who are aged over 22 at the date of the interview. As a result we obtained a sub-sample containing 1757 individuals. The elapsed job duration is constructed by determining for how long the individuals were employed in the present job. Of these job durations, 66% are censored in the sense that it is only known that the realized elapsed duration exceeds 5.4 years. From all 1757 individuals, 1461 (83%) gave an answer to the question about their reservation wage. Using a standard test we did not find a significant difference in the mean wage of respondents and nonrespondents on that question. This result is interpreted as favouring the assumption that per-period search costs do not matter and that nobody precludes transitions to another job. Figure 1 gives a scatter diagram of all 1461 wage, reservation wage points (measured in Dutch guilders per month). For only 5% of the individuals the observed reservation wage is smaller than the present wage. It is clear that there is a positive relationship between the variables.

3.2. The likelihood.

Information on elapsed job durations and observed reservation wages can be used to estimate the model. By assuming that the individual entry rate into the present job is constant before the moment of the interview and that $\xi(w)<\overline{w}$, i.e. $\theta(w)>0$, the elapsed job duration t has an exponential distribution with parameter $\theta(w)$ (see e.g. Ridder (1984)). The entry rate may depend on the wage of the present job and other observables without affecting this result. Young individuals, of course, have had only a few years to enter a job, so the constant entry rate assumption does not hold even approximately for them. Alternatively, if one views the labour market as a Markov process then one might say that for young individuals the process is not (approximately) in equilibrium because the origin of the process is only a couple of years before the point of observation. Because of this it was decided to delete all individuals aged below 23 from the sample. Let $d_1=1$ if t is censored and $d_1=0$ otherwise. The part of the individual log-likelihood contribution $\mathcal{L}$ due to the elapsed duration t is $\mathcal{L}_1$,

$$(8) \qquad \mathcal{L}_1=(1-d_1).\log\theta(w) - t.\theta(w).$$

The observed reservation wages are denoted by $\tilde{\xi}(w)$. These may differ from the true reservation wages



reservation wages of working individuals
reservation wage
present wage
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000

$$(9) \qquad \tilde{\xi}(w) = \xi(w) + \varepsilon$$

ε is an error term which is interpreted as a measurement error that is i.i.d. across individuals and independent of duration t and present wage w. Consequently, individuals use $\xi(w)$ instead of $\tilde{\xi}(w)$ as their strategy so θ depends on ξ instead of $\tilde{\xi}$ and equation (8) does not depend on ε. In addition, t and $\tilde{\xi}$ are independent. By assuming that the distribution of ε belongs to some parametric class (e.g. normal) the part of $\mathcal{L}$ due to $\tilde{\xi}$ can be constructed. Let $g(\varepsilon)$ be the p.d.f. of ε.

$$(10) \qquad \mathcal{L}_2=(1-d_2).\log\, g(\xi(w)-\tilde{\xi}(w))$$

with $d_2=1$ if $\tilde{\xi}$ is missing and 0 otherwise. The individual log-likelihood contribution is given by the sum of $\mathcal{L}_1$ and $\mathcal{L}_2$. The structural parameters and functions of the on-the-job search model (λ, $F(x)$, $c(w)$ and ρ) enter the likelihood via $\theta(w)$ in $\mathcal{L}_1$ and $\xi(w)$ in $\mathcal{L}_2$. The true reservation wage $\xi(w)$ is the solution of equation (7), deleting the $o(c(w))$ term in that equation.

$$(11) \qquad \xi(w)=w + \frac{\rho+\theta(w)}{1-c'(w)\theta(w)} \,.\, c(w).$$

When taking a closer look at the likelihood equations one sees that not all parameters are identified using data on t and $\tilde{\xi}$. In particular λ and F are not identified because both (8) and (11) only depend on the product $\lambda\overline{F}(.)$. This is also a commonly encountered problem in unemployment duration analysis using structural models (see e.g. Flinn & Heckman (1982)), and it basically results from the fact that only acceptable wage offers matter for the optimal strategy and the exit rate out of the present state. The general approach to obtain identification of a structural job search model is to assume recoverability of F and use data on post-spell wages. Because our data set is essentially a cross-section it does not provide information on wages that are earned after moving to another job than the present one so this approach cannot be used here. Alternatively, the present wage itself could be regarded as a drawing from the wage offer distribution, truncated at the value of the reservation wage at the previous job or at the spell of unemployment that preceded. However, we do not know anything about the values of these points of truncation, simply because the data set does not provide income variables for spells that ended before the date of the interview. Consequently, it seems that the model cannot be estimated.

However, as was set out in the previous sections, our main empirical interest is in factors that obstruct flexibility of the labour market and in particular in the costs associated with moving to another job. That is, $c(w)$ is the 'parameter' of interest. Now note from equations (10) and (11) that $c(w)$ is identified from the data on $\tilde{\xi}$ if θ is known. But θ is identified from the data on t (see equation (8)). Of course, θ depends on λ, F and ξ. However, we can do a reduced-form estimation of θ from (8) and use these estimates in the reservation wage equation (11) in order to estimate $c(w)$. Such an estimation method does not require identification of λ and F but yet uses the theoretical framework of on-the-job search theory to interpret the reservation wage data. One may say that the method is flexible in the sense that identification of a structural parameter of interest is achieved without the need to make strong assumptions on certain other structural parameters and functional forms. Moreover, by using a reduced form specification for $\theta(w)$ we are able to check whether certain predictions of the theory hold. For instance the theory predicts $\theta'(w)<0 \Leftrightarrow \xi'(w)>0$. A fully structural empirical specification of $\theta(w)$ imposes such restrictions and therefore makes such empirical checks impossible. In subsection 3.3. which deals with parameterizations of $c(w)$ and $\theta(w)$ some other predictions from the theory are derived.

In section 2 it was mentioned that the on-the-job search model could be given an alternative interpretation in terms of vacancy offers instead of job offers. However, in that case only λ and F obtain another meaning and because λ and F do not appear separately in the empirical specification this implies that there are no interpretation differences for the empirical results.

One can argue that because we use the approximation from proposition 5 for the true reservation wage or because the model is not well specified even if there is no approximation error in $\xi(w)$, we actually make a specification error. Specifically, $\xi(w)$ from equation (11) may not be the true reservation wage. The exit rate θ then depends on the unknown true reservation wage but since θ is estimated in a reduced form this is no problem. Further, ε in equation (9) then represents the sum of a specification error and a measurement error. Assume that the specification error is independently distributed across individuals and is independent of duration t. We can then still use the estimation method proposed above. (Note that an empirical analysis of a fully structural model would (apart from the identification problems) become very complicated if one allows for errors in the specification of $\xi(w)$.)

3.3. The empirical implementation.

Now that we have specified the empirical setting and described the data we discuss in this subsection parameterizations and the choice of explanatory variables. The cost of moving to another job $c(w)$ is written as a linear function of explanatory variables x_1 and the present wage on the relevant wage interval,

$$(12) \qquad c(w)=x_1'\gamma_1+\alpha.w.$$

Such a specification satisfies the assumptions of proposition 5 for any finite $\alpha<1/\lambda$. The vector x_1 includes characteristics of the neighbourhood in which one lives, personal characteristics and characteristics of the present job. The latter can be subdivided into occupation dummies and pecuniary and non-pecuniary fringes.

The exit rate out of the present job $\theta(w)$ is written as an exponential function of explanatory variables x_2 and the logarithm of the present wage

$$(13) \qquad \theta(w)=e^{x_2\gamma_2-\beta log(w)}.$$

This specification is in accordance with specifications in the literature of reduced-form hazards out of unemployment in that $\log\theta$ depends on log income and is a linear function of x. We assume that (13) gives a good approximation of (6) for the range of x and w in the data. From equation (6) it follows that θ depends on λ, F and ξ and therefore also depends on $c(w)$. Consequently, x_2 has to include all explanatory variables in x_1. Most of these explanatory variables also influence λ and F. For instance the age of an individual or whether he is married may influence $c(w)$ but may also give an indication of the productivity of the job searcher and therefore influence λ.

According to the theory the parameters γ_1, γ_2, α and β are interrelated and the estimation results can be used to check such interrelations. First, $\alpha<1/\lambda$ has to hold in order to be sure that one can safely use equation (11). This cannot be checked because λ is unidentified, but since $\theta\leq\lambda$ a necessary condition for $\alpha<1/\lambda$ that can be checked is that for every individual the estimate of α has to satisfy $\alpha<1/\theta$. From equation (6) it follows that θ

depends on w by means of ξ, so the sign of $\theta'(w)$ must be opposite to the sign of $\xi'(w)$. From (13), β and $\xi'(w)$ must have the same sign. The empirical model specification consists of the equations (11), (12), and (13). By differentiating ξ it can be shown that the relation between $\xi'(w)$ and β does not necessarily follow from the empirical specification and can be checked after estimation. Another interrelation predicted by the theory is about γ_1 and γ_2. Consider an explanatory variable that influences $c(w)$ while it can be safely assumed that it does not influence λ, F or ρ. In the appendix it is shown that according to the theoretical model (equations (6), (11) and (12)) the signs of the parameters in $\theta(w)$ and $c(w)$ associated with that variable must be opposite if $\alpha>-1/\rho$ and $\xi'(w)>0$, or $\alpha<-1/\rho$ and $\xi'(w)<0$. If the variable has a positive effect on the cost of moving to another job then it must have a negative effect on the exit rate to another job. Again this can be checked by comparing the estimates of γ_1 and γ_2.

The estimation procedure is as follows. First, β and γ_2 are estimated by ML using the BHHH algorithm. The likelihood function is (8) with (13) substituted for $\theta(w)$. (Note that we assume that there is no unobserved heterogeneity of $\theta(w)$ in the sample. In section 5 this assumption is tested). Next α and γ_1 are estimated by nonlinear least squares. The objective function follows from (9) and equals

$$\sum_{i=1}^{n}(\tilde{\xi}_i-\xi_i^2) \qquad n=1461$$

ξ_i is calculated from equation (11). We plug in the individual predicted $\theta(w)$ from the first estimation step and substitute (12) into (11). Note that by using this estimation procedure we do not have to make strong assumptions on the distribution of the error term ε. It is assumed that the distribution of ε does not depend on the explanatory variables w and x. However, in the previous subsection it was argued that the difference between the exact $\xi(w)$ in the model and the approximation of it (equation (11)) may be part of ε and in appendix 5 it is shown that for reasonable parameter values the approximation error is decreasing in w. Still, the approximation error is always very small and is therefore probably only a minor part of ε, so we do not expect it to cause a severe violation of the independence assumption on ε and w. The variance σ^2 of ε is the variance of the sum of the specification error and the measurement error. The subjective rate of discount ρ is fixed at 15% a year. In section 5 we examine the robustness of the results with respect to the numerical value of ρ.

4. RESULTS.

4.1. Parameter estimates.

The parameter estimates for the model described in section 3 are presented in the tables 1 and 2. The unit time period is one month. For the age and occupation dummies the reference categories are the age category 41–60 and the occupation category of scientists, engineers and artists. Though β and γ_2 are estimated prior to α and η_1 we start by discussing the results for the latter because those are structural parameters.

Housing accommodation circumstances have a strong influence on job changing costs. If one expects it to be hard to sell the present house or to find another house to rent when moving to another job, then job changing costs are (significantly) larger than when such problems are not expected. Further,

Table 1 Parameter estimates for the costs associated with changing jobs.

variable	estimate	(t–value)
constant	3233	(1.0)
small distance home/work	2410	(2.4)
civil servant	199	(0.2)
fringe benefits	851	(3.0)
attached to environment (social)	–109	(0.1)
married	–586	(0.5)
housing problems expected	2435	(2.6)
unsatisfied with job (non–pecuniary)	– 4290	(2.3)
occupation administrative/commercial	3302	(2.6)
occupation services	3614	(2.3)
occupation farm–labourer/industrial	– 416	(0.3)
aged below 30	–13865	(9.0)
aged between 30 and 40	–8915	(5.7)
log (# working in household)	61	(0.0)
wage	6.37	(7.7)
standard error σ	396	
1461 observations		

if the distance between house and working place is less than 10 km, then job changing costs are larger, indicating that one is reluctant to give up the advantage of short travelling times between home and work. Both pecuniary and non-pecuniary job characteristics are strong determinants of c. If the numbers of fringe benefits categories is large then transaction costs are high, whereas if one is very dissatisfied with the present job from a non-pecuniary point of view the opposite holds. The correlation coefficient of the present wage and the non-pecuniary satisfaction variable equals -0.02 so there is no multicollinearity effect here. One might argue that job characteristics do not show up in labour market behaviour just as elements of job changing costs but are in fact properties of a job that have intrinsic utility. However, that would imply that a job is represented by a vector of characteristics rather than by just a wage and the optimal strategy would be multidimensional and generally unsolvable. Also, certain job characteristics like special fringe benefits can be obtained only after having worked in a job for some time so a job transition implies a temporary loss of them which can therefore be represented as a transaction cost.

The occupation dummies show large differences. Apparently individuals who have an administrative job or who work in the commercial or services sector face high job changing costs. This may be because the possible loss of pension claims is high in these sectors or that in these sectors institutional restrictions discourage individuals to move to a competing company. It seems that the kind of occupation one has has more influence on c than whether one is a civil servant or not. Age is a very important and significant determinant of c. Both the accumulation of job-specific human capital and psychological factors like an increased attachment to the neighbourhood in which one lives may be responsible for the high c for older individuals. Also, the amount of pension claims increases with age. Finally, there may be a finite horizon effect which is not included in the model. Assume that there is a point of time T (say the retirement age) after which one cannot work and assume that $c(w)>0$ for every w. Then for points of time sufficiently close to T it is optimal to reject every possible offer. This is basically because the period of time that can be used to earn back $c(w)$ decreases as time proceeds. The age coefficient in $c(w)$ for older individuals may be biased upward because of this. Note that the argument implies that in that case the corresponding coefficient in θ is biased downward.

Rather surprisingly, other personal characteristics like marital status and number of working individuals in the household do not have influence on c. Also, it seems that it does not matter whether one is attached to the social life in the present environment. One (rather devastating) explanation of this result is that the "reservation wage" question was (mis)understood to refer to jobs in the present neighbourhood only. Another possible explanation is that individuals who are more attached restrict the job search to their present neighbourhood. In both cases one would expect that the variable under consideration does have a significant effect on θ.

The coefficient α related to the present wage w is very significant. Probably the wage variable takes account of many factors some of which are mentioned in section 2, because w influences the magnitude of the effects of those factors on c. The estimated standard deviation of ε is quite large as compared to the average value of ξ, which is about 2530. This confirms the supposition that the error due to using the approximation of the exact ξ is

Table 2 Parameter estimates for the transition rate from one job to other jobs.

variable	estimate	(t-ratio)
constant	-1.59	(1.1)
small distance home/work	-0.34	(3.8)
civil servant	-0.36	(3.9)
fringe benefits	-0.12	(4.6)
attached to environment (social)	-0.17	(2.0)
married	-0.18	(1.7)
housing problems expected	-0.09	(1.1)
unsatisfied with job (non-pecuniary)	0.51	(2.4)
high education	0.28	(2.6)
occupation administrative/commercial	-0.50	(4.3)
occupation services	-0.10	(0.7)
occupation farm-labourer/industrial	-0.40	(3.3)
aged below 30	1.69	(13.0)
aged between 30 and 40	0.86	(6.7)
log (# working in household)	0.24	(2.0)
log (wage)	-0.41	(2.2)

log likelihood = -3426.84

1757 observations

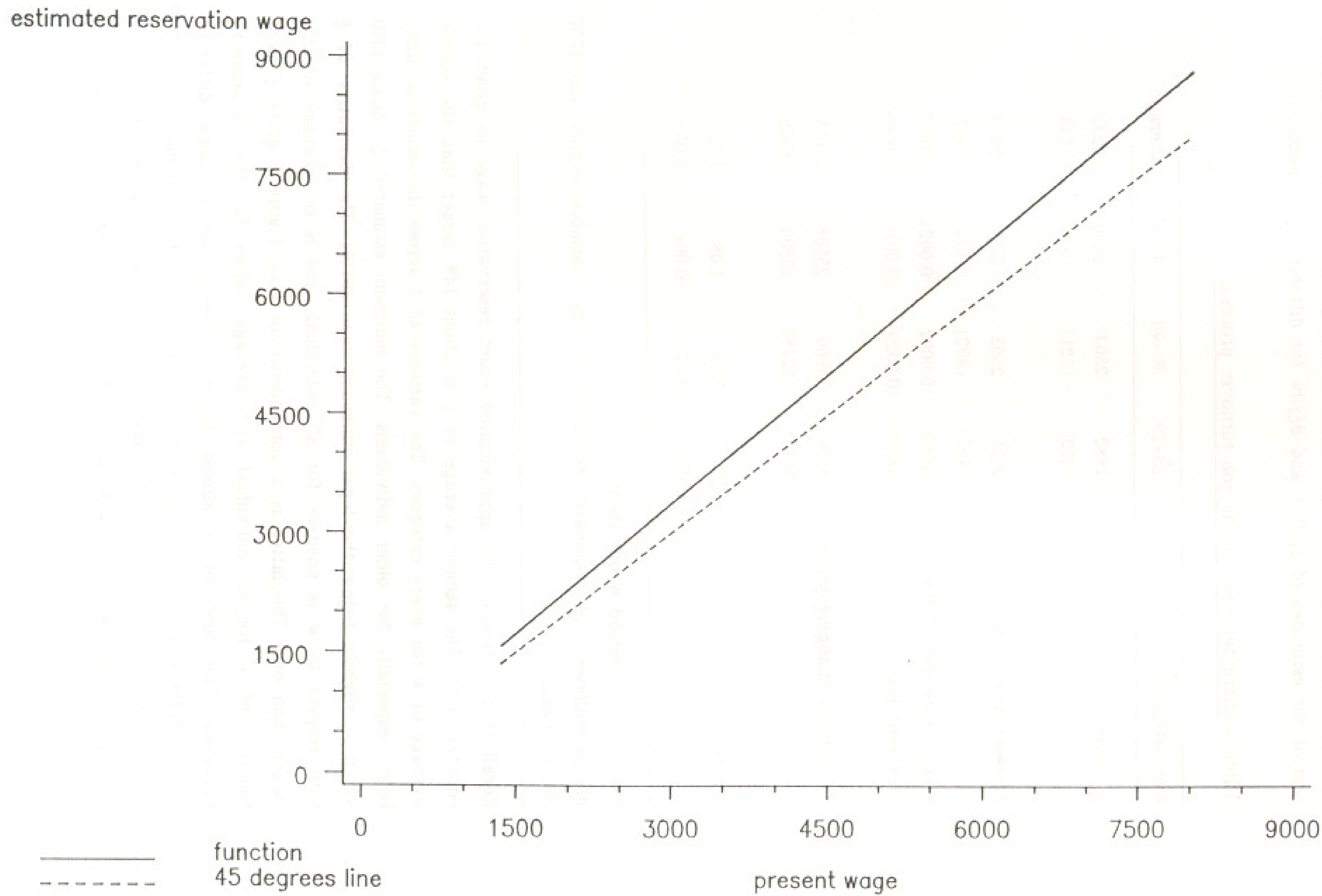
only a small part of ϵ.

Table 2 presents the parameter estimates for the exit rate out of the job θ. Note that explanatory variables entering θ represent determinants of λ, F and c. The present wage w has a negative influence on the exit rate. This confirms the prediction of the basic theory of on-the-job-search, though our extended on-the-job search model would not be incompatible with a nonnegative coefficient either. The common on-the-job search interpretation of the positive correlation of wages and tenure is that once a job with a high wage is obtained it is hard to find an even better job, so a high wage causes tenure. In our model a high wage also implies high job changing costs which makes individuals earning a high wage even more reluctant to change jobs.
Other factors that probably influence θ by way of c are factors related to housing and the non-wage characteristics of the present job. These variables all have the right sign in θ and are all significant except for the variable indicating whether housing problems are expected when one needs to move (which has the right sign but is insignificant). The occupational dummies probably reflect differences in λ and F across different segments of the labour market. Civil servants have a lower exit rate, which may indicate, for instance, that the arrival rate or the variation in wage offers is smaller for them. Higher educated individuals have a higher exit rate, which may indicate a higher arrival rate or higher variation is wage offers. Whether one is attached to the social life in the present social environment has a significant influence on job duration but not on job changing costs. As suggested in the previous paragraph, it may be that individuals who are more attached restrict the search for better jobs to their present geographical area only and do not experience high c by changing jobs within that area. Note that this argument cannot be deduced from our model. The number of working individuals in a household has a positive influence on θ (but no influence on c). The same effect for the exit rate out of unemployment was observed in van den Berg (1989). It may be a consequence of a positive relation between unobserved characteristics of the individual under consideration and characteristics of other household members, as far as these characteristics are relevant for employers. It may also reflect the fact that if the number of working household members is large then one has easier access to employers.

4.2. The characteristics of the search process.

Given the parameter estimates the main variables of the search process

estimated reservation wage as a function of present wage



can be estimated and the influence of changes of the explanatory variables on these main variables can be evaluated. Table 3 presents sample averages of w and of the estimates of ξ, θ, c and $\partial\xi/\partial w$ for different age categories.

Table 3 Characteristics of the job turnover process.

age category	23–29	30–40	41–65	average
w (wage)	1882	2304	2430	2231
	(412)	(721)	(843)	(733)
ξ (reservation wage)	2121	2595	2798	2534
	(487)	(802)	(914)	(817)
θ (exit rate out of the present job)	0.0161	0.0062	0.0025	0.0077
	(0.0071)	(0.0029)	(0.0010)	(0.0068)
c (costs of changing jobs)	8136	15866	25508	17015
	(3670)	(5248)	(5804)	(8502)
$\partial\xi/\partial w$	1.17	1.10	1.08	1.11
	(0.06)	(0.02)	(0.00)	(0.05)

the unit time period is one month
in parentheses: the standard deviation of the variable across all 1757 observations.

Recall that ξ denotes the approximated exact reservation wage as given in equation (11). The sample average of ξ is about 14% larger than the sample average of w for every category. The variance of ξ across the sample is fairly large, especially for older individuals. The minimum estimated ξ equals 1370 which is slightly below the legal minimum wage (1450). The derivative of ξ with respect to w is positive for all individuals and is on average slightly larger than one. The latter is a consequence of $\alpha>0$. Figure 2 gives ξ as a function of w for an individual with average values for the explanatory variables. The function is almost linear. However, by choosing different values of the explanatory variables the location of the function may change.

Generally, older individuals have both a higher wage and higher transaction costs (which is partly due to the higher wage). Note that on average an individual aged 50 faces job changing costs that are about three times as large as the job changing costs for someone aged 25. As a result, older individuals are more selective in their search for a better job and have much smaller exit rates.

The results so far enable us to investigate a number of questions related to the effectiveness of policies aimed at an increase of job mobility. In particular we are able to examine the effects of changes in the level of job changing costs and changes in the job offer arrival rate by calculating

Table 4 Elasticities.

elasticity		
(i) of the reservation wage ξ		
$\frac{\partial \log \xi}{\partial \log w}$	(with respect to the wage)	0.98 (0.06)
$\frac{\partial \log \xi}{\partial \log \lambda}$	(with respect to the job offer arrival rate)	0.04 (0.03)
$\frac{\partial \log \xi}{\partial \log c(w)}$	(with respect to the level of job changing costs)	0.12 (0.03)
(ii) of the transition rate from one job to other jobs θ		
$\frac{\partial \log \theta}{\partial \log w}$		-0.41 (0.00)
$\frac{\partial \log \theta}{\partial \log \lambda}$		0.98 (0.01)
$\frac{\partial \log \theta}{\partial \log c(w)}$		-0.05 0.01

in parentheses: the standard deviation of the elasticity across all 1757 observations.

several elasticities. Table 4 presents sample averages of the elasticities of the reservation wage and the transition rate to other jobs with respect to the present wage, the job offer arrival rate and the level of job changing costs.

Because the values of the elasticities do not differ substantially across different age categories we only present averages over the whole sample. The elasticities with respect to w can be calculated directly from the estimated model. It is impossible to calculate the elasticities with respect to λ and $c(w)$ using the empirical model specification only because the equation for θ (equation (13)) does not show how it depends on $c(w)$ and λ. Moreover, λ itself is unidentified. However, by assuming that (13) represents the theoretical equation (6) we can derive the elasticities, as is shown in the appendix. Unfortunately the method cannot be used to derive elasticities with respect to parameters of F. The elasticities with respect to $c(w)$ are derived conditional on the present wage and on α, so it is assumed that w and α do not change if $c(w)$ changes. For individuals who had $c(w)<0$ the elasticities with respect to $c(w)$ were calculated by defining $d\log c(w) = dc(w)/|c(w)|$.

The elasticity of θ with respect to $c(w)$ is very small. This can be explained as follows. First, because for a wide range of w the elasticities of θ and ξ with respect to w are about -0.4 and 1 respectively, it follows that for a wide range of ξ the elasticity of θ with respect to ξ is also about -0.4. This means that F has a very long tail and small changes in ξ do not affect θ very much. Secondly, note that if $c(w)$ were zero then $\xi(w)$ would equal w, so changing $c(w)$ can only affect the gap between $\xi(w)$ and w. In our sample this gap is on average about 12% of $\xi(w)$. Consequently, an increase of $c(w)$ will not make the individual much more selective. Because $c(w)$ influences θ by way of ξ these two arguments imply that θ is insensitive with respect to small changes in $c(w)$. The effect of λ on θ is both direct and indirect (via ξ). The direct effect by definition has elasticity one and clearly dominates the indirect effect, which can only influence ξ by affecting the gap between $\xi(w)$ and w.

In the absence of comparable studies it is hard to say whether these results are common or not. However, it should be noted that the data used to estimate the model are from a period in which there was a very slack labour market (see van den Berg (1989)), so it may well be that the elasticities have different values in other circumstances. In particular, if λ is larger, then more job-to-job transitions are possible in the future, which implies that ξ is larger and that ξ and θ are more sensitive with respect to changes in $c(w)$. Also, one can show that if ρ or $c(w)$ are larger than ξ and θ are more sensitive with respect to changes in $c(w)$. However, though the sample contains individuals with estimated $c(w)$ as large as 50000, the estimated absolute value of the elasticity of θ with respect to $c(w)$ never exceeds to 0.10.

From the results of table 4 one may conclude that if one is interested in an increase of job mobility then an increase of λ is more effective than a decrease of c. It is hard to say which explanatory variables influence duration mainly through λ and which exert their influence through c. From the reduced form estimation results for θ one can examine the effect of changing an explanatory variable on the expected duration. For instance, from table 2 it follows that if the number of fringe benefits categories decreases by one then the expected duration of the job (which is one over θ) decreases by 11%. Also, if someone changes from being a civil servant to not being a civil servant then the expected duration of the job decreases by 30%.

5. THE MODEL SPECIFICATION REVISITED.

In this section it is examined whether the estimation results satisfy non-imposed properties of the theoretical model and whether the results are sensitive with respect to changes in some of the assumptions made.

In subsection 3.3. it was shown that $\alpha<1/\theta$ is necessary in order to have a sensible empirical model specification. As $\alpha=6.37$ while the smallest estimate of $1/\theta$ in the dataset equals 21 it follows that this condition is satisfied for all individuals in the dataset. Also, the theory predicts that β and $\xi'(w)$ have the same sign. From the results, β is positive (0.41) and the smallest estimate of $\xi'(w)$ in the dataset equals 1.07 so the prediction is validated. Another prediction from the theory is that if $\alpha>-1/\rho$ and $\xi'(w)>0$ (which both hold according to the results) then the signs of parameters associated with explanatory variables x that only influence $c(0)$ are opposite in θ and c. It is hard to say which x influence c only but of all 13 explanatory variables in $c(0)$ 9 satisfy this restriction while the others (typically variables that represent household circumstances) are not significant in c. Thus, the reservation wage assumption is not invalidated and there are no inconsistencies in the results.

As said before, the rate of discount ρ is fixed at 15%. This is done basically because the data are not able to distinguish between ρ and the constant term in $c(0)$. In order to examine the robustness of the results with respect to the value of ρ the model is re-estimated with different ρ, specifically with ρ=10% and ρ=25% a year. Note that the estimation results of θ do not depend on ρ at all. The estimates for c do change although sign and significance generally remain preserved. The resulting sample average of c equals 12012 if ρ=25% and 21989 for ρ=10% (it is 17015 if ρ=15%). The value of c for older individuals in particular is very sensitive to alternative values of ρ. However, for all categories the values of the resulting characteristics ξ and $d\xi/dw$ and the various elasticities are almost completely insensitive to ρ. Also, the estimate of σ does not change when varying ρ. Consequently, the main results are unaffected by the value of ρ.

One may argue that gender should be included as a separate regressor in c and θ besides the other regressors indicating personal characteristics. However, not surprisingly, a "gender" dummy variable is highly correlated with the "married"-dummy variable and with the variable related to the number of working individuals in the household. Inclusion of a "gender" dummy variable in c and θ does not have notable consequences for the main results. The variable itself is insignificant in θ but the transaction costs are significantly higher (2669 guilders, t=2.5) for men than for women. The latter can be explained if the other variables that indicate personal characteristics are misspecified, or if females restrict attention to jobs in the present neighbourhood more than men do. Note that θ for females is over-estimated if for this category the transition rate into nonparticipation is not negligible.

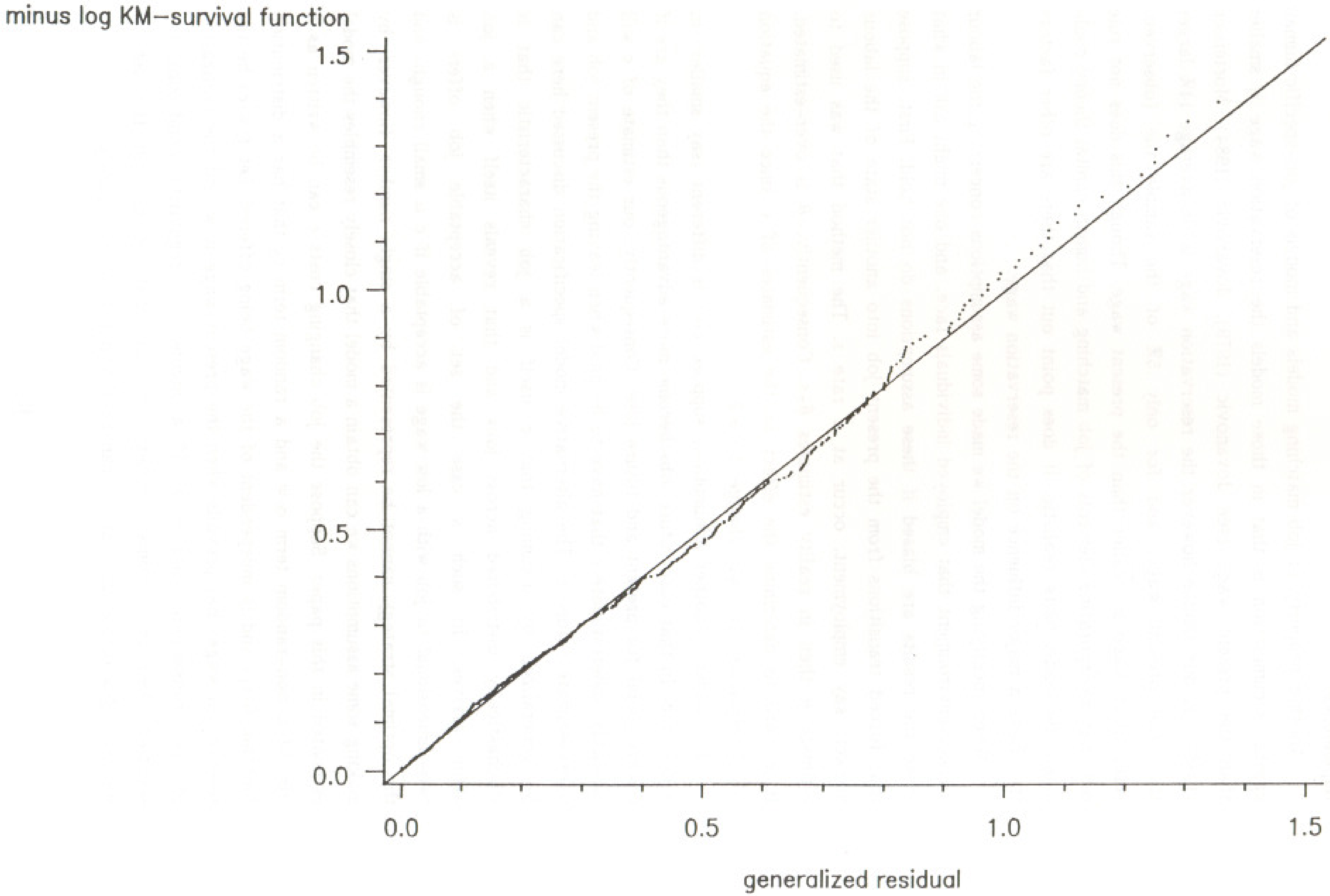
From the discussion of the elasticity estimates it is clear that the elasticity of θ with respect to ξ is an important determinant of those estimates. The elasticity of θ with respect to ξ is determined from the specifications of θ and ξ as functions of w. These in turn are of course completely determined by equations (11), (12) and (13). In order to examine whether the elasticity estimates are sensitive with respect to the (restrictive) specifications of θ and c as functions of w the model is re-estimated using more flexible functional forms for $\theta(w)$ and $c(w)$. Specifically, the variables $(\log(w))^2$ and w^2 are included as additional regressors in x_2 and x_1, respectively (see equations (13) and (12)). Adding w^2 in $c(w)$ has almost no effect on the estimation results, whether $(\log(w))^2$ is included in $\theta(w)$ or not. In both cases $c(w)$ is virtually linear on the wage interval of interest. If $(\log(w))^2$ is included in $\theta(w)$ then the estimates of the coefficients in $\theta(w)$ associated with (logw) and $(\log(w))^2$ are -17.79 (t=3.0) and -1.112 (t=3.0), respectively. This means that $\theta(w)$ attains a minimum at w=2970, so for individuals who have w>2970 (12% of the sample) $\theta(w)$ is increasing in w. However, if attention is restricted to the subsample for which w>2970, then it appears that $\theta(w)$ is not increasing on w>2970. The fact that the $(\log(w))^2$ term in $\theta(w)$ is significantly negative may therefore be due to the non-linearity of $\log\theta(w)$ in $\log(w)$ for small w. The estimates and standard errors of the other parameters in $\theta(w)$ and $c(w)$ and the main characteristics of the search process are almost identical to those in tables 1, 2 and 3. Because of the inclusion of the $(\log(w))^2$ term in $\theta(w)$, the sample average of the elasticity of θ with respect to w changes from -0.41 to -0.73. Since the elasticity of ξ with respect to w does not change much, this implies that on average θ is now more sensitive with respect to ξ. As a result, the average elasticities of θ with respect to c and λ are now -0.10 and 0.96, respectively. However, for individuals who have $w>2970$, $\theta'(w)>0$ and therefore the estimates of the elasticities of θ with respect to ξ and c are positive, which is of course in conflict with the theory. If, following the argument above, this result is regarded as a consequence of the rigidity of the quadratic specification of $\log\theta(w)$ as a function of logw, then this means that the sample averages of the elasticities of θ with respect to c and λ are over-estimated (that is, they are <-0.10 and <0.96, respectively). The standard errors over the sample of these elasticities equal 0.10 and 0.04 respectively. For some individuals in the sample (most of which have low wages) the elasticity of θ with respect to c is as small as -0.40. The estimates of the elasticities of ξ with respect to c and λ are identical to those in table 4. In sum, the main conclusions from section 4 seem to be insensitive with respect to the specifications of θ and c as functions of w, although the ineffectiveness of a reduction of c as a tool in stimulating job mobility is less extreme if a more flexible specification is used.

When estimating the model, no account has been taken of unobserved heterogeneity in the sample. This may in particular be a problem for the estimation of θ, because in duration models the estimates are inconsistent if unobserved heterogeneity is present in reality even if the heterogeneity is orthogonal to the included explanatory variables. Therefore we tested the assumption of no heterogeneity in θ. Specifically, we re-estimated θ, assuming that there is an unobserved heterogeneity term v that acts multiplicatively on θ and is independent of t. First assume that v in the stock of employed at t=0 has a normal distribution that is independent of x (this is sensible only if $P(v<0)$ is very small) and has variance σ^2. Testing the assumption of no heterogeneity means testing $\sigma^2=0$. We find $\hat{\sigma}^2=0.16$ with t-value 1.0 so a Wald test does not reject $\sigma^2=0$ ($P(v<0)$ is smaller than 0.01). Alternatively, let v in the stock have a gamma distribution independent of x (this is equivalent to assuming that the entry rate into the present job factorizes in terms of v and x and that v in the population is gamma distributed) with variance σ^2. Then $\hat{\sigma}^2$

= 0.14 (t=1.4) and the estimated variance of v in the population equals 0.16 (t=0.9) so again the Wald test does not reject. Though these results may seem a little surprising, recall that the set of observed explanatory variables is rather unique in that it contains an indicator of non-material job satisfaction and other characteristics of the (working) environment. As Holmlund & Lang (1985) point out these variables are generally unobserved which may cause (spurious) negative duration dependence of θ.

According to various theories of labour market behaviour of employed individuals, notably human capital theory and job matching theory, some of the basic assumptions of on-the-job search theory do not hold. It is argued that wages are not (approximately) constant within jobs and that the exit rate out of a job is truly duration dependent (see e.g. Mortensen (1986), Lancaster, Imbens & Dolton (1987), Mortensen (1988)). Though the former conjecture cannot be investigated given the data used, the latter one can. We examine the assumptions that θ is constant in a non-parametric way, in order to avoid the risk of not detecting certain (non-monotonic) alternatives. If θ is constant, then $z=t.\theta$ has an exponential distribution with parameter 1, so minus the log empirical survival function of the so-called generalized residuals $t.\hat{\theta}$ should approximately be a 45° line, $\hat{\theta}$ being the estimate of θ that was obtained before. If θ is not constant as a function of job duration then this result does not hold. Ridder (1987) examines for specific departures how the plot for the minus log empirical survival function of $t.\hat{\theta}$ is affected. In fact this method can also be used to detect unobserved heterogeneity. Though Ridder (1987)'s results apply to complete durations they can also be used for elapsed durations from a stock sample because of the intimate links between the distributions of these durations (see e.g. Ridder (1984), these links hold conditional on the constant-entry rate assumption). Figure 3 gives the minus log of the Kaplan-Meier estimator of the survival function of the generalized residuals. Note that every point corresponds to an uncensored observation of the job duration. For 78% of all 600 points the generalized residual is smaller than 0.5. The plot shows that the minus log survival function closely resembles the 45° line. Apparently job durations can be described fairly accurately by an exponential distribution that depends on the explanatory variables we used. Note however that departures from exponentially may be obscured because we use estimates of θ from a fitted parameterized model. For instance, if there is duration dependence due to job-specific human capital accumulation, then w is an increasing function of duration and the estimate of

residual plot for job durations



the coefficient in θ associated with w will pick out some of the duration dependence.

Another property of job matching models and models of job-specific human capital accumulation is that in those models the reservation wage is smaller than the present wage (see Jovanovic (1979), Jovanovic (1984), Mortensen (1988)). In our sample however the reservation wage is on average 14% larger than the present wage, and for only 5% of the sample the (observed) reservation wage is smaller than the present wage. Though this does not rule out that incorporating elements of job matching and human capital theory could make the model more realistic, it does point out that there are other factors that have a major influence on the reservation wage.

When specifying the model we made some assumptions concerning the labour market environment that employed individuals face, and one might ask in what sense the results are biased if these assumptions do not hold. First, suppose that forced transitions from the present job into another state of the labour market, say employment, occur at a rate s. The method that was used to estimate θ then in reality estimates θ+s. Consequently, θ is over-estimated. It is hard to determine the effect on the estimates of c since the equation for ξ (equation (11)) will change if $s \neq 0$.

To examine another assumption, suppose c(0) is different (say smaller) in a next job. In that case future jobs become more advantageous than they are if c were equal for present and future jobs. Consequently, our estimate of c will probably underestimate c that have to be paid when leaving the present job and over-estimate future c. The alternative model specification discussed here can be generalized by assuming that c itself is a job characteristic that is stochastically distributed across jobs and that reveals itself when a job offer arrives. In such a case the set of acceptable job offers is two-dimensional (a job with a low wage is acceptable if c is small enough) and the optimal strategy cannot be represented by a single number. However, by making some assumptions we can obtain a model that closely resembles the model estimated in this paper. Suppose the job changing costs c can be written as a sum of a non-random term α.w and a random term c_0 that has a distribution function $G(c_0)$ and is independent of the wage being offered. Let $\xi(w|c)$ be the reservation wage that prevails when the present wage is w and the realization of the transaction costs is c. If a number of regularity conditions are satisfied then the optimal strategy can be characterized by the set of functions $\xi(w|c)$ for all c and it can be shown that approximately

(14) $\xi(w|c)=w + \frac{\rho+\theta(w)}{1-\alpha\theta(w)} \cdot c$

with

(15) $\theta(w)=\lambda \int_{-\infty}^{\infty} \int_{\xi(w|c_0+\alpha w)}^{\bar{w}} dF(x)dG(c_0)$

Of course $\theta(w)$ is again the exit rate out of the present job. Suppose that the observed reservation wage $\tilde{\xi}(w)$ is the expected value over c of $\xi(w|c)$ and suppose that $E(c) = x_1'\gamma_1$. Then taking expectations over c in equation (14) and adding a measurement error results in the equation for $\tilde{\xi}(w)$ in the model from section 3. If we adopt equation (13) as a reduced-form representation of equation (15) then the resulting model is equivalent to the model that is estimated in this paper. The only consequence of adopting the model with stochastic c is that one should read E(c) instead of c in tables 3 and 4. Of course the assumption that $\tilde{\xi}(w) = E_c(\xi(w|c))$ is strong and cannot be tested using the data at hand. Alternatively, one might argue that $\tilde{\xi}(w)$ is the minimum over all possible c of $\xi(w|c)$. In that case, if one assumes that the minimum of all possible c can be written as $x_1'\gamma_1$, then again a model can be derived that is equivalent to the model estimated in this paper.

Another objection to our model specification might be that the costs ofmoving to another job may depend on the wage in the next job instead of the wage in the present job. In such a case condition 4 has to be strengthened by substituting $\rho+\lambda$ for λ, in order to guarantee the reservation wage property. It can be proven that if ρ is small then the model is approximately equal to the model we specified before.

6. CONCLUSION.

In this paper we have analyzed the labour market behaviour of employed individuals by estimating a structural on-the-job search model. The model allows for nonzero and wage-dependent costs associated with moving to another job. It was shown that the optimal strategy of an employed individual has the reservation wage property if the costs of moving do not increase too fast as a function of the wage. The model is estimated using Dutch data from 1980–1985. including responses on reservation wages of employed individuals. The results indicate that housing accommodation circumstances. characteristics of the present job and age have a large influence on the willingness to move and on job durations. If one is interested in increasing job mobility then increasing the job offer arrival rate is more effective than decreasing job changing costs. The estimation results appear to be robust to varying certain assumptions.

There are some straightforward directions for further research. In particular, it may be more realistic to allow for wage rates that vary (stochastically) during the period that one has a job. It also seems interesting to extend the model by allowing jobs to have more than one stochastic characteristic. The presence of such characteristics may bias the estimates of the job changing costs in the model presented. Another topic for further research concerns the quality of the responses to the reservation wage question and the meaning of those responses if other stochastic job characteristics or stochastic job changing costs are present. Note that all the extensions will make the analysis of the optimal strategy and the resulting model equations much more complicated while any empirical analysis will need longitudinal data.

APPENDIX.

1. Proof of proposition 1.

It is straightforward but tedious to show that if conditions 1, 2 and 3a hold then the right-hand side of equation (2) is a mapping T(R) that maps the space of continuous functions on $[0,\bar{w}]$ into itself, and the integrals in (2) are well-defined. Let $C[0,\bar{w}]$ denote the space of continuous functions on $[0,\bar{w}]$. Choose the following norm:

$$\text{for every } X \in C[0,\bar{w}] \ \|X\| = \sup_{0 \le w \le \bar{w}} |X(w)|.$$

Then $C[0,\bar{w}]$ is a Banach space (see Dunford & Schwartz (1957)). We now show that T is a contraction mapping, i.e. that there is an $\alpha \in <0,1>$ such that for every $R, R^* \in C[0,\bar{w}]$ it holds that $\|T(R)-T(R^*)\| \le \alpha . \|R-R^*\|$. For this it is sufficient that Blackwell (1965)'s conditions hold: for every $R, R^* \in C[0,\bar{w}]$:

(i) T has to be monotone: if for every $0 \le w \le \bar{w}$ $R(w) \le R^*(w)$ then for every $0 \le w \le \bar{w}$ $T(R)(w) \le T(R^*)(w)$.

(ii) There has to be a $0 \le \beta < 1$ such that for every constant δ, $T(R+\delta) = T(R) + \beta . \delta$.

One sees immediately that (i) holds for our mapping T: if $R(x) \le R^*(x)$ and $R(w) \le R^*(w)$ then $\max(R(x)-c(w), R(w)) \le \max(R^*(x)-c(w), R^*(w))$ and $T(R)(w) \le T(R^*)(w)$. To prove (ii) for our T we write

$$T(R+\delta)(w) = \frac{1}{\rho+\lambda}\,(w+\lambda E_x(\max(R(x)+\delta-c(w),\ R(w)+\delta)))$$

$$= \frac{1}{\rho+\lambda}\,(w+\lambda E_x(\delta+\max(R(x)-c(w),\ R(w))))$$

$$= \frac{1}{\rho+\lambda}\,(w+\lambda\delta+\lambda E_x(\max(R(x)-c(w),\ R(w))))$$

$$= T(R)(w)+\frac{\lambda}{\rho+\lambda}\,.\delta.$$

Consequently, T is a contraction mapping. From Banach's fixed point theorem (Wouk (1979)) it follows that T which is defined on $C[0,\bar{w}]$ has a unique fixed point. So, from equation (2), R exists and is the unique continuous function on $[0,\bar{w}]$ that solves (2).

2. Proof of proposition 2.

We know that if conditions 1, 2 and 3a hold then there exists a unique solution R(w) of equation (2) which is continuous on $[0,\bar{w}]$. Now it has to be shown that this R(w) is strictly increasing if condition 4a holds.

Let $0 \leq w < w^* \leq w$. From equation (2) it follows that

$$\text{(A1)} \qquad \rho(R(w^*)-R(w)) = w^*-w$$

$$+ \lambda E_x(\max(R(x)-c(w^*)-R(w^*),\ 0) - \max(R(x)-c(w)-R(w),\ 0))$$

Suppose $c(w^*) \leq c(w)$. If $R(w^*) \leq R(w)$ then the right-hand side (r.h.s.) of (A1) is positive. By contradiction it follows that $R(w^*)>R(w)$. Now suppose $c(w^*)>c(w)$. Equation (A1) can be rewritten as follows,

$$\text{(A2)} \qquad \rho(R(w^*)-R(w)) = w^*-w-\lambda c(w^*)+\lambda c(w)$$

$$+ \lambda E_x(\max(R(x)-R(w^*),\ c(w^*)) - \max(R(x)-R(w),\ c(w)))$$

The first part of the r.h.s. of (A2) is positive due to condition 4a. Consequently, if $R(w^*) \leq R(w)$ then the r.h.s. of (A2) is positive. Again, by contradiction it follows that $R(w^*)>R(w)$. As a result, for every $0 \leq w < w^* \leq \bar{w}$ $R(w^*)>R(w)$.

3. Proof of proposition 3.

First it is shown that if conditions 1, 2, 3b and 4a hold then R(w) has the property that there is a k>0 such that

$$\text{(A3)} \qquad \forall\ 0 \leq w < w^* \leq \bar{w} \qquad R(w^*) \leq R(w)+k.(w^*-w)$$

The function c(w) is continuously differentiable on the closed, bounded interval $[0,\bar{w}]$; therefore there exists an m>0 such that for every $w \in [0,\bar{w}]$ $c'(w) \geq -m$ (Limits in 0 and $\bar{w}$ denote right- and left-hand limits, respectively.) This implies that there is a m>0 such that

$$\text{(A4)} \qquad \forall\ 0 \leq w < w^* \leq \bar{w} c(w^*) \geq c(w)-m(w^*-w)$$

Take without loss of generality $m>\frac{1}{\rho}$. Now it has to be shown that the assertion at the beginning of this proof is true. Suppose it is not true. Then for k=m equation (A3) does not hold, that is, there are w and w^* $(0 \leq w < w^* \leq \bar{w})$ such that $R(w^*) > R(w) + m.(w^* - w)$. Combining this with equation (A4) shows that $R(w^*) + c(w^*) > R(w) + c(w)$. From equation (A1) then, $\rho[R(w^*) - R(w)] \leq w^* - w$. By contradiction it follows that the assertion above is true.

We now proceed to show that R is differentiable. Equation (2) can be rewritten by using the reservation wage property of the optimal strategy.

$$R(w) = \frac{w}{\rho} + \frac{\lambda}{\rho} \cdot \int_{\xi(w)}^{\bar{w}} R(x) - c(w) - R(w) dF(x)$$

so

$$\frac{R(w+h)-R(w)}{h} = \frac{1}{\rho} + \frac{\lambda}{\rho h} \int_{\xi(w)}^{\bar{w}} R(w) + c(w) - R(w+h) - c(w+h) dF(x)$$

$$- \frac{\lambda}{\rho h} \cdot \int_{\xi(w)}^{\xi(w+h)} R(x) - c(w+h) - R(w+h) dF(x).$$

Therefore,

$$\text{(A5)} \qquad \frac{R(w+h)-R(w)}{h} \left\{1 + \frac{\lambda}{\rho} \cdot \bar{F}(\xi(w))\right\} - \frac{1}{\rho} + \frac{\lambda}{\rho} \bar{F}(\xi(w)) \cdot \frac{c(w+h)-c(w)}{h}$$

$$= - \frac{\lambda}{\rho h} \cdot \int_{\xi(w)}^{\xi(w+h)} R(x) - c(w+h) - R(w+h) dF(x)$$

Consider the right-hand side of (A5). Assume h>0. If $\xi(w+h) \geq \xi(w)$ then $R(x) \leq c(w+h) + R(w+h)$ which implies that the right-hand side is non-negative. If $\xi(w+h) \leq \xi(w)$ then $R(x) \geq c(w+h) + R(w+h)$ and again the right-hand side is non-negative, so the right-hand side is always non-negative. Further, if $\xi(w+h) \geq \xi(w)$ then $R(x) \geq c(w) + R(w)$ while if $\xi(w+h) \leq \xi(w)$ then $R(x) \leq c(w) + R(w)$. Therefore in both cases the right-hand side is smaller than or equal to

$$\frac{\lambda}{\rho h} \cdot \int_{\xi(w)}^{\xi(w+h)} R(w+h) + c(w+h) - R(w) - c(w) dF(x)$$

$$\text{(A6)} \qquad = \frac{\lambda}{\rho} \cdot (\bar{F}(\xi(w)) - \bar{F}(\xi(w+h))) \cdot \left\{\frac{R(w+h)-R(w)}{h} + \frac{c(w+h)-c(w)}{h}\right\}.$$

Suppose $\xi(w) \le \xi(w+h)$. Because of equation (A3) and condition 4a, (A6) is smaller than or equal to

$$\text{(A7)} \qquad \frac{\lambda}{\rho}.(\overline{F}(\xi(w))-\overline{F}(w+h))).(k+\frac{1}{\lambda})$$

If, on the other hand, $\xi(w)>\xi(w+h)$ then, because of equation (A4) and because $R(w+h)$ exceeds $R(w)$, (A6) is smaller than or equal to

$$\text{(A8)} \qquad \frac{\lambda}{\rho}(\overline{F}(\xi(w+h))-\overline{F}(\xi(w)).m$$

So the left-hand side of equation (A5) is non-negative and smaller than or equal to the maximum of (A7) and (A8). If we take lim $h\downarrow 0$ of (A7) and (A8) then the result is zero because of the continuity of F and ξ in $\xi(w+h)$ and $w+h$ respectively. Therefore lim $h\downarrow 0$ of the left-hand side of equation (A5) equals zero. The same holds for lim $h\uparrow 0$. As a result,

$$\text{(A9)} \qquad \lim_{h\to 0}\left[\frac{R(w+h)-R(w)}{h}\,(1+\frac{\lambda}{\rho}\,\overline{F}(\xi(w)))-\frac{1}{\rho}+\frac{\lambda}{\rho}\,\overline{F}(\xi(w)).\frac{c(w+h)-c(w)}{h}\right]=0$$

Because c is differentiable it follows from (A9) that R is differentiable: $R'(w)$ can be obtained by taking the limit. The functions c', ξ and $\overline{F}$ are continuous in their arguments so from the expression for $R'(w)$ (see equation (4)) if follows that $R'(w)$ is continuous on $[0,\overline{w}]$.

4. Proof of proposition 4.

If condition 4b is satisfied then $c'(w).\lambda<1$ and therefore also $c'(w).\lambda\overline{F}(\xi(w))<1$. From equation (4) it then follows that $R'(w)>0$ on $[0,\overline{w}]$.

If $0<\xi(w)<\overline{w}$ then equation (3) holds. Let h be small in the sense that also $0<\xi(w+h)<\overline{w}$. Then

$$\text{(A10)} \qquad \frac{R(\xi(w+h))-R(\xi(w))}{\xi(w+h)-\xi(w)}.\frac{\xi(w+h)-\xi(w)}{h}=\frac{R(w+h)-R(w)}{h}+\frac{c(w+h)-c(w)}{h}$$

Because R and c are differentiable the lim $h\to 0$ of the right-hand side of equation (A10) equals $R'(w)+c(w)$. According to the mean value theorem there exists a $x(w,h)$ lying between $\xi(w)$ and $\xi(w+h)$ such that the first part of the left hand-side of equation (A10) equals $R'(x(w,h))$. Consider the lim $h\to 0$ of

$R'(x(w,h))$. Because $x(w,h)$ lies between $\xi(w)$ and $\xi(w+h)$ and because $\xi(w)$ and $\xi(w+h)$ lie between 0 and $\bar{w}$ it follows that R' is continuous in a neighbourhood of $x(w,h)$. The function ξ is continuous so the lim $h \to 0$ of $\xi(w+h)$ equals $\xi(w)$. This implies that the lim $h \to 0$ of $x(w,h)$ also equals $\xi(w)$. As a result, the lim $h \to 0$ of $R'(x(w,h))$ equals $R'(\xi(w))$ which is positive. Consequently, we can deduce from (A10) that ξ is differentiable in its argument w if $0<\xi(w)<\bar{w}$ and that

$$\text{(A11)} \qquad \xi'(w) = \frac{R'(w)+c'(w)}{R'(\xi(w))}$$

Substitution of equation (4) into equation (A11) gives equation (5). From the continuity of R', ξ and c' their arguments it follows from equation (A11) that $\xi'(w)$ is continuous if $0<\xi(w)<\bar{w}$.

5. Proof of proposition 5.

The function $c(w)$ is written as $c(w)=\eta+q$, in which q may depend on w but not on η. The reservation wage ξ is expanded as a function of η around $\eta=-q$. Note that η does not depend on w so changing the value of η does not affect w. We use notation $R(w,\eta)$ and $\xi(w,\eta)$ in order to make explicit which value of η holds. It is tedious to show that if η lies in a convex, bounded, closed set (which we take for granted), then R and ξ are continuous both in w and η.

If $\eta=-q$ then $c(w)=0$ and $\xi(w,-q)$ equals w (from the definition of $\xi(w)$). The next thing to do is to calculate $\partial\xi/\partial\eta$ if it exists at $\eta=-q$. We want to compare ξ if $\eta=-q+h$ with ξ if $\eta=-q$. Now for every $w \in \langle 0,\bar{w} \rangle$ one can take h small enough in order to have $0<\xi(w,-q+h)<\bar{w}$. In that case equation (3) is valid.

$$R(\xi(w,-q+h),\ -q+h) = R(w,-q+h)+h$$

Therefore,

$$\text{(A12)} \qquad \frac{R(\xi(w,-q+h),\ -q+h)-R(w,-q+h)}{\xi(w,-q+h)-w} \cdot \frac{\xi(w,-q+h)-w}{h} = 1$$

According to the mean value theorem there exists a $x(w,-q+h)$ between w and $\xi(w,-q+h)$ such that the first part of the left-hand side of (A12) equals $R'(x(w,-q+h),\ -q+h)$ (in which R' denotes the derivative with respect to the first argument) which is positive. From equation (4), this derivative equals

(A13) $$\frac{1-c'(x(w,-q+h)).\lambda\bar{F}(\xi(w,-q+h),\ -q+h))}{\rho+\lambda\bar{F}(\xi(x(w,-q+h),\ -q+h))}$$

Because of the continuity of ξ in η,

$$\lim_{h\to 0}\xi(w,-q+h) = w$$

and therefore

$$\lim_{h\to 0} x(w,-q+h) = w$$

and $\lim_{h\to 0}\xi(x(w,-q+h),\ -q+h) = w$

The lim $h\to 0$ of expression (A13) can now be derived using the continuity of c'and $\bar{F}$. The result is

$$\frac{1-c'(w)\lambda\bar{F}(w)}{\rho+\lambda\bar{F}(w)}$$

From equation (A12), therefore,

(A14) $$\lim_{h\to 0}\frac{\xi(w,-q+h)-w}{h} = \frac{\rho+\lambda\bar{F}(w)}{1-c'(w)\lambda\bar{F}(w)}$$

The left-hand side of (A14) is of course $\partial\xi/\partial\eta$ at $\eta=-q$. Note that the denominator of the right-hand side is positive. We now have two terms of the expansion. The remainder is $o(\eta+q)$. Consequently, for arbitrary w,

$$\xi(w,\eta) = w + \frac{\rho+\lambda\bar{F}(w)}{1-c'(w)\lambda\bar{F}(w)}.(\eta+q)+o(\eta+q)$$

which can be rewritten by substituting c(w) for $\eta+q$ and suppressing the dependence of ξ on η,

(A15) $$\xi(w)=w + \frac{\rho+\lambda\bar{F}(w)}{1-c'(w)\lambda\bar{F}(w)}.c(w)+o(c(w)).$$

For reasons that will be explained in section 3 it is preferable to have

$\lambda\overline{F}(\xi(w))$ instead of $\lambda\overline{F}(w)$ in the second term on the right-hand side of (A15). However, the difference between the second term on the right-hand side of (A15) and the second term on the right-hand side of (7) is $o(c(w))$ so equation (7) follows.

6. The approximation error in a special model.

In order to be able to derive explicit results, we have to assume that c does not depend on w. Using equations (2) and (3) one can show that if $c>0$ then the exact $\xi(\overline{w}-\rho c)$ equals $\overline{w}$. Also, from equation (7) it follows that the approximate $\xi(\overline{w}-\rho c)$ equals $\overline{w}$. Consequently, for $w=\overline{w}-\rho c$ the approximation error is zero. Since in general the error is nonzero, this result may suggest that the error (in absolute value) is decreasing in w.

To obtain more results we assume that, in addition to $c'(w)=0$ for all w,

$$F(x) = \frac{e^{\beta(x-w_0)}-1}{e^{\beta(x-w_0)}+\gamma} \qquad x \geq w_0$$

with $\gamma>-1$, $w_0 \geq 0$ and $\beta>0$, while $F(x)=0$ for $x<w_0$. This wage offer distribution is in conflict with condition 2 from the main text in the sense that here w_0 may be positive and $\overline{w}=\infty$. However, as noted before, choosing zero to be the lower bound of the wage offers is just a matter of convenience and may be relaxed without loss. Also, we may truncate F at some $\overline{w}>w_0$, but it seems reasonable to suspect that for sufficiently large $\overline{w}$ this will not influence the results. The median of F(x) equals $w_0+\frac{1}{\beta}.\log(\gamma+2)$ and for $\gamma \leq 1$ the wage offer density increases on $[w_0,\infty>$. For $\gamma=0$ F(x) reduces to an exponential distribution while for $\gamma<0$ the density decreases at a somewhat faster rate than an exponential density.

We also assume the following relationship between c, ρ, λ, γ and β:

$$\gamma>-\frac{\lambda}{\rho+\lambda}$$

$$c=\frac{1}{\rho\beta}.\log\frac{\lambda(\gamma+1)}{\lambda(\gamma+1)+\rho\gamma}$$

These are obviously very strong relationships and it is clear that this model cannot be used for empirical analyses. Not that the relationships imply that c and γ have opposite sign.

In this model there holds that for individuals earning sufficiently high w the probability of obtaining an acceptable offer is negligible. Consequently, the boundary condition of the differential equation (5) is

$$\text{(A16)} \qquad \lim_{w \to \infty} \xi(w) - w - \rho c = 0$$

Suppose w is such that $w_0 < \xi(w) < \infty$. One can show that the exact reservation wage and exit rate out of the present job satisfy

$$\text{(A17)} \qquad \xi(w) = w + \rho c + \frac{1}{\beta} \cdot \log(1 - \gamma e^{\beta(w_0 - w - \rho c)})$$

$$\theta(w) = [\lambda(\gamma+1) + \rho\gamma] e^{\beta(w_0 - w)}$$

By rewriting equation (7) it follows that in this model the approximate $\xi(w)$ is the solution of the following implicit equation.

$$\text{(A18)} \qquad \xi(w) = w + \rho c + c \cdot \frac{\lambda(\gamma+1)}{e^{\beta(\xi(w) - w_0)} + \gamma}$$

As an example the following parameter values were taken: $\rho=\lambda=0.15$, $\gamma=-0.1$, $w_0=20000$, $\beta=0.0001$ (time unit: 1 year, money unit: 1 Guilder). Then c=7852. E(x)=29482 and the 95th percentile of F(x) is 48959. For these a priori reasonable values and for w ranging from 20000 to 50000 the exact and approximate $\xi(w)$ were calculated from (A17) and (A18) respectively. The approximation error tends to zero for large values of w. (For instance, if w=50000 then the exact $\xi(w)$ equals 51222 while the approximate $\xi(w)$ equals 51225). This is not surprising since the approximate $\xi(w)$ also satisfies equation (A16). For every w the approximate $\xi(w)$ exceeds the exact $\xi(w)$ and the difference is decreasing in w. However, even for the smallest possible w (20000) the difference is only 82, which is less than 0.4% of the exact $\xi(w)$ (which equals 22029). For w equal to E(x) (29482) the difference is 25, which is less than 0.1% of the exact $\xi(w)$ (which is 30999). Concluding, for parameter values that seem to be reasonable and for a wide range of wage rates the approximation error is quite small.

7. Proof of relation between γ_1 and γ_2.

The theoretical model consists of equations (6), (11) and (12).

Further, equation (13) can be interpreted as a summary of $\theta(w)$ in the sense that for an explanatory variable y of c(w), $\gamma_{2y}.\theta$ which is the partial derivative of θ with respect to y, has to equal

$$\frac{\partial\theta(w)}{\partial c(0)} \cdot \frac{\partial c(0)}{\partial y} = \frac{\partial\theta(w)}{\partial c(0)} \cdot \gamma_{1y}$$

in which $\partial\theta(w)/\partial c(0)$ can be deduced from equations (6), (11) and (12). It follows that γ_{1y} and γ_{2y} have opposite signs if $\partial\theta(w)/\partial c(0)<0$. From equation (6) $\partial\theta(w)/\partial c(0)$ has the opposite sign of $\partial\xi(w)/\partial c(0)$. The latter can be written as

$$\frac{\partial\xi(w)}{\partial c(0)} = \frac{(\rho+\theta)(1-\alpha\theta)}{(1-\alpha\theta)^2+\lambda f(\xi).(1+\alpha\rho).c(w)}$$

with f=F'. From equation (6),

$$-\lambda f(\xi) = \frac{\theta'(w)}{\xi'(w)}$$

Consequently,

$$\frac{\partial\xi(w)}{\partial c(0)} = \frac{(\rho+\theta).\xi'(w)}{1+\alpha\rho}$$

and the result follows.

8. Derivation of elasticities.

The general procedure is as follows. From the theoretical specification (equations (6), (11) and (12)) that underlies the empirical specification ((11), (12) and (13)) we derive expressions for the derivatives of θ and ξ with respect to c(w) and λ. These expressions contain the unknown λ and F' but by using the equality of (6) and (13) and the equality of the derivatives of (6) and (13) with respect to w we can make some substitutions that result in calculable functions. Consider the elasticities with respect to c(w). From (6), (11) and (12),

$$\text{(A19)} \qquad \frac{\partial\theta}{\partial c(w)} = -\lambda f(\xi).\frac{\partial\xi}{\partial c(w)}$$

(A20) $$\frac{\partial\xi}{\partial c(w)} = \frac{1+\alpha\rho}{(1-\alpha\theta)^2}.c(w).\frac{\partial\theta}{\partial c(w)} + \frac{\rho+\theta}{1-\alpha\theta}$$

From (A19) and (A20),

(A21) $$\frac{\partial\theta}{\partial c(w)} = \frac{-\lambda f(\xi).(\rho+\theta)(1-\alpha\theta)}{(1-\alpha\theta)^2+\lambda f(\xi)(1+\alpha\rho).c(w)}.$$

By differentiating equations (6) and (13) with respect to w,

$$\lambda f(\xi) = \frac{\beta_1}{w}.\frac{\theta}{\xi'(w)}.$$

Now $\xi'(w)$ can be obtained simply by differentiating (11) after substitution of (12) and (13). As a result (A21) can be simplified to

$$\frac{\partial\theta}{\partial c(w)} = -\frac{(\rho+\theta)}{(1+\alpha\rho)}.\frac{\beta_1\theta}{w}.$$

Analogously one can derive e.g.

$$\frac{\partial\log\theta}{\partial\log\lambda} = 1-\frac{\beta_1.\theta.c(w)}{w(1-\alpha\theta)}$$

etc. The key identifying restriction is the equality between (6) and (13). In effect, the functional form of (13) implicitly ties up the hazard of the wage offer distribution on the relevant wage interval. This is not enough to identify F and λ but it is enough to identify elasticities with respect to λ and c(w).

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