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Labor force participation and the discouraged worker effect

Abstract:
This paper analyzes labor force participation with particular reference to the discouraged worker effect. Discouraged workers are those who do not search for work because they view their chances of finding a suitable job as too low. The theoretical point of departure is a search model where the worker evaluates the expected utility of searching for work and decides to participate in the labor market if the expected utility of the search exceeds the utility of not working. From this framework we derive an empirical model for the probability that the worker will be unemployed or employed as a function of the probability of getting an acceptable job, given that the worker searches for work. The model is estimated on a sample of married and cohabitating women in Norway covering the period from 1988 to 2008. The results show that the discouraged worker effect is substantial. On average, about one third of those who are out of the labor force are discouraged according to our analysis.

Keywords: Discouraged workers, Labor force participation, Random utility modeling

JEL classification: J21, J22, J64

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1. Introduction

In many countries it has been observed that the supply of labor seems to depend on business cycle fluctuations. That is, it is commonly believed that the labor supply is higher when the labor market is tight than when it is slack, where slackness is represented by the unemployment rate. One popular explanation of this phenomenon is that during a recession, workers become discouraged and give up searching for work. Economists view this as the result of workers believing that their chances of finding a job are so low that the implied monetary and psychological costs of searching yield a utility of searching that is lower than the utility of being out of the labor force (as perceived by the worker). An additional source of business cycle variation in labor supply may be variations in individual wage rates.

The observation that the labor supply seems to vary according to the business cycle has given rise to the "discouraged worker" concept. A discouraged worker is one who is not searching for work under the current business cycle conditions, but otherwise would have been searching if the chances of obtaining an acceptable job were sufficiently high. Although the discouraged worker concept has been around for a long time (Ehrenberg and Smith, 1988), there are surprisingly few studies based on microdata that address this issue within a structural framework.

The purpose of this paper is to analyze married or cohabiting women's decisions on labor force participation and employment in a way that explicitly accommodates the discouraged worker effect within a structural setting. In particular, we wish to establish behavioral relations that enable us to analyze the effect on labor supply behavior as a result of changes in the probability of obtaining a suitable job. Our point of departure is a simple search model that is used as a theoretical rationale to motivate the structure of the utility of looking for work. From this theoretical characterization, an empirical model is developed and represented by the probabilities of not participating in the labor force, working, and being unemployed, respectively. Our approach enables us to characterize these probabilities in terms of market wage rates, demographic factors, nonlabor income, and the probability that an acceptable job offer is available given that the woman searches for work.

Empirical micro studies that analyze the effect of unemployment on labor supply include Ham (1986), Blundell, Ham, and Meghir (1987, 1998), Connolly (1997), and Başlevent and Onaran (2003). Bloemen (2005) estimates an empirical job search model with endogenously determined search intensity. The paper that is closest in spirit to our work is Blundell, Ham, and Meghir (1998), henceforth BHM (1998). However, our analysis departs from BHM (1998) in several aspects. First, whereas they analyze labor force participation, employment, and hours of work, we analyze only employment and labor force participation. Thus, in one aspect, our modeling assumptions are weaker than in BHM (1998) because we do not specify an hours of work relation. Because we do not address the supply of hours of work relation, we are unable to distinguish between concepts such as the fixed cost of working and search costs. This is in contrast to BHM (1998), who address this issue. Second, we extend earlier search theoretic approaches by showing how one can conveniently allow for non-pecuniary job attributes in our formulation. This is an important extension. Remember that in the standard search theoretic formulation one cannot identify the arrival rate of job offers and the distribution of wages of the incoming job offers without additional strong functional form assumptions (Flinn and Heckman, 1982, pp. 121−125), unless one has data on actual job offers. In our context, where jobs are characterized by both wages and non-pecuniary attributes the value of arriving job offers is unobservable, and the researcher thus faces an additional challenge when specifying empirical structural relations. In our paper we show that our assumptions imply an interesting and useful explicit functional form characterization of the utility of being unemployed as a function of the search cost, the arrival rate of acceptable job offers, and the utility of being employed. This is the main theoretical contribution of our paper and it yields a characterization that is particularly useful for motivating the specification of the empirical model. Finally, we propose a particular version of Heckman's method of correcting for selectivity bias in the estimation of the wage equation that applies when participation in the labor force is modeled by a logit model (cf. Heckman, 1979).

Our approach also differs from the one employed by Bloemen (2005) in that we base our empirical model on simpler assumptions about the agent's knowledge and ability to account for future uncertain events (job arrivals and layoffs). However, in another sense our approach is more general in that it is consistent with a setting in which the agent accounts for non-pecuniary aspects of the jobs.

The empirical model is estimated on a sample of independent cross-sections of married and cohabiting women in Norway, for each quarter from the second quarter of 1988 to the fourth quarter of 2008.[1] The reason why we focus on married women is that this subgroup of persons is most responsive to market incentives. As regards the discouraged worker effect, we find that, on average, about one third of the married women outside the labor force are discouraged.

The paper is organized as follows. In the next section, the theoretical framework is developed and the general structure of the choice model is obtained. In Section 3, the discouraged worker effect is

[1] To simplify the verbal exposition, we refer to both these types of females as married in the rest of the paper.

defined formally within our structural setting and in Section 4 the empirical version of the model is specified. Section 5 contains a description of the data, and the estimation procedure and estimation results are discussed in Section 6. Section 7 reports elasticities and simulation results, including selected elasticities for different population groups as well as for all women in different periods.

2. The model

In this section, we build on a simple theoretical framework that subsequently will enable us to formulate an empirical model for individuals' labor supply behavior as a function of the probability of obtaining an acceptable job. Specifically, we shall apply search theory to obtain a characterization of the option value of being unemployed. Note that an agent who decides to search for work may have to stay unemployed for some time before an acceptable job offer arrives. This requires that the agent is able to evaluate the utility of the respective job offers and to judge whether or not they are acceptable.

Consider now what happens when an unemployed agent is searching for a job. The agent is viewed as being uncertain about her opportunities in the labor market and about the utility of arriving job offers. Jobs are characterized by (real) wages and non-pecuniary attributes. Job offers have utilities that are i.i.d., and job offers arrive according to a Bernoulli process at discrete time epochs. This means that at most one offer arrives at each time epoch. From the agent's point of view the randomness is due to future uncertain job-specific wages and non-pecuniary attributes. Examples of non-pecuniary aspects are; job-specific tasks to be performed, job-specific fixed hours of work, location of the job, and quality of the social and physical environment of the job. The notion of non-pecuniary attributes is similar to Lancaster's characteristic approach, see Lancaster (1971). The uncertainty about job attributes is assumed to be revealed upon inspection once a job offer has been received. Thus this setting is different from the typical job matching models such as those used by Jovanovic (1979) where it is assumed that there is an unknown match quality that is revealed gradually to the firm and to the worker after the job has been accepted. The job arrival rate and the distribution of the random component of the utility function are assumed known by the agent. At a given point in time, the agent behaves as if future job arrival rates and the distribution of the utilities of potential jobs do not change (stationary case). However, the agent may in each period revise her perception about the job arrival rate and the distribution of the random component of the utility of the job offers. In general, we view the assumption of stationary search environment as a more realistic assumption than a non-stationary setting since the agent hardly has much information about future changes in real wages and the distribution of job types. Thus, the best she can do is to make utility evaluations based on the assumption that the current situation will prevail for some time. However, in the typical situation where unemployment benefits have a limited duration, known by the agent, the stationarity assumption is clearly restrictive and unrealistic. Unfortunately, without the stationary assumption the model will be rather complicated and intractable for empirical analysis. Moreover, the agent is also assumed bounded rational in the sense that she ignores the possibility of changing job or being laid off in the future when evaluating the value of search. This, of course, does not mean that she will never consider changing job in the future. It simply means that she is unable to (or does not care) to account for the uncertainty with respect to future job loss when evaluating the current value of search. Also, for the same reason, we assume that when the agent is out of the labor force, she receives no job offers.

Let λ be the probability of a job offer arrival at a given time and let V denote value of search. Following Lippman and McCall (1976),[2] it follows readily that

$$V = (1-\lambda)V + \lambda \tilde{E} \max(V, U_2) - c, \tag{1}$$

where $\tilde{E}$ denotes the subjective expectation operator, U_2 is the utility of the arriving job offer and c is the search cost. Here, the search cost is to be interpreted as disutility of search and it is never fully observable. A major part of the disutility of search may consist of psychological factors such as search effort and persistence. Eq. (1) says that the present value of searching for work is evaluated as follows: When searching, two things can happen in a period. With (subjective) probability $1-\lambda$ no job offer arrives at the current epoch so that the expected utility in this case equals V times $1-\lambda$ Otherwise, a job offer arrives at the current epoch with probability λ, in which case expected utility equals $\lambda \tilde{E} \max(V, U_2)$. Finally, the cost of searching equals c. After rearranging (1) we obtain

$$V = \tilde{E} \max\left(V, U_2\right) - \frac{c}{\lambda}. \tag{2}$$

Eq. (2) is quite intuitive. When the optimal policy is determined by (2) one may interpret U_2 as the lump sum value of the job offer over the infinite horizon. The expected interval between two job arrivals is equal to $1/\lambda$. Consequently, c/λ is the expected search cost until a job arrives. Thus, V is equal to the expectation of the maximum of the utility of working and the utility of searching minus the expected cost of searching until a job arrives.

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[2] For a thorough survey of search models see Rogerson et al. (2005).

Although the relation in (2) is of theoretical interest it is not directly applicable for empirical analysis. For the sake of developing a tractable empirical model we shall in the following introduce further assumptions. Recall that the utility U_2 depends on the (real) wage rate and non-pecuniary attributes of the job. However, for the purpose of this section it is sufficient to assume the following representation

(3) $$U_2 = v_2 + \xi + \tau\omega,$$

where v_2 is the mean utility across agents, τ is a positive constant, ξ is a term that is supposed to capture the effect of unobservables (to the researcher) affecting the utility, and ω is a zero mean random term, with c.d.f. *F,* that is continuous, strictly increasing and has unit variance. However, ξ is perfectly certain to the individual agent. In contrast, the term ω is uncertain to the agent, and is thus perceived as a random variable to both the agent and the researcher.[3] Unfortunately, the researcher can not separate the two sources of randomness, ξ and $\tau\omega.$ Nevertheless, we need to use the representation (3) (or a similar one) to make our theoretical discussion precise and to facilitate the subsequent empirical specification in Section 4. The c.d.f. *F*, as well as τ, may be individual-specific, and we assume (with no loss of generality) that *F* has support with the upper bound equal to $\bar{\omega}.$

Let $H^*(u) = \tilde{E}\max(0, \omega - u).$ By straightforward integration by parts, it follows that

(4) $$\begin{aligned}&\tilde{E}\max\left(0,\omega-u\right)=\tilde{E}\max\left(0,\omega-u\right)=\int_u^{\bar{\omega}}(x-u)dF(x)\\&=-\Big|_u^{\bar{\omega}}(x-u)\left(1-F(x)\right)+\int_u^{\bar{\omega}}\left(1-F(x)\right)dx=\int_u^{\bar{\omega}}\left(1-F(x)\right)dx.\end{aligned}$$

Since *F* is strictly increasing it follows by differentiation that $H^*(u)$ is strictly decreasing and convex for $u < \bar{\omega}.$ Consequently, the inverse function *H* of H^* exists and $H(y)$ is strictly decreasing and convex. If we insert (3) into (2) and rearrange, we obtain

(5) $$\begin{aligned}&\frac{c}{\lambda}=\tilde{E}\max\left(0,U_2-V\right)=\tilde{E}\max\left(0,\tau\omega+v_2+\xi-V\right)\\&=\tau\tilde{E}\max\left(0,\omega-\left(V-v_2-\xi\right)/\tau\right)=\tau H^*\left(\frac{V-v_2-\xi}{\tau}\right).\end{aligned}$$

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[3] The reason why we introduce τ in the notation is that we later wish to study the effect of changing the variance of $\tau\omega_t$ while keeping the distribution of ω fixed.

Hence, it follows that one can express V as

(6) $$V = V\left(\frac{c}{\lambda}\right) = v_2 + \xi + \tau H\left(\frac{c}{\tau\lambda}\right).$$

Note that the function $H(y)$ neither depends on v_2 nor ξ. Moreover, one can easily show that $H(0) = \bar{\varpi}$.

It is of interest to consider the special case in which the agent is indifferent about job attributes, real wages are the same for all jobs and the only source of uncertainty is whether or not she will get a job offer. This case can be obtained by letting the degree of uncertainty, as represented by τ, decrease towards zero. Then (4) reduces to $\max\left(0, v_2 + \xi - V\right) = c/\lambda$, from which it follows that in the case without uncertainty about the value of the jobs, one obtains

(7) $$V\left(\frac{c}{\lambda}\right) = U_2 - \frac{c}{\lambda}.$$

In this case, where the agent's option value of being unemployed is given by Eq. (7), she will accept the first offer that arrives.

To clarify further the interpretation and intuition of the model we consider next the case when $\tau \to \infty$. Then Eq. (5) implies that V tends towards infinity. The intuition is that since the left hand side of Eq. (5), c/λ, is finite, then the distribution of $\tau\omega - (V - v_2 - \xi)$ must remain bounded when τ increases; this can only happen if V tends towards infinity. The interpretation is that when the job offer distribution F has unbounded support, then when τ increases, the chances of receiving a very valuable job offer increases, and therefore the value of searching will increase. Similarly, when $\tau > 0$ and the search cost c decreases towards zero, $\tau H\left(c/\tau\lambda\right)$ will increase to $\tau H(0) = \tau\bar{\varpi}$. The intuition is that when it costs very little to search, the agent will find it worthwhile to search for a "long time" before accepting a job offer.

The fact that the utility V depends on λ through the transformation H makes the interpretation of Eq. (6) less transparent. Recall also that in the standard search model where jobs are identified by job-specific wages, the distribution of wages and the job arrival rate cannot be identified with data on durations and accepted wages unless strong and typically unjustified functional form assumptions are imposed, cf. Flinn and Heckman (1982, pp. 121−125). Thus, empirical applications based on Eq. (6), or similar restrictions derived from search theory, are difficult and controversial because the functional form of *F,* or equivalently of the function *H,* are typically selected in an ad hoc way. It would therefore be desirable to express *V* in a way that does not depend on *H*. Surprisingly, this is in fact possible, although only in an approximate way. To this end, note first that one can express the probability that a job is acceptable as

(8) $$\tilde{P}\left(U_2 > V\right) = \tilde{P}\left(\tau\omega + v_2 + \xi > v_2 + \xi + \tau H\left(\frac{c}{\tau\lambda}\right)\right) = 1 - F\left(H\left(\frac{c}{\tau\lambda}\right)\right),$$

where $\tilde{P}$ indicates that the probability is conditional on the agent's information. Moreover, by implicit differentiation of $H^*(H(x)) = x$ it follows that

(9) $$H'\left(\frac{c}{\tau\lambda}\right) = \frac{1}{H^{*}{}'\left(H\left(c/(\tau\lambda)\right)\right)} = -\frac{1}{1 - F\left(H\left(c/(\tau\lambda)\right)\right)} = -\frac{1}{\tilde{P}\left(U_2 > V\right)}.$$

By first order Taylor expansion of the function *H*(*x*) around the point $c/\tau\lambda,$ we obtain that

(10) $$H(x) \cong H\left(\frac{c}{\tau\lambda}\right) + H'\left(\frac{c}{\tau\lambda}\right)\left(x - \frac{c}{\tau\lambda}\right).$$

This Taylor expansion is valid for positive *x*, but since $H(x)$ is continuous at *x* = 0, Eq. (10) will also hold for *x* = 0. Hence, for *x* = 0, Eq. (9) and Eq. (10) imply that we can rewrite Eq. (6) as

(11) $$V \cong v_2 + \xi + \tau\varpi - \frac{c}{q^*} = V(0) - \frac{c}{q^*},$$

where $q^* = \lambda\tilde{P}(U_{2t} > V)$ is the arrival intensity of the acceptable jobs (conditional on the agent's information). In the general case the convexity of *H* implies by well known results that

$$H\left(\frac{c}{\tau\lambda}\right) \le H(0) + H'\left(\frac{c}{\tau\lambda}\right),$$

which implies that the right hand side of Eq. (11) is an upper bound of *V*.

The relation obtained in Eq. (11) is the main theoretical result of this section. The intuition of the relation is as follows: First, since job offers arrive according to a Bernoulli process, with parameter λ, then also the acceptable job offers arrive according to a Bernoulli process. This is quite intuitive.[4] This implies that the expected length of time until the next acceptable job arrival equals $1/q^*$. Consequently, c/q^* is the expected search cost (or disutility) until an *acceptable* job offer arrives. Thus V is equal to the utility of search with no search costs (equal to the utility of being employed) minus the expected cost of searching until an acceptable job offer arrives. Eventual unemployment benefits enter this model through c.[5] To the best of our knowledge, Eq. (11) does not seem to have appeared previously in the literature.

In contrast to Eq. (6), Eq. (11) depends on the business cycle fluctuations through an observable term q^*, and in addition, V is *linear* as a function of $1/q^*$; that is, no nonlinear transformation is involved.

The structure of the utility of search given in Eq. (11) is intuitive because it corresponds to a reasonable assumption about search behavior of a bounded rational agent who is able to form expectations about search costs, the expected value of arriving jobs given information about the arrival rate of acceptable jobs and the distribution of the random component of the job-specific utilities. The role of the search theoretic development above is two-fold: First, it serves to demonstrate that a version of the search theoretic approach can be adapted and modified to obtain an empirical tractable version, in contrast to the standard approach that in our context will depend too heavily on unobservable terms. Second, the approximation in Eq. (11) is close if $c/\tau\lambda$ is small, but it may be crude if this is not the case, which means that the theoretical support for Eq. (11) may be weak if $c/\tau\lambda$ is not small. Nevertheless, since our decision rule in Eq. (11) appears quite plausible because it has such a clear and intuitive interpretation, we feel confident to base our empirical analysis on this relation.

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[4] For the sake of completeness a formal proof is given in Appendix B. In the same appendix we also prove that the expected time until the first acceptable offer is equal to $1/q^*$.

[5] The level of unemployment benefits depend on previous employment/unemployment spells and may therefore be endogenous. Consequently, it is not trivial to include benefits as an independent variable. In any case, in our data set we do not have separate information on benefits.

3. The discouraged worker effect

In this section we propose a formal definition of the discouraged worker effect. First, we need to define a "reference" regime with "low" unemployment. As reference regime, we choose a setting in which $\lambda = \infty$, which means that the worker receives job offers instantly upon search. This setting implies that there will be no unemployment. Although this evidently is an idealized setting, which will never occur in practice, we nevertheless believe that it serves as a natural reference case. Since $\lambda = \infty$ implies that $c/\lambda = 0$, with corresponding value of search equal to $V(0)$, we immediately obtain that a worker is discouraged when

(12) $$V(0) = v_2 + \xi + \tau\bar{\omega} > U_0 > V\left(\frac{c}{\lambda}\right) = v_2 + \xi + \tau H\left(\frac{c}{\lambda\tau}\right),$$

where U_0 is the worker's utility of being out of the labor force and $H(0)$ is equal to the upper bound $\bar{\omega}$ of the support of F. The term $V(0)$ can be interpreted as the highest possible level of the value of searching for work, occurring when $c/\lambda = 0$. The first inequality above says that the worker would like to search for work if the job arrival intensity λ is infinite, or $c = 0$, whereas the second inequality says that she will not search under the current labor market conditions. Note that if the upper bound $\bar{\omega} = \infty$, then $H(0) = \infty$, which means that no agent would be out of the labor force in this case with zero expected cost of search.

When taking into account the approximation given in Eq. (11) the condition for being discouraged, as given in Eq. (12), becomes

(13) $$V(0) > U_0 > V(0) - \frac{c}{q^*}.$$

4. Empirical specification

We shall now discuss how we can use the results obtained above to formulate an empirical model for individuals' assignment to the following 3 states: "Out of the labor force" (state 0), "Unemployed" (state 1), and "Employed" (state 2). Although we are primarily interested in a model for the probability of supplying labor (being in the labor force), we need to specify a complete model for the 3 states above for the purpose of efficient use of the information available in the data. Recall that in the treatment above, we only considered uncertainty from the perspective of the individual agent. In contrast, when specifying the empirical model, we need in addition to take into account variables that are known by the individual agent, but unobserved by the econometrician (unobservables).

Let W denote the real wage that corresponds to the job offer with utility U_2 and assume that

(14) $$U_2 = \log W + \zeta,$$

where ζ is a term that represents the value of non-pecuniary aspects of the job offer. The term ζ may vary across agents due to heterogeneity in agents' preferences. We call $W\exp(\zeta)$ the modified wage. The modified wage takes into account that non-pecuniary aspects also matter to the agents. Thus, an attractive job with respect to non-pecuniary aspects corresponds to a high value of ζ. Hence, the agent may accept this job even if the wage rate is low as long as the modified wage is high.

In our data we only observe the current wage of those who work, that is, the wage conditional on acceptable job offers. Therefore, we need to specify a (real) wage equation and an estimation procedure for recovering the unconditional distribution of the real wage. To this end we assume that

(15) $$\log W = \beta_0 + X\beta + \eta,$$

where X consists of length of schooling, experience, experience squared and a variable representing regional population density, and η is a zero mean random variable that is independent of X and has variance σ^2. Experience is defined as age minus schooling (number of years) minus school start. Here, we allow the intercept β_0 in the real wage equation to depend on calendar time. If we combine Eq. (3) with Eq. (14) and Eq. (15) it follows that

(16) $$v_2 = \beta_0 + X\beta,$$

whereas $\xi + \tau\omega$ has the interpretation as $\xi + \tau\omega \equiv \eta + \zeta$. Note that whereas the value of search, V, is known to the agent, it is not observable to the researcher and may vary across agents due to unobservables. Also, q^* is not necessarily observed by the researcher. What the researcher observes is *q,* defined as the aggregate fraction of employed (or equivalently unemployed) persons in the labor force. Thus, $q = E(q^* \mid V > U_0)$. Consequently, we can express V as

(17) $$V = v_2 - \frac{c}{q} + \varepsilon_2,$$

where ε_2 is a random term defined by

$$\varepsilon_2 = \xi + \tau\varpi + \frac{c}{q^*} - \frac{c}{q}.$$

Furthermore, assume that

$$U_0 = v_0 + \varepsilon_0, \tag{18}$$

where v_0 is a systematic term that depends on observed individual characteristics, whereas ε_0 is a random error term that is supposed to account for the effect of unobservables. In the following, we will assume that $(\theta\varepsilon_0, \theta\varepsilon_2)$ are jointly standard extreme value distributed (see Appendix C) and serially independent, where θ is a suitable positive parameter whose role is to standardize the standard deviations of ε_j, $j = 0,2.$ Moreover, we assume that $\theta v_0 = -Z\gamma,$ where Z is a vector of variables consisting of one, age, age squared, the logarithm of real nonlabor income, and three variables representing the number of children with age less than 3 years, number of children with age between 4 and 6 and number of children with age above 6 in the household. The real nonlabor income variable is the husband's income. Since labor supply decisions of wife and husband are interdependent this raises the question to what extent this variable is endogenous. To deal with interdependent household labor supply properly requires a model for joint labor supply of wife and husband, which will, however, be beyond the scope of this paper. Note furthermore that length of schooling is not included in *Z*. This is consistent with the standard labor supply literature. Although there are grounds for including length of schooling in *Z* this would lead to serious identification problems.[6]

Without loss of generality we can normalize such that ε_2 has the same mean as ε_0. The assumptions above and the theory of discrete choice imply that the probability of being in the labor force equals

$$P \equiv P(V > U_0) = P\left(v_2 - \frac{c}{q} + \varepsilon_2 > v_0 + \varepsilon_0\right) = \frac{1}{1 + \exp\left(-\left(\theta v_2 + Z\gamma - \tilde{c}(1/q - 1)\right)\right)}, \tag{19}$$

[6] In a standard life cycle setting, v_0 will depend on some measure of permanent or lifetime income (through the marginal utility of wealth). Furthermore, for obvious identification reasons we follow the convention in labor supply analysis by not allowing preferences to depend on education.

where $\tilde{c} = \theta c$, and where we have replaced $1/q$ by $1/q-1$.[7] Since $Z\gamma$ contains an intercept this substitution represents no loss of generality. Although the choice probability follows from well known results (see for example McFadden, 1984), we provide a proof in Appendix C to make the paper self-contained. There we also demonstrate that there is no loss of generality in assuming that the error terms ε_0 and ε_2 are independent.

To complete the empirical specification we need a model of the probability q, i.e., the probability of facing an acceptable job given that the individual searches. We are unfortunately not able to give a structural specification of q that explicitly accounts for the fact that q depends on both preferences and on the job arrival rate. Instead we assume the following reduced form representation

$$q = \frac{1}{1+\exp\left(-B\delta\right)}, \tag{20}$$

where B is a vector consisting of length of schooling, experience, experience squared, number of children in three age groups, logarithm of real nonlabor income, and time dummies. This specification is sufficient for the purpose of this paper, since the role of q is to serve as an instrument variable that enables us to predict the probability of getting unemployed for subgroups defined by the vector B. Note that $1-q$ corresponds to the probability of getting unemployed for agents with characteristics B.

It is easily realized that there is no identification problem here because our data set contains information about which of the three states “out of the labor force”, “unemployed” and “employed”, the agent occupies at time t. The relation in (20) can therefore be identified from the subsample of persons who are in the labor force (i.e., employed or unemployed). Specifically, the dependent variable that is relevant for estimating (20) is equal to one if the agent is employed and zero if the agent is unemployed. However, since all the individual covariates represented by X and Z also enter the vector B in q, identification is achieved because of B contain time dependent dummy variables representing business cycle variations.[8]

We have estimated the model by a simultaneous quasi-maximum likelihood procedure, to be discussed in Section 6. Alternatively, one could estimate the model in several stages. By this we mean that q is

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[7] This normalization is convenient because it implies that the term $\tilde{c}(1/q-1)$ vanishes when $q = 1$.

[8] It may be possible in principle to achieve identification without business cycle variations in q. This identification will however depend crucially on the functional form of q, and therefore be fragile.

estimated in a first stage, and that we use the estimated value as an independent variable together with the other explanatory variables, to estimate the probability of being in the labor force in a second stage, given by (19). This requires that the (real) wage equation has been estimated first. In the estimation of the wage equation one faces a potential selection bias problem. In Appendix C it is demonstrated that one can use $-\log P$ as an additional regressor to control for selection bias in the (real) wage equation. Hence, a reduced form specification of (19) can be used to obtain an estimate of $\log P$. Consequently, one can thereby identify the parameters of the wage rate equation, which determines v_2. Recall that whereas v_2 depends on length of schooling, Z does not contain length of schooling. Hence, since q is observable, and $1/q-1, v_2$ and Z are not linearly dependent, the parameters θ, $\tilde{c}$, and γ in (19) are identified. Consequently, the model is identified.

Finally, let us consider the implication for the prediction of the discouraged worker effect. When $q=1$, we have “full” employment. From (19) we thus get that the probability of being discouraged equals

(21) $$P(1)-P(q)=\frac{1}{1+\exp\left(-\left(\theta v_2+Z\gamma\right)\right)}-\frac{1}{1+\exp\left(-\left(\theta v_2+Z\gamma-\tilde{c}(1/q-1)\right)\right)}.$$

5. Data

The data were obtained by merging the Labor Force Survey (LFS) 1988–2008 and three different register data sets—the Tax Register for personal tax payers 1988–1992, the Tax Return Register 1993–2008, and the National Education database—with additional information about incomes, family composition, children, and education.[9] Information about whether the person lives in a densely populated area is also linked to the dataset. The classification in the LFS is based on answers to a broad range of questions. Persons are asked about their attachment to the labor market during a particular week. For a person to be defined as unemployed, she must not be employed in the survey week, she must have been seeking work actively during the preceding four weeks, and she must wish to return to work within the next two weeks.

Information about actual and formal working times in a worker's main job, as well as in a possible second job, and background variables such as demographic characteristics and occupation are also included in the LFS. Conditional on labor market participation, respondents are asked whether they

[9] This is possible owing to a system with unique personal identification numbers for every Norwegian citizen.

consider themselves as self-employed or as employees. Based on this information, we have excluded self-employed women in the empirical analysis. Working time is measured as formal hours of work on an annual basis in both the main and possible second job. If this information is missing and the respondent is participating in the labor market, information about actual working time is used. The actual sample we use is a subset of the LFS and consists of independent cross-sections for all years from 1988 (second quarter) to 2008 (fourth quarter). A woman in the sample is observed in one quarter only.

In order to expand the analysis period of this study, we use data (incomes, demographic characteristics, family composition) from both the Tax Register 1988–2002 and the Tax Return Register 1993-2008. Unfortunately, the Tax Register for personal taxpayers (which is an register with selected income and tax variables) does not include very detailed information about different types of incomes. We have chosen to use a measure of nonlabor income that includes salaries of the husband as well as stipulated labor incomes for self-employed husbands. Nominal hourly wages are measured as labor incomes divided by (formal) annual working time, as defined above. The nominal hourly wage and nonlabor income variables are deflated by using the official Norwegian consumer price index, with 1998 as the base year.

The number of children aged 0–3 years, 4–6 years and 7–18 years for the years 1993–2008 can easily be calculated from information in the Tax Return Register using information on family identification number, date of birth and information about whether a person is considered being a child or an adult in the family. Since the Tax Register does not include information about persons less than 18 years, we have to predict the number of children in the three age groups for the years 1988–2002. This is done by extrapolating information about the number of children in all ages 0–23 in 2003 year by year, from 2002 and back until 1988. The predicted age distributions of children for the years 1988 to 2002 looks very similar to the observed age distribution in 2003 using this procedure.

Education is measured in years of achieved level of schooling. An area is defined as densely populated if at least 200 persons live in the area and the distance from one house to another normally is less than 50 meter.

The sample is further reduced by including only married or cohabiting females ranging in age between 25 and 60 years. The motivation for the age restriction is that education is an important activity for women under 25 years of age, and that for those older than 60 years, early retirement is rather frequent.[10] Married women with zero nonlabor income are also excluded from the sample. Moreover, married women with real nonlabor income higher than one million NOK in real terms are also excluded. This leaves us with a final sample for all years of 57,440 females used in the estimation of the model. The average proportion of women outside the labor force is 12.1 percent (6,953 females), the average unemployment rate is 2.1 percent (1,202 females), and the average employment rate is 85.8 percent (49,285 females). In the estimation we have removed real wage observations where either the real wages are below the 3rd percentile or above the 99th percentile. However, we have not removed the corresponding women with these wages. As a result, the set of observations that enter the part of the loglikelihood function that concerns real wages is reduced from 49,285 to 47,329 employed women.

Two characteristics are evident in the sample: There has been an upward trend in female labor market participation over the period, and the unemployment share shows business cycle fluctuations over the years covered by the sample. In Appendix D, Table D1, we report the share of total number of persons in different labor market states for each year in the time span 1988–2008. Furthermore, in Table D2 of that Appendix we report summary statistics on an annual basis for the variables used in our econometric analysis. Table 1 reports, as an example, a segment of these two extensive tables corresponding to 1995.

Table 1. Summary statistics in 1995

Variable	Mean	Std. dev.	Minimum	Maximum	No. of obs.
Share of employed persons	0.8394				4,017
Share of unemployed persons	0.0286				4,017
Real wage[a]	117.53	40.83	44.22	395.67	3,221
Real nonlabor income[a]	198,030	92,512	148,36	669,920	4,017
Age	40.99	9.18	25	60	4,017
Length of schooling	11.85	2.67	6	20	4,017
Number of children aged 0–3 years	0.31	0.56	0	3	4,017
Number of children aged 4–6 years	0.23	0.47	0	3	4,017
Number of children aged 7–18 years	0.76	0.93	0	5	4,017
Dummy for densely populated area[b]	0.76	0.43	0	1	4,017

[a] NOK (in constant 1998 prices). [b]The dummy variable is equal to 1 if the person is from a densely populated area, otherwise it is 0.

[10] Norway has an early retirement program for workers. It was introduced for the first time in 1988, originally only for 66 years old workers working in firms that were participating in the program. Today the program covers most workers aged 62–66 years.

6. Estimation and empirical results

In this section we report estimation procedures and estimation results. Recall that the individual at any time is in one of the 3 states "Out of the labor force" (state 0), "Unemployed" (state 1) and "Employed" (state 2). To this end it is convenient to introduce individual- and time indexation. Let P_{ijt}^{*} be the probability that individual *i* is in state *j* in period *t*. Clearly, $P_{i2t}^{*} = q_{it}P_{it}$, $P_{i1t}^{*} = (1-q_{it})P_{it}$, and $P_{i0t}^{*} = 1 - P_{it}$. In Appendix C we demonstrate that the (real) wage equation for woman *i* at time *t* who works can be written as

$$\log W_{it} = \beta_{0t} + X_{it}\beta - \rho \log P_{it} + \eta_{it}^{*},$$

where ρ is a positive parameter and the random error term η_{it}^{*} has zero mean (conditional on working and given the regressors). All the parameters of the model have been estimated simultaneously, including the selection bias parameter ρ. We use a quasi-maximum likelihood approach to this end since we do not know the distribution of the error term η_{it}^{*}. Even if one makes distributional assumptions about the error term η_{it} in the original wage equation one cannot infer much about the distribution of η_{it}^{*} without making specific assumptions about the joint distribution of $(\varepsilon_{i2t}, \eta_{it})$. The Figures D1 and D2 in Appendix D provide evidence that support the assumption that the distribution of this error term is close to the normal distribution. Thus, we have formed the quasi-likelihood function as if the error term η_{it}^{*} were normally distributed.

Let $Y_{ijt} = 1$ if woman *i* is in state *j* in year *t*, and zero otherwise. The log quasi-likelihood function is given by (apart from an additive constant)

(22) $$\log L = \sum_i \sum_t \sum_j Y_{ijt} \log P_{ijt}^{*} - \sum_i \sum_t Y_{i2t} \left(\left[\log W_{it} - \beta_{0t} - X_{it}\beta + \rho \log P_{it} \right]^2 / 2\sigma^2 + \log \sigma \right).$$

Although all the parameters of the model are estimated simultaneously, we find it convenient to present the results in different tables. The estimates of the parameters in the (real) wage equation and in q_{it} are reported in Table A1 and Table A2 in Appendix A, respectively, whereas the results for the structural parameters (of the participation probability) are presented in Table 2. From Table A1, we observe that the sample selection variable has an insignificant effect. The effects of schooling and experience are consistent with findings in previous analyses using Norwegian data (see, for example, Dagsvik and

Strøm, 2006). In agreement with our a priori belief we find, ceteris paribus, that females living in densely populated areas have higher expected real wage rates than females living in sparsely populated areas.

Recall that since $q = E(q^* \mid V > U_0)$, q depends on the variables that enter λ, V and U_0. According to the results in Table A2, both length of schooling and (potential) work experience have a positive effect on the probability of getting an acceptable job, conditional on search. The presence of children reduces this probability. This may be because utility of nonparticipation increases with the number of children. This, in turn, implies that it is less likely that a woman with children will decide that an arriving job is acceptable compared to a woman with no children. In addition, we find that an increase in (real) nonlabor income increases the probability of finding a job conditional on search. If labor market skills and qualifications are positively correlated among partners, we expect to find high correlation between the real nonlabor income of the female and her qualifications in the labor market In this case we would expect that the job arrival rate λ (which is a component of q) may be correlated with real nonlabor income.[11]

Figure 1. Mean of predicted probabilities of being unemployed 1988–2008. In percent

[11] From the outset we included the dummy for densely populated area in the expression for q. However, since the estimated coefficient attached to this variable was highly insignificant it was dropped in the final estimation. As a sensitivity check we have also estimated the complete model when the 21 annual dummies are replaced by 83 quarterly dummies. Whereas the loglikelihood value in the maintained model is 9,595.77, the log-likelihood value of this alternative model is 9,613.14. Given the number of degrees of freedom gained, this may be interpreted as support for the maintained model. The estimates of the other parameters in the model do not vary substantially between these two specifications.

In Table 2, we report, for the sake of comparison, both the estimation results of the structural model and the results of a constrained model where it is assumed a priori that the discouraged worker effect does not enter the model. Apart from a significant loss of explanatory power, the most striking feature is the higher coefficient associated with the predicted log real wage rate, and the reduced coefficient (in absolute value) associated with log real nonlabor income. This means that when we ignore the discouraged worker effect, we overestimate the effects of changes in wages on participation, whereas the effects of changes in nonlabor income are underestimated. All the estimates in Table 2 related to the maintained model have the a priori expected signs. Apart from the estimate of the coefficient attached to the first order term of age, they are all significant.[12] Utilizing the parameter estimates in Table A2 we may predict the probability of being unemployed for each woman in the sample. In Figure 1 we graph the annual mean of 100(1-q), i.e., the annual mean of perceived probabilities of getting unemployed given in percent. As can be seen from Figure 1, this variable shows business cycle variation over time which is of vital importance from an empirical point of view when estimating the discouraged worker effect.

Table 2. Maximum likelihood estimates of key structural parameters characterizing the participation probability

Parameter	Variable	With discouraged worker effect		Without discouraged worker effect	
		Estimate	t-value	Estimate	t-value
θ	Predicted log real wage	4.1293	22.2685	5.5067	43.4264
γ_1	Intercept	−10.5602	−9.5639	−21.8942	−36.1267
γ_2	Age	−0.0274	−1.2168	0.0563	3.4298
γ_3	(Age/10)^2	−0.0547	−2.1339	−0.1388	7.2388
γ_4	log(real nonlabor income)	−0.2884	−10.7158	−0.0900	−5.7080
γ_5	Number of children aged 0–3 years	−1.0466	−24.3394	−1.0340	−35.4472
γ_6	Number of children aged 4–6 years	−0.6929	−15.2760	−0.7576	−25.4533
γ_7	Number of children aged 7–18 years	−0.2734	−11.2493	−0.3526	−21.4700
$\tilde{c}$	Discouraged worker effect	19.0884	9.5468	0[a]	
Number of observations		57,440		57,440	
Log-likelihood value		9,595.77		9,512.10	

[a] A priori restriction.

[12] A previous study by Dagsvik, Kornstad, and Skjerpen (2006) based on a similar model, and a sample of microdata from 1988 to 2002 produced somewhat different empirical results. This is due to different specification of the variables representing the number of children in different age groups and the fact that the new data set covering the period from 1988 to 2008 covers additional major business cycle variations.

7. Elasticities and various model predictions

We will now investigate some key properties of the estimated structural model. In Table 3, we compare, on a three year period basis, the mean of the predicted labor market participation probabilities and the corresponding empirical labor market participation shares (cf. the second and fourth column of the table, respectively).[13] Our parsimonious model does rather well in picking up the positive trend in female labor market participation over the years covered by the sample. The mean of the absolute value of the deviations taken over the seven 3-years periods from 1988–2008 is about 0.006. The largest deviation, 0.008, is found for the period 1991−1993.

Table 3. Participation rates and discouraged worker effect

Period	Observed partici-pation rate	Observed unemploy-ment rate	Mean of predicted participation rates and discouraged worker effect						
			Participation rate		Discouraged worker effect			No wage trend[a]	
			Estimate	Std. err.[b]	Estimate	Std. err.[b]	Share of discour. persons[c]	Estimate	Std. err.[b]
1988–1990	0.8138	0.0194	0.8114	0.0160	0.0764	0.0076	0.3645	0.8017	0.0170
1991–1993	0.8500	0.0283	0.8417	0.0140	0.0685	0.0067	0.3766	0.8003	0.0174
1994–1996	0.8682	0.0262	0.8607	0.0121	0.0570	0.0054	0.3493	0.8090	0.0164
1997–1999	0.8939	0.0175	0.8893	0.0110	0.0389	0.0048	0.2986	0.8245	0.0168
2000–2002	0.9140	0.0136	0.9130	0.0092	0.0275	0.0036	0.2674	0.8357	0.0164
2003–2005	0.9267	0.0222	0.9214	0.0085	0.0325	0.0039	0.3347	0.8218	0.0175
2006–2008	0.9427	0.0112	0.9509	0.0059	0.0162	0.0024	0.2507	0.8522	0.0158
1988–2008	0.8790	0.0209	0.8748	0.0113	0.0498	0.0047	0.3292	0.8171	0.0165

[a] This column corresponds to the case where the estimates are taken from the maintained model, but where the estimates of the dummy variables in the (real) wage equation for 1989–2008 are all replaced by the estimated value of the dummy variable for 1988. [b] Bootstrap estimates. The number of replications is equal to 5,000. The bootstrapped standard errors are obtained by bootstrapping new parameter values from the multivariate normal distribution with the mean equal to the estimated coefficient vector and with the covariance matrix equal to the estimated covariance matrix of the parameter estimates. [c] The share of persons outside the labor force that is discouraged workers, according to the model. For each of the indicated periods we calculate the mean of [*P(1)*-*P(q)]/[1-P(q)]* over the women.

To assess the magnitude of the discouraged worker effect, we have in the sixth column of Table 3 predicted the mean of *P(1)-P(q)* in different time periods. Furthermore, we have in the eight column of Table 3 predicted the share of women outside the work force that are discouraged workers. This share is computed as the mean (over women in the respective time periods) of the predicted ratios *[P(1)-P(q)]/[1-P(q)]*. Recall that *P(1)* is a "reference" case that corresponds to an ideal situation in which the agent perceives with perfect certainty that she will get an acceptable job if she

[13] Our primary reason for reporting figures for three years periods is to reduce the sampling uncertainty such that we may obtain more precise estimates of the share of discouraged workers reported in the third last column of Table 3.

decides to search, whereas the second probability is the one that follows from the maintained model. As seen from the last row of the table, the global predicted mean increases by about 0.05, which implies that, on average, about one third of those outside the labor force are discouraged as reported in the third last column of Table 3. The share shows some variation through the periods.

In the column of Table 3 next to the last, we have simulated labor supply behavior in the counterfactual case with real wage rates generated by the wage equation with the intercept as in 1988. As a consequence, the increase in labor force participation from 1988−1990 to 2006−2008 reduces to about 5 percentage points. Most of this increase in labor force participation is due to increased education levels, increasing real wage levels and reduced unemployment during the sample period considered in this analysis.

Next, consider elasticities, which are characterized by being invariant to the arbitrary choice of units of measurement in both variables. In this section, we calculate a different type of elasticities. We use so-called quasi-elasticities (see Cramer, 2001, p. 8). The motivation for this is that "probability" is itself a relative concept and its scale is not arbitrary. The individual quasi-wage and quasi-nonlabor elasticities of the participation rate are given by, respectively[14]

$$(23)\qquad E_{EW}^{P} \equiv \frac{\partial P(q)}{\partial \log EW} = \theta\big(1-P(q)\big)P(q)$$

and

$$(24)\qquad E_{Z_4}^{P} \equiv \frac{\partial P(q)}{\partial Z_4} = \gamma_4\big(1-P(q)\big)P(q),$$

where Z_4 denotes the log of real nonlabor income. Note that here it is understood that the real wage rate changes we have in mind are solely changes in the mean of the distribution of the logarithm of the real wage rate. The quasi-elasticity of the participation rate with respect to the probability of not receiving an acceptable job offer,[15] is given by

[14] Note that it follows from Eq. (15) that $\log EW = E\log W + \delta$, where δ is a suitable constant. This implies that $\partial P(q)/\partial \log EW = \partial P(q)/\partial E\log W$.

[15] Using a nickname we refer to this as an unemployment elasticity. As both P and $(1-q)$ are probabilities and hence dimensionless, we find it consistent with Cramer's intuition to label the derivatives in Eqs. (23) - (28) quasi-elasticities.

(25) $$E^{P}_{(1-q)} \equiv \frac{\partial P(q)}{\partial (1-q)} = -\tilde{c}\left(1-P(q)\right)P(q)\frac{1}{q^2}.$$

Furthermore, we define the quasi-elasticities of the discouraged worker effect with respect to the same three variables as

(26) $$E^{D}_{EW} \equiv \frac{\partial P(1)}{\partial \log EW} - \frac{\partial P(q)}{\partial \log EW} = \theta\left[\left(1-P(1)\right)P(1) - \left(1-P(q)\right)P(q)\right],$$

(27) $$E^{D}_{Z_4} \equiv \frac{\partial P(1)}{\partial Z_4} - \frac{\partial P(q_i)}{\partial Z_4} = \gamma_4\left[\left(1-P(1)\right)P(1) - \left(1-P(q)\right)P(q)\right]$$

and

(28) $$E^{D}_{(1-q)} \equiv \frac{\partial P(1)}{\partial (1-q)} - \frac{\partial P(q)}{\partial (1-q)} = -E^{P}_{(1-q)}.$$

In columns 2−4 in Table 4, we report for selected years the annual mean of the quasi-wage (E^{P}_{EW}), the quasi-nonlabor income (E^{P}_{Z4}), and the quasi-unemployment elasticity (E^{P}_{u}) which measure the effects on participation (Eqs. 23−25), and the corresponding quasi-elasticities of the discouraged worker effect (Eqs. 26−28) in the sample.[16] For instance, let us consider the mean participation elasticities in 1988 and 2008. In 1988, the mean quasi-elasticities for real wage, real nonlabor income, and unemployment are 0.60, –0.042, and –4.15, respectively, whereas the corresponding figures for 2008 are 0.15, –0.011, and –0.79. From Table 3, we note that the mean predicted labor force participation rate is 0.80 in 1988 and 0.96 in 2008. If we counterfactually assume a 5 percent universally increase in the real wage rate in 1988, the mean predicted participation rate would have increased to 0.83. Correspondingly, a 10 percent universal increase in real nonlabor income would have lowered the mean predicted participation rate by 0.004. Finally, if all the predicted perceived unemployment rates had been increased by 0.05, the mean predicted labor participation probability would have decreased to 0.59. If we make the same type of calculations for 2008, the changes in the mean predicted participation probabilities in the three counterfactual situations would have been about 0.008, –0.001,

[16] Estimates of mean quasi-elasticities of all years in the time span 1988–2008 are provided in Table D4 in Appendix D.

and –0.040, respectively. Over the time span considered in this analysis, there is a positive trend in female labor participation, and this leads to a negative trend in the mean quasi-wage elasticity over time. The mean quasi-nonlabor income elasticity is rather small in magnitude. The quasi-unemployment elasticity, which picks up the discouraged worker effect, shows business cycle variation over time. Ceteris paribus, the quasi-unemployment elasticity will become higher as the perceived probability of being unemployed given search efforts becomes higher.

Table 4. Mean quasi-elasticities of labor market participation and discouraged worker effect

Year	Quasi-elasticity of participation probability, *P(q)*[a]			Quasi-elasticity of discouraged worker effect, *P(1)-P(q)*[b]	
	E^P_{EW}	E^P_{Z4}	$E^P_{(1-q)}$	E^D_{EW}	E^D_{Z4}
1988	0.6011	–0.0420	–4.1457	–0.1883	0.0131
1995	0.4570	–0.0319	–2.9659	–0.1580	0.0110
2002	0.2992	–0.0209	–1.7016	–0.0943	0.0066
2008	0.1536	–0.0107	–0.7889	–0.0370	0.0026

[a] Cf. Eqs. (23) – (25) for formal definition of the quasi-elasticities; [b] Cf. Eqs. (26) – (27) for formal definition of the quasi-elasticities.

One advantage of using microdata in structural analysis is that it allows the researcher to assess the importance of population heterogeneity when partial effects from changes in exogenous variables are considered. In Table 5, we report simulations of quasi-elasticities related to real wage, real nonlabor income, and the probability of getting unemployed for 31 different groups of females. In addition to the quasi-elasticities of participation defined in (23)-(25), we also report elasticities of the discouraged worker effect given by (26) and (27) (two last columns), similarly to what we did in Table 4.[17] The cases differ with respect to combinations of real wage rate (100 and 200 NOK in constant 1998-prices), real nonlabor income (100,000 and 300,000 NOK), age (30 and 45 years), the number of children in different age groups (0–3, 4–6 and 7–18 years) and the probability of getting an acceptable job, given search (q equal to 0.92, 0.97, and 1, respectively). The values for age, number of children in different age groups and q are chosen in order to embrace the possible variation in these variables. A level of real wages of 100 NOK corresponds to the lower wage rate deciles in Norway. A probability of getting a job, given search, equal to 0.97 is close to the situation in Norway today, whereas the probability 0.92 is considered to be a rather extreme case in Norway, but not in many other European countries.

Table 5. Probability of being in the labor force and quasi–elasticities of labor market participation and discouraged worker effect for different groups of females

Case	Real wage rate[a]	Real non–labor income[a]	Age	Number of children aged 0–3 years	Number of children aged 4–6 years	Number of children aged 7–18 years	Probability of getting an acceptable job, given search, q	Probability of labor force participation, $P(q)$	Quasi–elasticity of participation probability, $P(q)$[b]: E^P_{EW}	E^P_{Z4}	E^P_u	Quasi–elasticity of discouraged worker effect, $P(1)–P(q)$[c]: E^D_{EW}	E^D_{Z4}
1	100	100,000	30	0	0	0	0.92	0.897	0.382	–0.027	–2.087	–0.296	0.021
2	100	100,000	30	0	0	0	0.97	0.962	0.151	–0.011	–0.741	–0.064	0.004
3	100	100,000	30	0	0	0	1	0.979	0.087	–0.006	–0.400		
4	100	100,000	30	0	1	0	0.92	0.813	0.628	–0.044	–3.429	–0.462	0.032
5	100	100,000	30	0	1	0	0.97	0.927	0.280	–0.020	–1.376	–0.114	0.008
6	100	100,000	30	0	1	0	1	0.958	0.166	–0.012	–0.767		
7	100	100,000	30	1	0	0	0.92	0.753	0.768	–0.054	–4.192	–0.540	0.038
8	100	100,000	30	1	0	0	0.97	0.899	0.375	–0.026	–1.843	–0.147	0.010
9	100	100,000	30	1	0	0	1	0.941	0.228	–0.016	–1.054		
10	100	100,000	30	0	2	1	0.92	0.623	0.970	–0.068	–5.296	–0.588	0.041
11	100	100,000	30	0	2	1	0.97	0.828	0.588	–0.041	–2.887	–0.206	0.014
12	100	300,000	30	1	0	0	0.92	0.690	0.884	–0.062	–4.826	–0.584	0.041
13	100	300,000	30	1	0	0	0.97	0.866	0.478	–0.033	–2.350	–0.179	0.012
14	100	300,000	30	0	2	1	0.92	0.546	1.023	–0.071	–5.589	–0.537	0.038
15	100	300,000	30	0	2	1	0.97	0.778	0.713	–0.050	–3.501	–0.226	0.016
16	200	100,000	30	1	0	0	0.92	0.982	0.074	–0.005	–0.407	–0.060	0.004
17	200	100,000	30	1	0	0	0.97	0.994	0.026	–0.002	–0.129	–0.012	0.001
18	200	100,000	30	0	2	1	0.92	0.967	0.133	–0.009	–0.728	–0.107	0.007
19	200	100,000	30	0	2	1	0.97	0.988	0.048	–0.003	–0.235	–0.021	0.001
20	200	300,000	30	1	0	0	0.92	0.975	0.101	–0.007	–0.551	–0.081	0.006
21	200	300,000	30	1	0	0	0.97	0.991	0.036	–0.002	–0.176	–0.016	0.001
22	200	300,000	30	0	2	1	0.92	0.955	0.179	–0.012	–0.975	–0.142	0.010
23	200	300,000	30	0	2	1	0.97	0.984	0.065	–0.005	–0.320	–0.028	0.002
24	100	300,000	45	0	0	0	0.92	0.694	0.877	–0.061	–4.789	–0.582	0.041
25	100	300,000	45	0	0	0	0.97	0.869	0.471	–0.033	–2.315	–0.177	0.012
26	100	300,000	45	0	2	1	0.92	0.302	0.870	–0.061	–4.750	0.007	–0.000
27	100	300,000	45	0	2	1	0.97	0.557	1.019	–0.071	–5.006	–0.142	0.010
28	200	300,000	45	0	0	0	0.92	0.975	0.099	–0.007	–0.540	–0.079	0.006
29	200	300,000	45	0	0	0	0.97	0.991	0.035	–0.002	–0.172	–0.015	0.001
30	200	300,000	45	0	2	1	0.92	0.883	0.426	–0.030	–2.328	–0.327	0.023
31	200	300,000	45	0	2	1	0.97	0.957	0.172	–0.012	–0.843	–0.073	0.005

[a] In NOK (1998–prices); [b] Cf. Eqs. (23)–(25) for formal definition of the quasi–elasticities; [c] Cf. Eqs. (26)–(27) for formal definition of the quasi–elasticities.

[17] In Table D5 in Appendix D, we report results for an additional number of cases as well as most of the cases in Table 5.

Participation probabilities

As seen from formulae (23)-(28), the levels of the participation probabilities have a major impact on the value of the quasi-elasticities. Specifically, we note that an increase in the probability of labor market participation decreases the absolute value of the quasi-elasticities in most cases.

Labor market participation rates (column for *P(q)*, Table 5) and the elasticities are strongly influenced by the real wage rate, and the higher the real wage rate is, the higher is the participation rate. For instance, if we consider a 30 years old woman, with one child aged 0–3 years, real nonlabor income equal to 100,000 NOK and q=0.97 (Case 8 and Case 17), an increase in the real wage rate from 100 NOK to 200 NOK leads to an increase in the predicted probability of labor force participation from 0.90 to 0.99.

With real wages at 100 or 200 NOK, the probability of labor force participation varies significantly across different age groups and different probabilities of getting an acceptable job, given search. For instance, the participation rate of a female with real wage rate 100 NOK, real nonlabor income 300,000 NOK, two children aged 4–6 years, one child aged 7–18 years and q=0.97 is reduced by 22 percentage points, from 0.78 to 0.56, when her age increases from 30 to 45 years (Case 15 and Case 27).

The number of children and the age of each of them also have a noticeable effect on the participation rate. While the participation rate of a 30 year old female with real wage rate 100 NOK, real nonlabor income 100,000 NOK and zero children is 0.90 when q=0.92 (Case 1), the participation rate is only 0.75 when the female, ceteris paribus, has one child aged 0–3 years (Case 7). The older the child is, the lower is the effect on the participation rate. For instance, if the child is 4–6 years, the participation rate is 0.81 (Case 4). On the other hand, if the mother has more children, two children aged 4–6 years and one child 7–18 years, her preferences for staying out of the labor force increases, and the participation rate is only 0.62 (Case 10).

Quasi-elasticities of participation probability

From Table 5 we note that whereas the nonlabor income elasticity of participation ($E^P_{Z_4}$) does not show much variations, there is much more variation in the corresponding wage (E^P_{EW}) and unemployment ($E^P_{(1-q)}$) elasticities.

By looking at the quasi-wage elasticity of participation (E^{P}_{EW}), we see that this elasticity is very small (0.026) for a 30 years old female with real wage rate 200 NOK, real nonlabor income of 100,000 NOK, one child aged 0–3 years and q = 0.97 (Case 17), whereas it is as high as 1.02 for a 30 years old female with real wage rate equal to 100 NOK, real nonlabor income of 300,000 NOK, two children aged 4−6 years, one child aged 7−18 years and q=0.92 (Case 14). A shift in the real wage rate from 100 NOK to 200 NOK leads to a significant reduction in the wage elasticity as well as the two other elasticities related to participation. For females with real wage rates of 200 NOK, the quasi-elasticities are of rather moderate size, whereas, in contrast, the elasticities for females with real wage rate 100 NOK are of considerable magnitude. For the latter group of females with low real wage rate, we notice that the elasticities vary significantly with the age of the female and also with her probability of getting an acceptable job, given search. The elasticities are higher in absolute value for older women compared with younger ones.

Quasi-elasticities of the discouraged worker effect

The two last columns in Table 5 show the responses in the discouraged worker effect with respect to changes in the real wage rate and in real nonlabor income. The quasi-nonlabor income elasticity (E^{D}_{Z4}) is positive, but rather small for most combinations of real wages, ages, real nonlabor income, number of children in the three age groups and the probability of getting an acceptable job, given search. In contrast, the quasi-wage elasticity of the discouraged worker effect (E^{D}_{EW}) is negative, and it shows much more variation. It is reduced by an increase in the real wage rate, see for instance Case 7 and Case 8 versus Case 16 and Case 17. It is also typically reduced by an increase in the probability of getting an acceptable job. As for the participation wage elasticity, the number of children and the age of each of them are of importance for the discouraged worker wage elasticity, cf. for instance Case 1 and Case 2; Case 4 and Case 5; Case 7 and Case 8; and Case 10 and Case 11. The wage elasticity of the discouraged worker effect is lower for older females than for younger ones.

8. Conclusions

In this paper, we have proposed a simple search theoretic framework for rationalizing the discouraged worker effect, namely that labor force participation depends negatively on unemployment. In particular, we have demonstrated that our theory yields an explicit characterization of the value of searching for work as a function of the distribution of the utility of working and the arrival rate of acceptable job offers. Based on this framework, we have specified an empirical model for the probability that a person is out of the labor force, unemployed, or employed in a given period. Subsequently, we have estimated the model by means of a sample of independent cross-sections for married and cohabitating women in Norway, covering the years from 1988 to 2008.

Our analysis indicates that the discouraged worker effect is of considerable magnitude. On average, the fraction of the subpopulation of married or cohabiting women that is discouraged is 5 percent, varying from about 7.6 percent in 1988–1990, to about 1.6 percent in 2006–2008. This corresponds to about one third of those who are out of the labor force, varying from about 36 percent in 1988–1990, to about 25 percent in 2006–2008. The reason why the discouraged worker effect decreases over time is mainly due to the increase in the participation rate, namely from 0.81 in 1988–1990, to 0.95 in 2006–2008. Our simulation experiments demonstrate that how much the discouraged worker effect responds to a change in real income and the probability of getting unemployed depends substantially on the woman's real wage, her age and the number of children in different age groups.

The estimation results show that the model explains the data very well without introducing time dummies for the utility of being out of the labor force. In other words, according to our model the increase in labor market participation from 1988 to 2008 is mainly due to the increase in the real wage. Due to the fact that there is little variation in the real wage rate apart from an increasing trend effect we cannot rule out that this trend in the real wage rate captures a possible unobserved drift in preferences for labor market participation.

References

Başlevent C, Onaran Ö (2003): Are Married Women in Turkey More Likely to Become Added or Discouraged Workers? Labour 17:439–458 .

Berck P, Sydsæter K (1999): Economists' Mathematical Manual. Second edition. Springer -Verlag, Berlin.

Bloemen, HG (2005): Job Search, Search Intensity, and Labor Market Transitions. An Empirical Analysis. J Human Res 40:231–269.

Blundell R, Ham J, Meghir C. (1987): Unemployment and Female Labour Supply. Econ J 97:44-64

Blundell R, Ham J, Meghir C. (1998): Unemployment, Discouraged Workers and Female Labour Supply. Res Econ 52:103-131.

Connolly S (1997): A Model of Female Labour Supply in which Supply is Dependent upon the Chances of Finding a Job. Appl Econ 29:1379-1386.

Cramer JS (2001): An Introduction to the Logit Model for Economists, 2nd edition. Timberlake Consultants Ltd., London.

Dagsvik, JK, Strøm S (2006): Sectoral Labor Supply, Choice Restrictions and Functional Form. J Appl Econometrics 21:803-826.

Dagsvik, JK, Kornstad T, Skjerpen T (2006): Analysis of the Discouraged Worker Phenomenon. Evidence from Micro Data. Statistics Norway, Discussion Papers, No 453.

Ehrenberg R., Smith R (1988): Modern Labor Economics: Theory and Public Policy, 3rd edition. Scott, Foreman, and Co., London.

Flinn C, Heckman JJ (1982): New Methods for Analyzing Structural Models of Labor Force Dynamics. J Econometrics 18, 115-168.

Ham, J. (1986): On the Interpretation of Unemployment in Empirical Labor Supply Analysis. In R. W. Blundell, RW, Walker I (eds) Unemployment, Search and Labour Supply. Cambridge University Press, Cambridge, pp 121−142.

Heckman JJ (1979): Sample Selection Bias as a Specification Error. Econometrica 47: 153-161.

Jovanovic B (1979): Job Matching and the Theory of Turnover. J Polit Economy 87: 972-990.

Lancaster K (1971): Consumer Demand: A New Approach. Columbia University Press, New York.

Lippman SA, McCall JJ (1976): The Economics of Job Search: A Survey, Part I. Econ Inquiry 14:155-189.

McFadden D (1984): Econometric Analysis of Qualitative Response Models. In: Grililches Z, Intriligator, MD (eds) Handbook of Econometrics, vol. II. Elsevier Science Publishers BV, New York, pp 1395-1457.

Rogerson R., Shimer R, Wright R (2005): Search-Theoretic Models of the Labor Market: A Survey. J Econ Lit 43:959-988.

Appendix A: Further estimation results

Table A1. Estimates of the parameters in the real wage equation

Explanatory variable	Estimate	t-value
Length of schooling	0.0415	63.2885
Experience	0.0175	27.3790
$(\text{Experience}/10)^2$	–0.0268	–20.3686
Dummy for densely populated area	0.0271	9.1890
Dummy for 1988	3.8676	258.3510
Dummy for 1989	3.8769	267.0807
Dummy for 1990	3.9037	270.2732
Dummy for 1991	3.9420	275.8603
Dummy for 1992	3.9422	271.2966
Dummy for 1993	3.9480	279.5194
Dummy for 1994	3.9523	278.3426
Dummy for 1995	3.9678	277.7944
Dummy for 1996	3.9927	280.2320
Dummy for 1997	3.9863	272.0027
Dummy for 1998	4.0133	274.8805
Dummy for 1999	4.0351	277.9447
Dummy for 2000	4.0378	274.8990
Dummy for 2001	4.0497	274.2861
Dummy for 2002	4.0787	276.8074
Dummy for 2003	4.0789	276.2117
Dummy for 2004	4.1202	277.6105
Dummy for 2005	4.1423	274.6959
Dummy for 2006	4.1590	271.5570
Dummy for 2007	4.1804	264.3797
Dummy for 2008	4.1990	284.8828
Selection, $-\log P$	0.0026	0.2107
Variance of error term	0.0886	208.6418

Table A2. Estimates of parameters entering the probability of getting an acceptable job, conditional on search

Explanatory variable	Estimate	t-value
Length of schooling	0.2717	19.1616
Experience	0.0908	7.4278
$(\text{Experience}/10)^2$	–0.1084	–4.5051
Number of children aged 0–3 years	–0.0367	–0.8400
Number of children aged 4–6 years	–0.1039	–2.2367
Number of children aged 7–18 years	–0.0987	–3.8540
log(real nonlabor income)	0.2260	12.9338
Dummy for 1988	–3.3332	–10.4278
Dummy for 1989	–3.2879	–10.3005
Dummy for 1990	–3.3743	–10.3936
Dummy for 1991	–3.4764	–10.5414
Dummy for 1992	–3.5219	–10.7085
Dummy for 1993	–3.2850	–10.1205
Dummy for 1994	–3.3006	–10.2029
Dummy for 1995	–3.4544	–10.5567
Dummy for 1996	–3.3970	–10.2651
Dummy for 1997	–3.3256	–9.9607
Dummy for 1998	–3.1017	–9.1739
Dummy for 1999	–3.3035	–9.6494
Dummy for 2000	–3.1868	–9.1884
Dummy for 2001	–3.0551	–8.7289
Dummy for 2002	–3.3891	–9.7033
Dummy for 2003	–3.5105	–10.0073
Dummy for 2004	–3.6420	–10.3827
Dummy for 2005	–3.6552	–10.1738
Dummy for 2006	–3.6332	–9.9934
Dummy for 2007	–3.4821	–8.9531
Dummy for 2008	–3.3506	–8.9286

Appendix B: Proof of the property that the number of acceptable jobs follows a Bernoulli process

By assumption the job offers arrive according to a Poisson process with arrival intensity $\lambda.$ Moreover, the utilities of the respective jobs are independent i.i.d. random variables. Let $p = P(U_{2t} > V).$ Let X be the number of acceptable jobs. Given N job offers, the probability that x out of them are acceptable is Binomially distributed. Also within an interval (0, T), (say), N is Binomially distributed. Hence

$$P(X = x \mid N = n) = \binom{n}{x} p^x (1-p)^{n-x},$$

for $x \le n,$ and

$$P(N = n) = \binom{T}{n} \lambda^n (1-\lambda)^{T-n},$$

for $n \le T.$ Consequently, the probability mass of X is given by

$$P(X = x) = EP(X = x \mid N) = \sum_{n=x}^{T} \binom{n}{x} p^x (1-p)^{n-x} \cdot \binom{T}{n} \lambda^n (1-\lambda)^{T-n}$$

$$= \sum \frac{T!}{x!(n-x)!(T-n)!} \cdot p^x (1-p)^{n-x} \lambda^n (1-\lambda)^{T-n}.$$

Inserting $m = n - x$, the last expression transforms to

$$\sum_{m=0}^{T-x} \frac{T!}{x!m!(T-x-m)!} \cdot (\lambda p)^x (\lambda(1-p))^m (1-\lambda)^{T-x-m}$$

$$= \frac{T!}{x!(T-x)!} (\lambda p)^x \sum_{m=0}^{T-x} \binom{T-x}{m} \cdot (\lambda(1-p))^m (1-\lambda)^{T-x-m},$$

which by Newton's Binomial formula, Berck and Sydsæter (1999, Eq. (8.28)), reduces to

$$\frac{T!}{x!(T-x)!}(\lambda p)^x \cdot (\lambda(1-p)+1-\lambda)^{T-x} = \binom{T}{x}(\lambda p)^x \cdot (1-\lambda p)^{T-x}.$$

The last expression above shows that the number of acceptable jobs is a Bernoulli process, such that the number of acceptable offers that arrives in (0, *T*) is Binomially distributed with parameter λp.

The expected time until an acceptable job offer can readily be derived. The probability that the first acceptable job offer arrives at time epoch *n* is equal to $(1-\lambda p)^{n-1}\lambda p.$ The corresponding expected value therefore equals

$$\sum_{n\geq 1} n(1-\lambda p)^{n-1}\lambda p = \frac{1}{\lambda p}.$$

To see this, note that for real *s* with $|s|<1,$ we have that

$$\sum_{n\geq 0}(1-s)^n = \frac{1}{s}.$$

If we differentiate the latter equation with respect to *s* and subsequently put $s=\lambda p$ we get the desired result.

Appendix C: Some useful results on conditional distributions

Lemma 1

Assume that $U_j = u_j + \varepsilon_j$, $j = 1,2$, *where* ε_1 *and* ε_2 *are random variables with joint standard bivariate extreme value c.d.f.*

$$P\left(\varepsilon_1 \le x_1, \varepsilon_2 \le x_2 \middle| u_j,\ j=1,2\right) = \exp\left(-\left(e^{-x_1/\mu} + e^{-x_2/\mu}\right)^{\mu}\right), \tag{C.1}$$

and $\mu^2 = 1 - corr\left(\varepsilon_1, \varepsilon_2\right)$, $\mu \in (0,1]$. *Then*

$$P\left(U_2 > U_1\right) = \frac{1}{1 + \exp\left(\left(u_1 - u_2\right)/\mu\right)}, \tag{C.2}$$

and

$$P\left(\varepsilon_2 \le x \middle| U_2 > U_1\right) = P\left(\max\left(U_1, U_2\right) \le x + u_2\right) = \exp\left(-\left(1 + e^{(u_1 - u_2)/\mu}\right)^{\mu} e^{-x}\right). \tag{C.3}$$

The first part of Lemma 1, (C.2), is well known; see for example McFadden (1984). For the readers' convenience, the proof is given below.

Proof:

Under the distributional assumption in (C.1), it follows that

(C.4)

$$P\left(U_2 \in \left(x, x+dx\right), U_1 \le y\right)$$
$$= \exp\left(-\left\{\exp\left(\left(u_2 - x\right)/\mu\right) + \exp\left(\left(u_1 - y\right)/\mu\right)\right\}^{\mu}\right)\left\{\exp\left(\left(u_2 - x\right)/\mu\right) + \exp\left(\left(u_1 - y\right)/\mu\right)\right\}^{\mu-1} \exp\left(\left(u_2 - x\right)/\mu\right)dx.$$

Hence,

$$P(U_2 > U_1) = \int_{-\infty}^{\infty} P(U_2 \in (x, x+dx), U_1 \le x) =$$

$$\int_{-\infty}^{\infty} \exp\Big(-\big\{\exp((u_1 - x)/\mu) + \exp((u_2 - x)/\mu)\big\}^{\mu}\Big)\big\{\exp((u_1 - x)/\mu) + \exp((u_2 - x)/\mu)\big\}^{\mu-1} \exp((u_2 - x)/\mu)\, dx$$

$$= \big\{e^{u_1/\mu} + e^{u_2/\mu}\big\}^{\mu-1} e^{u_2/\mu} \int_{-\infty}^{\infty} \exp\Big(-e^{-x}\big\{e^{u_1/\mu} + e^{u_2/\mu}\big\}^{\mu}\Big) e^{-x} dx = \frac{\exp(u_2/\mu)}{\exp(u_2/\mu) + \exp(u_1/\mu)},$$

which proves (C.2). To prove (C.3), note that it follows from (C.4) that

(C.5)
$$\begin{aligned} &P\big(\max(U_1, U_2) \in (x, x+dx), U_2 > U_1\big) = P\big(U_2 \in (x, x+dx), x > U_1\big) \\ &= \exp\Big(-e^{-x}\big\{\exp(u_1/\mu) + \exp(u_2/\mu)\big\}^{\mu}\Big)\big\{\exp(u_1/\mu) + \exp(u_2/\mu)\big\}^{\mu-1} e^{-x} \exp(u_2/\mu)\, dx. \end{aligned}$$

Furthermore, we have

$$P\big(\max(U_1, U_2) \le x\big) = P(U_1 \le x, U_2 \le x) = \exp\Big(-e^{-x}\big\{\exp(u_1/\mu) + \exp(u_2/\mu)\big\}^{\mu}\Big),$$

which yields

(C.6)
$$P\big(\max(U_1, U_2) \in (x, x+dx)\big) = \exp\Big(-e^{-x}\big\{\exp(u_1/\mu) + \exp(u_2/\mu)\big\}^{\mu}\Big) e^{-x}\big\{\exp(u_1/\mu) + \exp(u_2/\mu)\big\}^{\mu} dx.$$

By combining (C.1), (C.5) and (C.6), we obtain

(C.7)
$$\begin{aligned} &P\big(\max(U_1, U_2) \in (x, x+dx) \mid U_1 > U_2\big) = \frac{P\big(\max(U_1, U_2) \in (x, x+dx), U_1 > U_2\big)}{P(U_1 > U_2)} \\ &= \exp\Big(-e^{-x}\big\{\exp(u_1/\mu) + \exp(u_2/\mu)\big\}^{\mu}\Big) e^{-x}\big\{\exp(u_1/\mu) + \exp(u_2/\mu)\big\}^{\mu} dx \\ &= P\big(\max(U_1, U_2) \in (x, x+dx)\big). \end{aligned}$$

Consequently, we obtain

$$
\begin{aligned}
&P\left(\varepsilon_2 \le x \middle| U_2 > U_1\right) = P\left(U_2 \le x + u_2 \middle| U_2 > U_1\right) \\
&= P\left(\max\left(U_1, U_2\right) \le x + v_2 \middle| U_2 > U_1\right) = P\left(\max\left(U_1, U_2\right) \le x + u_2\right) \\
&= \exp\left(-\left\{\exp((-x)/\mu) + \exp\left((u_1 - u_2 - x)/\mu\right)\right\}^{\mu}\right) = \exp\left(-\exp(-x)\left\{1 + \exp\left((u_1 - u_2)/\mu\right)\right\}^{\mu}\right),
\end{aligned}
$$

which completes the proof.

Correction for selectivity bias

We shall now discuss a particular version of Heckman's method, which is similar to Heckman (1979). To this end, we need to calculate $E(\eta \mid \varepsilon_2$, the individual works). We assume that

(C.8) $$\eta = \rho\left(\theta\varepsilon_2 - 0.5772\right) + \eta^*,$$

where η^* is a zero mean random variable that is independent of ε_2 and ε_0, and ρ is an unknown parameter. The reason why we have subtracted 0.5772 (Euler's constant) from the error term is because $E(\theta\varepsilon_2) = 0.5772$. If all three random variables that enter (C.8) were jointly normally distributed, a representation like (C.8) would always be true. However, in our case, one of the variables, ε_2, is not normally distributed; therefore, (C.8) represents an approximation to the true relation. Before we proceed, we need the following result: Consider the joint distribution of the error term $\theta\varepsilon_2$ and the event that the individual is working. We have

$$P\left(\theta\varepsilon_2 < x, \text{individual works}\right) = P\left(\theta\varepsilon_2 < x, V > U_0\right)q.$$

From this relation, it follows that

$$P\left(\theta\varepsilon_2 < x \middle| \text{individual works}\right) = P\left(\theta\varepsilon_2 < x \middle| V > U_0\right).$$

From Lemma 1, it follows that

(C.9) $$
\begin{aligned}
&P\left(\theta\varepsilon_2 < x \middle| V > U_0\right) = P\left(\max\left(V, U_0\right) < x + \theta v_2\right) \\
&= \exp\left(-\left(1 + \exp\left(-Z\gamma - \theta v_2 + \tilde{c}/q - \tilde{c}\right)/\mu\right)e^{-x}\right).
\end{aligned}
$$

We realize that we can set $\mu = 1$ in the expression in (C.9) without loss of generality. Recall that the expectation of a stochastic variable that follows the type III extreme value distribution $\exp\left(-e^{b-x}\right)$ equals $b + 0.5772.$ Consequently, it follows from (C.9) that

$$E\left(\theta\varepsilon_2 \,\middle|\, V > U_0\right) = \log\left(1 + \exp\left((-Z\gamma - \theta v_2 + \tilde{c}/q - \tilde{c}\right)\right) + 0.5772$$

which is equivalent to

(C.10) $\quad E\left(\theta\varepsilon_2 \,\middle|\, V > U_0\right) = -\log P + 0.5772,$

where we recall that P is the probability of being in the labor force. As a result of (C.10) and assumption (C.1), we obtain

$$E\left(\eta \,\middle|\, \text{individual works}\right) = -\rho \log P.$$

Hence, the regression model to be estimated on our self-selected sample is given by

(C.11) $\quad \log W = \beta_0 + X\beta - \rho \log P + \eta^*.$

Equation (C.11) is similar to Heckman's selectivity corrected wage equation, apart from being derived from other distributional assumptions.

Consider finally the conditional variance of η given that the individual works. Note that it follows from (C.9) that the variance of the conditional distribution of $\theta\varepsilon_2$, given that the individual works, is equal to the unconditional variance (which is equal to $\pi^2/6$). Moreover, since η^* is independent of the error terms of the decision rule that governs the labor force participation entrance, we obtain

(C.12)
$$\begin{aligned} \text{Var}\left(\eta \,\middle|\, \text{individual works}\right) &= \rho^2 \text{Var}\left(\varepsilon_2 \,\middle|\, \text{individual works}\right) + \text{Var}\left(\eta^* \,\middle|\, \text{individual works}\right) \\ &= \rho^2 \text{Var}\varepsilon_2 + \text{Var}\eta^* = \text{Var}\eta. \end{aligned}$$

Hence, we have demonstrated that the variance of the error term in the wage equation is not affected by selection.

Appendix D: Supplementary calculations

This appendix provides supplementary calculations (Table D1-Table D5) to the ones presented in the main part of this paper as well as 2 figures. We now explain how these additional calculations are related to the tables in the main part of the paper. Note that the numbering of the tables in the appendix begins with a capital letter referring to appendix number, while the tables in the main part of the paper are numbered consecutively.

In Table D1 we report the share of persons outside the labor force, the share of unemployed persons and the share of employed persons for all years from 1988 to 2008. Note that these shares add identically to one. In Table 1 we report the share of employed and unemployed persons for 1995 only.

In Table D2 we report summary statistics for a selection of variables for the years 1988 to 2008, whereas the five last rows of Table 1 contain summary statistics for 1995.

Table D3 contains estimates of all the parameters in the model estimated on the full sample 1988–2008. These estimates are also found in Table 2, Tables A1 and A2 in Appendix A. For comparative reasons we in Table D3 also report estimates based on the sub-sample period 1988–2002.

In Table D4 we report mean quasi-elasticities related to participation *P(q)* and the discouraged worker effect *P(1)-P(q)* for all years in the time span 1988 to 2008, whereas Table 4 contains such information for the years 1988, 1995, 2002 and 2008.

In Table 5 we report the predicted probability of labor force participation and quasi-elasticities related to participation and the discouraged worker effect for 31 groups of women. Totally in Table D5 we consider 117 cases. Not all cases in Table 5 are included in Table D5. Instead, Table D5 shows the effects of larger variations in the covariates (in particular the number of children in different age intervals).

The estimated parameters of the wage equation are reported in Table A1. Here we display two figures, Figure D1 and Figure D2, which are based on the residuals of the wage equation, cf. η_{it}^{*} in the unnumbered equation at the beginning of Section 6 in the main part of the paper.

Tables

Table D1. Share of total number of persons in different labor market states

Year	Outside the labor force	Unemployed	Employed
1988	0.2012	0.0147	0.7841
1989	0.1825	0.0245	0.7930
1990	0.1791	0.0179	0.8030
1991	0.1582	0.0272	0.8146
1992	0.1627	0.0289	0.8084
1993	0.1306	0.0287	0.8407
1994	0.1424	0.0234	0.8341
1995	0.1319	0.0286	0.8394
1996	0.1189	0.0266	0.8545
1997	0.1116	0.0238	0.8646
1998	0.0952	0.0166	0.8883
1999	0.1106	0.0110	0.8785
2000	0.0886	0.0153	0.8960
2001	0.0789	0.0127	0.9084
2002	0.0904	0.0129	0.8966
2003	0.0848	0.0203	0.8949
2004	0.0722	0.0221	0.9057
2005	0.0630	0.0242	0.9128
2006	0.0703	0.0163	0.9134
2007	0.0514	0.0069	0.9416
2008	0.0449	0.0101	0.9450

Table D2. Summary statistics of selected variables

Year	Statistic	Real wage rate	Real non-labor income	Age	Length of schooling	No. of children aged 0-3 years	No. of children aged 4-6 years	No. of children aged 7-18 years	Dummy for region
1988	Mean	103.4	183,410	41.2	10.9	0.23	0.20	0.76	0.77
	Std. dev.	33.0	79,865	9.4	2.4	0.50	0.44	0.90	0.42
	Min	32.1	90	25	6	0	0	0	0
	Max	251.3	495,167	60	20	3	2	4	1
	# obs.	1,869	2,515	2,515	2,515	2,515	2,515	2,515	2,515
1989	Mean	104.0	181,535	40.6	11.0	0.26	0.20	0.76	0.76
	Std. dev.	34.2	78,589	9.5	2.4	0.53	0.43	0.91	0.43
	Min	35.6	173	25	6	0	0	0	0
	Max	320.0	518,227	60	20	3	2	5	1
	# obs.	2,490	3,309	3,309	3,309	3,309	3,309	3,309	3,309
1990	Mean	108.8	184,808	41.3	11.2	0.24	0.20	0.79	0.76
	Std. dev.	36.4	79,020	9.2	2.6	0.50	0.44	0.91	0.43
	Min	36.6	250	25	6	0	0	0	0
	Max	348.3	556,812	60	20	3	3	5	1
	# obs.	2,745	3,579	3,579	3,579	3,579	3,579	3,579	3,579
1991	Mean	112.5	185,637	41.1	11.3	0.26	0.20	0.79	0.75
	Std. dev.	37.1	86,127	9.2	2.6	0.53	0.43	0.94	0.43
	Min	43.6	245	25	6	0	0	0	0
	Max	336.1	586,645	60	20	3	3	5	1
	# obs.	2,831	3,641	3,641	3,641	3,641	3,641	3,641	3,641
1992	Mean	113.7	192,916	41.6	11.4	0.24	0.20	0.81	0.75
	Std. dev.	39.8	91,125	9.0	2.6	0.50	0.44	0.94	0.43
	Min	38.6	157	25	6	0	0	0	0
	Max	461.8	585,174	60	20	3	2	6	1
	# obs.	2,761	3,565	3,565	3,565	3,565	3,565	3,565	3,565
1993	Mean	113.3	188,065	40.8	11.5	0.30	0.20	0.80	0.75
	Std. dev.	38.3	89,738	9.3	2.6	0.56	0.43	0.95	0.43
	Min	37.5	77	25	6	0	0	0	0
	Max	367.5	613,993	60	20	3	3	6	1
	# obs.	3,119	3,873	3,873	3,873	3,873	3,873	3,873	3,873
1994	Mean	114.3	189,919	40.9	11.5	0.30	0.23	0.75	0.77
	Std. dev.	38.7	88,717	9.3	2.6	0.56	0.47	0.92	0.42
	Min	40.5	76	25	6	0	0	0	0
	Max	419.4	621,121	60	20	3	3	5	1
	# obs.	3,158	3,967	3,967	3,967	3,967	3,967	3,967	3,967
1995	Mean	117.5	198,031	41.0	11.9	0.31	0.23	0.76	0.76
	Std. dev.	40.8	92,513	9.2	2.7	0.56	0.47	0.93	0.43
	Min	44.2	148	25	6	0	0	0	0
	Max	395.7	669,920	60	20	3	3	5	1
	# obs.	3,221	4,017	4,017	4,017	4,017	4,017	4,017	4,017
1996	Mean	121.1	202,979	41.0	12.0	0.30	0.23	0.77	0.76
	Std. dev.	42.7	96,071	9.3	2.7	0.55	0.46	0.94	0.43
	Min	42.6	147	25	6	0	0	0	0
	Max	454.5	700,312	60	20.0	4	2	8	1
	# obs.	2,751	3,340	3,340	3,340	3,340	3,340	3,340	3,340

Table D2 (continued)

Year	Statistic	Real wage rate	Real non-labor income	Age	Length of schooling	No. of children aged 0-3 years	No. of children aged 4-6 years	No. of children aged 7-18 years	Dummy for region
1997	Mean	119.4	207,132	40.9	12.0	0.31	0.24	0.79	0.74
	Std. dev.	38.1	102,665	9.2	2.6	0.56	0.48	0.97	0.44
	Min	28.4	356	25	6	0	0	0	0
	Max	395.4	724,098	60	20	3	3	7	1
	# obs.	2,043	2,437	2437	2,437	2,437	2,437	2,437	2,437
1998	Mean	123.2	213,547	41.5	11.99	0.31	0.23	0.78	0.76
	Std. dev.	40.5	100,267	9.42	2.64	0.55	0.46	0.97	0.43
	Min	36.0	1,119	25	6	0	0	0	0
	Max	436.1	768,440	60	20	3	2	6	1
	# obs.	1,812	2,112	2,112	2,112	2,112	2,112	2,112	2,112
1999	Mean	129.1	218,923	41.4	12.3	0.31	0.22	0.77	0.74
	Std. dev.	48.5	107,802	9.46	2.72	0.56	0.46	0.98	0.44
	Min	37.2	616	25	6	0	0	0	0
	Max	482.3	817,057	60	20	3	3	8	1
	# obs.	1,784	2,098	2,098	2,098	2,098	2,098	2,098	2,098
2000	Mean	127.9	221,905	42.2	12.2	0.28	0.21	0.77	0.76
	Std. dev.	42.1	108,382	9.38	2.72	0.54	0.45	0.98	0.43
	Min	37.6	798	25	6	0	0	0	0
	Max	377.7	853,378	60	20	3	2	5	1
	# obs.	1,805	2,087	2,087	2,087	2,087	2,087	2,087	2,087
2001	Mean	130.5	230,601	42.0	12.5	0.3	0.23	0.76	0.76
	Std. dev.	43.3	114,113	9.3	2.75	0.55	0.48	0.96	0.43
	Min	40.2	776	25	6	0	0	0	0
	Max	438.7	883,351	60	20	3	3	7	1
	# obs.	1,863	2,128	2,128	2,128	2,128	2,128	2,128	2,128
2002	Mean	135.5	236,136	42.3	12.5	0.28	0.22	0.78	0.77
	Std. dev.	46.0	119,495	9.48	2.71	0.53	0.45	0.99	0.42
	Min	44.8	640	25	6	0	0	0	0
	Max	480.8	921,201	60	20	3	3	7	1
	# obs.	1,876	2,167	2,167	2,167	2,167	2,167	2,167	2,167
2003	Mean	136.5	242,309	42.6	12.6	0.28	0.21	0.8	0.78
	Std. dev.	46.4	125,704	9.54	2.76	0.55	0.44	0.99	0.42
	Min	32.3	612	25	6	0	0	0	0
	Max	426.4	1,001,500	60	20	3	2	6	1
	# obs.	1,705	1,970	1,970	1,970	1,970	1970	1,970	1,970
2004	Mean	143.3	248,826	43.0	12.7	0.2	0.2	0.82	0.75
	Std. dev.	50.6	132,185	9.39	2.75	0.44	0.44	0.97	0.43
	Min	34.0	131	25	6	0	0	0	0
	Max	501.4	1,008,552	60	20	2	2	5	1
	# obs.	1,783	2,035	2,035	2,035	2,035	2,035	2,035	2,035
2005	Mean	144.7	255,517	42.9	12.8	0.27	0.21	0.79	0.78
	Std. dev.	45.5	135,670	9.34	2.77	0.54	0.45	0.96	0.42
	Min	49.1	369	25	6	0	0	0	0
	Max	434.6	1,033,620	60	20	3	2	4	1
	# obs.	1,756	1984	1,984	1,984	1,984	1,984	1,984	1,984

Table D2 (continued)

Year	Statistic	Real wage rate	Real non-labor income	Age	Length of schooling	No. of children aged 0-3 years	No. of children aged 4-6 years	No. of children aged 7-18 years	Dummy for region
2006	Mean	149.4	268,684	42.9	12.9	0.25	0.21	0.85	0.77
	Std. dev.	48.0	136,080	9.35	2.73	0.52	0.45	1.01	0.42
	Min	34.2	891	25	6	0	0	0	0
	Max	376.6	1,066,317	60	20	3	2	5	1
	# obs.	1,675	1,905	1,905	1,905	1,905	1,905	1,905	1,905
2007	Mean	157.6	272,085	42.8	13.6	0.29	0.2	0.83	0.78
	Std. dev.	53.2	132,355	9.5	2.63	0.55	0.43	0.99	0.41
	Min	51.3	466	25	6	0	0	0	0
	Max	511.7	902,559	60	20	3	2	5	1
	# obs.	1,301	1,439	1,439	1,439	1,439	1,439	1,439	1,439
2008	Mean	161.4	292,542	43.1	13.8	0.26	0.21	0.86	0.78
	Std. dev.	53.0	146,412	9.19	2.57	0.52	0.45	1	0.41
	Min	55.3	589	25	6	0	0	0	0
	Max	443.1	1,094,695	60	20	3	3	5	1
	# obs.	2,981	3,272	3,272	3,272	3,272	3,272	3,272	3,272

Table D3. Estimates of parameters using the full data set for 1988–2008 and the subsample data-set for 1988–2002

	1988–2008		1988–2002	
	Estimate	t-value	Estimate	t-value
Variables entering the expression for *q*:				
Length of schooling	0.2717	19.1616	0.2794	16.6454
Experience	0.0908	7.4278	0.1031	7.5177
$(\text{Experience}/10)^2$	–0.1084	–4.5051	–0.1322	–4.8976
Number of children aged 0−3 years	–0.0367	–0.8400	–0.0249	–0.5034
Number of children aged 4−6 years	–0.1039	–2.2367	–0.1074	–2.0067
Number of children aged 7−18 years	–0.0987	–3.8540	–0.1240	–4.0613
log real nonlabor income	0.2260	12.9338	0.2360	11.8378
Dummy for 1988	–3.3332	–10.4278	–3.6076	–9.8732
Dummy for 1989	–3.2879	–10.3005	–3.5794	–9.7791
Dummy for 1990	–3.3743	–10.3936	–3.6703	–9.8328
Dummy for 1991	–3.4764	–10.5414	–3.8174	–9.9888
Dummy for 1992	–3.5219	–10.7085	–3.8693	–10.1467
Dummy for 1993	–3.2850	–10.1205	–3.6300	–9.6680
Dummy for 1994	–3.3006	–10.2029	–3.6388	–9.7182
Dummy for 1995	–3.4544	–10.5567	–3.8173	–10.0382
Dummy for 1996	–3.3970	–10.2651	–3.7651	–9.7802
Dummy for 1997	–3.3256	–9.9607	–3.6884	–9.5270
Dummy for 1998	–3.1017	–9.1739	–3.4565	–8.8570
Dummy for 1999	–3.3035	–9.6494	–3.6585	–9.1775
Dummy for 2000	–3.1868	–9.1884	–3.5518	–8.8395
Dummy for 2001	–3.0551	–8.7289	–3.4261	–8.4478
Dummy for 2002	–3.3891	–9.7033	–3.7751	–9.2430
Dummy for 2003	–3.5105	–10.0073		
Dummy for 2004	–3.6420	–10.3827		
Dummy for 2005	–3.6552	–10.1738		
Dummy for 2006	–3.6332	–9.9934		
Dummy for 2007	–3.4821	–8.9531		
Dummy for 2008	–3.3506	–8.9286		

Table D3 (continued)

	1988–2008		1988–2002	
	Estimate	t-value	Estimate	t-value
Variables entering the real wage equation:				
Length of schooling	0.0415	63.2885	0.0390	51.2386
Experience	0.0175	27.3790	0.0162	21.9481
$(\text{Experience}/10)^2$	–0.0268	–20.3686	–0.0251	–16.5596
Dummy for densely populated area	0.0271	9.1890	0.0251	7.7436
Dummy for 1988	3.8676	258.3510	3.9187	230.0770
Dummy for 1989	3.8769	267.0807	3.9286	236.3089
Dummy for 1990	3.9037	270.2732	3.9543	239.1169
Dummy for 1991	3.9420	275.8603	3.9926	244.3919
Dummy for 1992	3.9422	271.2966	3.9931	240.6759
Dummy for 1993	3.9480	279.5194	3.9996	247.0133
Dummy for 1994	3.9523	278.3426	4.0029	245.9650
Dummy for 1995	3.9678	277.7944	4.0193	245.7575
Dummy for 1996	3.9927	280.2320	4.0436	248.4667
Dummy for 1997	3.9863	272.0027	4.0375	243.1077
Dummy for 1998	4.0133	274.8805	4.0642	246.0315
Dummy for 1999	4.0351	277.9447	4.0845	247.9648
Dummy for 2000	4.0378	274.8990	4.0884	246.2095
Dummy for 2001	4.0497	274.2861	4.1006	245.4237
Dummy for 2002	4.0787	276.8074	4.1286	247.5143
Dummy for 2003	4.0789	276.2117		
Dummy for 2004	4.1202	277.6105		
Dummy for 2005	4.1423	274.6959		
Dummy for 2006	4.1590	271.5570		
Dummy for 2007	4.1804	264.3797		
Dummy for 2008	4.1990	284.8828		
Selection effect, $-\log P$	0.0026	0.2107	–0.0074	–0.5726
Variance of real wage equation	0.0886	208.6418	0.0888	179.7285
Variables entering the expression for the participation probability:				
Predicted log real wage	4.1293	22.2685	4.7740	17.2953
Intercept	–10.5602	–9.5639	–13.6246	–8.8208
Age	–0.0274	–1.2168	–0.0280	–1.1699
$(\text{Age}/10)^2$	–0.0547	–2.1339	–0.0540	–1.9767
log of real nonlabor income	–0.2884	–10.7158	–0.2884	–9.9887
Number of children aged 0−3 years	–1.0466	–24.3394	–1.0590	–23.6529
Number of children aged 4−6 years	–0.6929	–15.2760	–0.7058	–14.7784
Number of children aged 7−18 years	–0.2734	–11.2493	–0.2725	–10.3395
Discouraged worker effect	19.0884	9.5468	16.3601	7.6368
Number of observations	57,440		44.835	
log-likelihood value	9,595.77		5,282.75	

Table D4. Mean quasi-elasticities of labor market participation and discouraged worker effect

Year	Quasi-elasticity of participation probability, *P(q)*[a]			Quasi-elasticity of discouraged worker effect, *P(1)-P(q)*[b]	
	E^P_{EW}	E^P_{Z4}	$E^P_{(1-q)}$	E^D_{EW}	E^D_{Z4}
1988	0.6011	–0.0420	–4.1457	–0.1883	0.0131
1989	0.5779	–0.0404	–3.9159	–0.1779	0.0124
1990	0.5434	–0.0379	–3.6612	–0.1755	0.0123
1991	0.5079	–0.0355	–3.4078	–0.1841	0.0129
1992	0.5130	–0.0358	–3.4736	–0.1872	0.0131
1993	0.4677	–0.0327	–2.9741	–0.1482	0.0104
1994	0.4649	–0.0325	–2.9865	–0.1471	0.0103
1995	0.4570	–0.0319	–2.9659	–0.1580	0.0110
1996	0.4158	–0.0290	–2.6132	–0.1406	0.0098
1997	0.4131	–0.0289	–2.5323	–0.1300	0.0091
1998	0.3603	–0.0252	–2.0956	–0.0945	0.0066
1999	0.3472	–0.0242	–2.0505	–0.1061	0.0074
2000	0.3278	–0.0229	–1.8634	–0.0898	0.0063
2001	0.3024	–0.0211	–1.6724	–0.0715	0.0050
2002	0.2992	–0.0209	–1.7016	–0.0943	0.0066
2003	0.3111	–0.0217	–1.8138	–0.1057	0.0074
2004	0.2674	–0.0187	–1.5360	–0.1016	0.0071
2005	0.2604	–0.0182	–1.4900	–0.0986	0.0069
2006	0.2402	–0.0168	–1.3685	–0.0877	0.0061
2007	0.1768	–0.0123	–0.9308	–0.0507	0.0035
2008	0.1536	–0.0107	–0.7889	–0.0370	0.0026

[a] Cf. Eqs. (23)-(25) for formal definition of the quasi-elasticities; [b] Cf. Eqs. (26)-(27) for formal definition of the quasi-elasticities.

Table D5. Probability of being in the labor force and quasi–elasticities of labor market participation and discouraged worker effect for different groups of females

Case	Real wage rate[a]	Real non–labor income[a]	Age	Number of children			Probability of getting an acceptable job, given search, *q*	Probability of labor force participation, *P(q)*	Quasi–elasticity of participation probability, *P(q)*[b]			Quasi–elasticity of discouraged worker effect, *P(1)–P(q)*[c]	
				aged 0–3 years	aged 4–6 years	aged 7–18 years			E^P_{EW}	E^P_{Z4}	E^P_u	E^D_{EW}	E^D_{Z4}
1	100	100,000	30	0	0	0	0.92	0.897	0.382	–0.027	–2.087	–0.296	0.021
2	100	100,000	30	0	0	0	0.97	0.962	0.151	–0.011	–0.741	–0.064	0.004
3	100	100,000	30	0	0	0	1	0.979	0.087	–0.006	–0.400		
4	100	100,000	30	1	0	0	0.92	0.753	0.768	–0.054	–4.192	–0.540	0.038
5	100	100,000	30	1	0	0	0.97	0.899	0.375	–0.026	–1.843	–0.147	0.010
6	100	100,000	30	1	0	0	1	0.941	0.228	–0.016	–1.054		
7	100	100,000	30	0	1	0	0.92	0.813	0.628	–0.044	–3.429	–0.462	0.032
8	100	100,000	30	0	1	0	0.97	0.927	0.280	–0.020	–1.376	–0.114	0.008
9	100	100,000	30	0	1	0	1	0.958	0.166	–0.012	–0.767		
10	100	100,000	30	0	0	1	0.92	0.869	0.471	–0.033	–2.574	–0.359	0.025
11	100	100,000	30	0	0	1	0.97	0.951	0.194	–0.014	–0.952	–0.081	0.006
12	100	100,000	30	0	0	1	1	0.972	0.112	–0.008	–0.519		
13	100	100,000	30	1	1	1	0.92	0.537	1.027	–0.072	–5.607	–0.527	0.037
14	100	100,000	30	1	1	1	0.97	0.772	0.727	–0.051	–3.572	–0.228	0.016
15	100	100,000	30	1	1	1	1	0.859	0.499	–0.035	–2.308		
16	100	100,000	30	1	2	2	0.92	0.306	0.878	–0.061	–4.793	–0.009	0.001
17	100	100,000	30	1	2	2	0.97	0.563	1.016	–0.071	–4.992	–0.147	0.010
18	100	100,000	30	1	2	2	1	0.699	0.869	–0.061	–4.015		

Table D5 (Continued)

Case	Real wage rate[a]	Real non–labor income[a]	Age	Number of children			Probability of getting an acceptable job, given search, q	Probability of labor force participation, $P(q)$	Quasi–elasticity of participation probability, $P(q)$[b]			Quasi–elasticity of discouraged worker effect, $P(1)–P(q)$[c]	
				aged 0–3 years	aged 4–6 years	aged 7–18 years			E^P_{EW}	E^P_{Z4}	E^P_u	E^D_{EW}	E^D_{Z4}
19	100	300,000	30	1	0	0	0.92	0.690	0.884	–0.062	–4.826	–0.584	0.041
20	100	300,000	30	1	0	0	0.97	0.866	0.478	–0.033	–2.350	–0.179	0.012
21	100	300,000	30	1	0	0	1	0.921	0.300	–0.021	–1.386		
22	100	300,000	30	0	1	0	0.92	0.760	0.753	–0.053	–4.114	–0.533	0.037
23	100	300,000	30	0	1	0	0.97	0.902	0.364	–0.025	–1.790	–0.144	0.010
24	100	300,000	30	0	1	0	1	0.943	0.221	–0.015	–1.020		
25	100	300,000	30	0	0	1	0.92	0.828	0.588	–0.041	–3.211	–0.437	0.031
26	100	300,000	30	0	0	1	0.97	0.933	0.256	–0.018	–1.260	–0.105	0.007
27	100	300,000	30	0	0	1	1	0.962	0.151	–0.011	–0.697		
28	100	300,000	30	1	1	1	0.92	0.458	1.025	–0.072	–5.599	–0.406	0.028
29	100	300,000	30	1	1	1	0.97	0.711	0.848	–0.059	–4.165	–0.229	0.016
30	100	300,000	30	1	1	1	1	0.816	0.619	–0.043	–2.861		
31	100	300,000	30	1	2	2	0.92	0.243	0.761	–0.053	–4.154	0.203	–0.014
32	100	300,000	30	1	2	2	0.97	0.484	1.031	–0.072	–5.067	–0.067	0.005
33	100	300,000	30	1	2	2	1	0.629	0.964	–0.067	–4.456		
34	200	100,000	30	1	0	0	0.92	0.982	0.074	–0.005	–0.407	–0.060	0.004
35	200	100,000	30	1	0	0	0.97	0.994	0.026	–0.002	–0.129	–0.012	0.001
36	200	100,000	30	1	0	0	1	0.996	0.015	–0.001	–0.067		
37	200	100,000	30	0	1	0	0.92	0.987	0.053	–0.004	–0.289	–0.043	0.003
38	200	100,000	30	0	1	0	0.97	0.996	0.018	–0.001	–0.091	–0.008	0.001
39	200	100,000	30	0	1	0	1	0.998	0.010	–0.001	–0.047		
40	200	100,000	30	0	0	1	0.92	0.991	0.035	–0.002	–0.192	–0.028	0.002
41	200	100,000	30	0	0	1	0.97	0.997	0.012	–0.001	–0.060	–0.005	0.000
42	200	100,000	30	0	0	1	1	0.998	0.007	0.000	–0.031		
43	200	100,000	30	1	1	1	0.92	0.953	0.185	–0.013	–1.008	–0.147	0.010
44	200	100,000	30	1	1	1	0.97	0.983	0.067	–0.005	–0.331	–0.030	0.002
45	200	100,000	30	1	1	1	1	0.991	0.038	–0.003	–0.175		
46	200	100,000	30	1	2	2	0.92	0.885	0.419	–0.029	–2.287	–0.322	0.022
47	200	100,000	30	1	2	2	0.97	0.958	0.168	–0.012	–0.826	–0.071	0.005
48	200	100,000	30	1	2	2	1	0.976	0.097	–0.007	–0.447		
49	250	300,000	30	0	0	0	0.92	0.996	0.015	–0.001	–0.080	–0.012	0.001
50	250	300,000	30	0	0	0	0.97	0.999	0.005	–0.000	–0.025	–0.002	0.000
51	250	300,000	30	0	0	0	1	0.999	0.003	–0.000	–0.013		
52	250	300,000	30	1	0	0	0.92	0.990	0.041	–0.003	–0.226	–0.033	0.002
53	250	300,000	30	1	0	0	0.97	0.997	0.014	–0.001	–0.071	–0.006	0.000
54	250	300,000	30	1	0	0	1	0.998	0.008	–0.001	–0.037		
55	250	300,000	30	0	1	0	0.92	0.993	0.029	–0.002	–0.160	–0.024	0.002
56	250	300,000	30	0	1	0	0.97	0.998	0.010	–0.001	–0.050	–0.005	0.000
57	250	300,000	30	0	1	0	1	0.999	0.006	–0.000	–0.026		
58	250	300,000	30	0	0	1	0.92	0.995	0.019	–0.001	–0.105	–0.016	0.001
59	250	300,000	30	0	0	1	0.97	0.998	0.007	–0.000	–0.033	–0.003	0.000
60	250	300,000	30	0	0	1	1	0.999	0.004	–0.000	–0.017		
61	250	300,000	30	1	1	1	0.92	0.974	0.105	–0.007	–0.575	–0.084	0.006
62	250	300,000	30	1	1	1	0.97	0.991	0.037	–0.003	–0.184	–0.017	0.001
63	250	300,000	30	1	1	1	1	0.995	0.021	–0.001	–0.097		
64	250	300,000	30	1	2	2	0.92	0.934	0.255	–0.018	–1.390	–0.200	0.014
65	250	300,000	30	1	2	2	0.97	0.976	0.095	–0.007	–0.469	–0.041	0.003
66	250	300,000	30	1	2	2	1	0.987	0.054	–0.004	–0.250		
67	100	300,000	45	0	1	0	0.92	0.532	1.028	–0.072	–5.616	–0.521	0.036
68	100	300,000	45	0	1	0	0.97	0.768	0.736	–0.051	–3.617	–0.229	0.016
69	100	300,000	45	0	1	0	1	0.856	0.508	–0.035	–2.346		
70	100	300,000	45	0	0	1	0.92	0.633	0.959	–0.067	–5.238	–0.590	0.041
71	100	300,000	45	0	0	1	0.97	0.834	0.571	–0.040	–2.807	–0.202	0.014
72	100	300,000	45	0	0	1	1	0.901	0.369	–0.026	–1.706		

Table D5 (Continued)

Case	Real wage rate[a]	Real non–labor income[a]	Age	Number of children			Probability of getting an acceptable job, given search, q	Probability of labor force partici-pation, $P(q)$	Quasi–elasticity of participation probability, $P(q)^b$			Quasi–elasticity of discouraged worker effect, $P(1)–P(q)^c$	
				aged 0–3 years	aged 4–6 years	aged 7–18 years			E^P_{EW}	E^P_{Z4}	E^P_u	E^D_{EW}	E^D_{Z4}
73	100	300,000	45	0	2	3	0.92	0.200	0.661	–0.046	–3.607	0.353	–0.025
74	100	300,000	45	0	2	3	0.97	0.421	1.007	–0.070	–4.946	0.007	0.000
75	100	300,000	45	0	2	3	1	0.568	1.013	–0.071	–4.684		
76	200	100,000	45	0	1	0	0.92	0.965	0.141	–0.010	–0.770	–0.113	0.008
77	200	100,000	45	0	1	0	0.97	0.988	0.051	–0.004	–0.249	–0.022	0.002
78	200	100,000	45	0	1	0	1	0.993	0.028	–0.002	–0.131		
79	200	100,000	45	0	0	1	0.92	0.976	0.095	–0.007	–0.519	–0.076	0.005
80	200	100,000	45	0	0	1	0.97	0.992	0.034	–0.002	–0.165	–0.015	0.001
81	200	100,000	45	0	0	1	1	0.995	0.019	–0.001	–0.087		
82	200	100,000	45	0	2	3	0.92	0.857	0.505	–0.035	–2.761	–0.383	0.027
83	200	100,000	45	0	2	3	0.97	0.946	0.211	–0.015	–1.038	–0.088	0.006
84	200	100,000	45	0	2	3	1	0.969	0.123	–0.009	–0.568		
85	250	300,000	45	0	0	0	0.92	0.990	0.041	–0.003	–0.222	–0.033	0.002
86	250	300,000	45	0	0	0	0.97	0.997	0.014	–0.001	–0.069	–0.006	0.000
87	250	300,000	45	0	0	0	1	0.998	0.008	–0.001	–0.036		
88	250	300,000	45	0	1	0	0.92	0.980	0.080	–0.006	–0.434	–0.064	0.004
89	250	300,000	45	0	1	0	0.97	0.993	0.028	–0.002	–0.138	–0.012	0.001
90	250	300,000	45	0	1	0	1	0.996	0.016	–0.001	–0.072		
91	250	300,000	45	0	0	1	0.92	0.987	0.053	–0.004	–0.289	–0.043	0.003
92	250	300,000	45	0	0	1	0.97	0.995	0.019	–0.001	–0.091	–0.008	0.001
93	250	300,000	45	0	0	1	1	0.998	0.010	–0.001	–0.048		
94	250	300,000	45	0	2	3	0.92	0.917	0.316	–0.022	–1.724	–0.247	0.017
95	250	300,000	45	0	2	3	0.97	0.970	0.121	–0.008	–0.596	–0.052	0.004
96	250	300,000	45	0	2	3	1	0.983	0.069	–0.005	–0.319		
97	350	300,000	45	0	0	0	0.92	0.998	0.010	–0.001	–0.056	–0.008	0.001
98	350	300,000	45	0	0	0	0.97	0.999	0.004	–0.000	–0.017	–0.002	0.000
99	350	300,000	45	0	0	0	1	1.000	0.002	–0.000	–0.009		
100	350	300,000	45	0	1	0	0.92	0.995	0.020	–0.001	–0.112	–0.017	0.001
101	350	300,000	45	0	1	0	0.97	0.998	0.007	–0.000	–0.035	–0.003	0.000
102	350	300,000	45	0	1	0	1	0.999	0.004	–0.000	–0.018		
103	350	300,000	45	0	0	1	0.92	0.997	0.013	–0.001	–0.074	–0.011	0.001
104	350	300,000	45	0	0	1	0.97	0.999	0.005	–0.000	–0.023	–0.002	0.000
105	350	300,000	45	0	0	1	1	0.999	0.003	–0.000	–0.012		
106	350	300,000	45	0	0	3	0.92	0.994	0.023	–0.002	–0.126	–0.019	0.001
107	350	300,000	45	0	0	3	0.97	0.998	0.008	–0.001	–0.039	–0.004	0.000
108	350	300,000	45	0	0	3	1	0.999	0.004	–0.000	–0.021		
109	250	250,000	55	0	0	0	0.92	0.979	0.085	–0.006	–0.467	–0.069	0.005
110	250	250,000	55	0	0	0	0.97	0.993	0.030	–0.002	–0.148	–0.013	0.001
111	250	250,000	55	0	0	0	1	0.996	0.017	–0.001	–0.078		
112	250	250,000	55	0	0	1	0.92	0.972	0.111	–0.008	–0.606	–0.089	0.006
113	250	250,000	55	0	0	1	0.97	0.990	0.039	–0.003	–0.194	–0.017	0.001
114	250	250,000	55	0	0	1	1	0.995	0.022	–0.002	–0.102		
115	250	250,000	55	0	0	3	0.92	0.953	0.184	–0.013	–1.006	–0.146	0.010
116	250	250,000	55	0	0	3	0.97	0.983	0.067	–0.005	–0.330	–0.029	0.002
117	250	250,000	55	0	0	3	1	0.991	0.038	–0.003	–0.175		

[a] In NOK (1998–prices); [b] Cf. Eqs. (23)–(25) for formal definition of the quasi–elasticities; [c] Cf. Eqs. (26)–(27) for formal definition of the quasi–elasticities.

Figures

Figure D1. QQ-plot of the residuals in the real wage equation

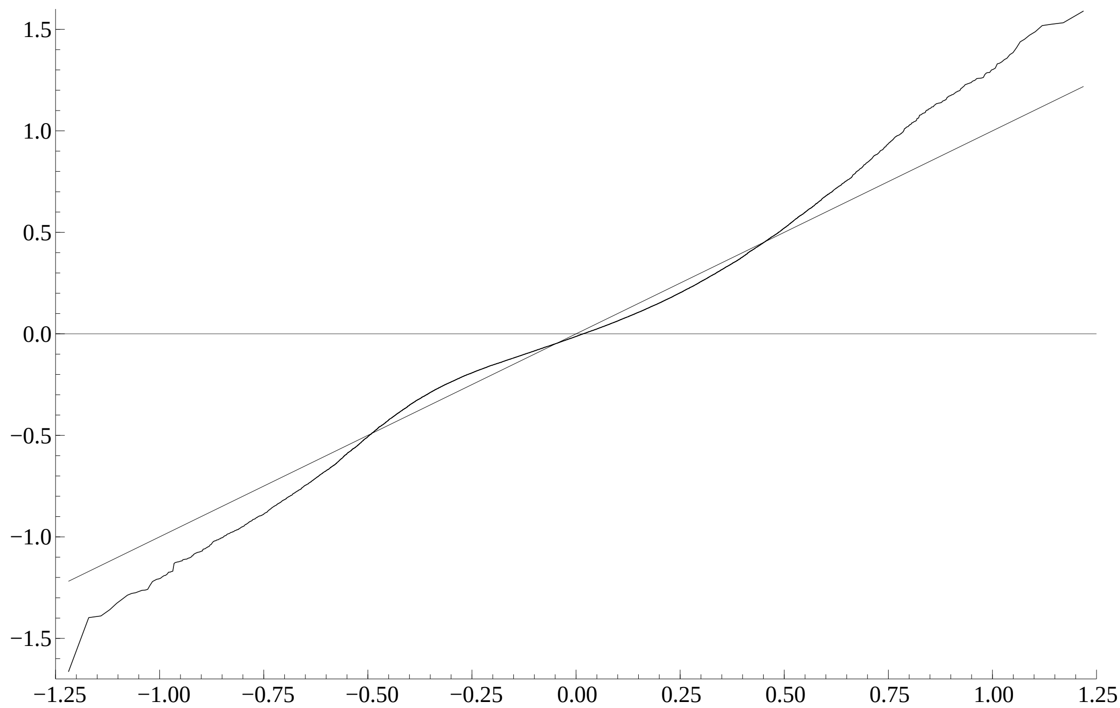

Figure D2. Density of the residuals in the real wage equation