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Search for Nonwage Job Characteristics: A Test of the Reservation Wage Hypothesis

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Previous structural models of job search behavior have been based upon the reservation wage property. This article provides estimates of a more general search model that nests models with the reservation wage property. The estimates lead to rejection of the reservation wage property. The model includes hours of work in the utility function, but other nonwage job characteristics can be included as well. An experiment based on the estimated parameters indicates that a significant proportion of job offers would be mistakenly predicted to be accepted or rejected under the restrictions implied by the reservation wage property.

I. Introduction

Estimation of structural models of job search behavior has become increasingly common. Examples include Kiefer and Neumann (1979); Flinn and Heckman (1982); Lancaster and Chesher (1983); Narendranathan and Nickell (1985); Jensen and Westergaard-Nielsen (1987); Wolpin (1987); Stern (1989); and Eckstein and Wolpin (1990). Such studies can provide greater insight into the job search process than studies based on reduced form estimates. For example, the issue of whether observed unemployment

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durations are accounted for mainly by the rate of arrival of job offers or by the selectivity of searchers in accepting offers has begun to be addressed.

All of the structural models of job search that have been estimated to date have assumed that the optimal search strategy has the reservation wage property.¹ This means, among other things, that searchers are assumed to be risk neutral (or risk averse with no recall of past offers), place no value on nonwage characteristics of jobs, and face a known and stationary distribution of wage offers. Some of these assumptions have been shown to be inconsistent with evidence in other contexts. For example, workers seem to care about the number of hours they work according to the labor supply literature (see, e.g., Killingsworth and Heckman 1986; and Pencavel 1986), and they also seem to behave as if other nonwage job characteristics matter (see, e.g., Woodbury 1983). None of the studies in which structural models were estimated explicitly tested the reservation wage property.

In this article, I estimate a job search model in which utility when employed depends on weekly hours of work in addition to weekly earnings.² It is straightforward to show that such a model does not have the reservation wage property but instead has the reservation utility property. My estimates lead to rejection of the restrictions implied by the reservation wage property. More important, I find that imposing the reservation wage property on the model results in estimates that lead to a high frequency of incorrect predictions about acceptance or rejection of offers. This calls into question the value of predictions based on models estimated under the assumption that the reservation wage property holds.

The contribution of this article may be viewed as a generalization of the typical empirical structural job search model and also as an effort to link empirical search models more closely to the literature on hours of work. The model presented here is consistent with alternative models of hours of work found in the literature. For example, the implicit contracts literature typically assumes that hours and earnings are part of a take-it-or-leave-it job package offered by firms (Abowd and Card 1987). In this model, workers are assumed to have no access to capital markets. Long-term con-

¹ Most of the studies cited assume that the unit of measurement for the reservation wage is a week. Stern (1989) measures wages on a daily basis, Jensen and Westergaard-Nielsen (1987) on a monthly basis, and Flinn and Heckman (1982) on an hourly basis. The key point is that all previous studies assume income maximization. In this article the wage is measured on a weekly basis, so the reservation-wage hypothesis is actually the reservation-weekly-earnings hypothesis.

² The estimation method used in this study can easily incorporate multiple nonwage job characteristics. This extension was not implemented because of lack of data on additional job characteristics. See Rosen (1986, pp. 682–84) for a discussion of the literature on modeling hours of work as a nonpecuniary job characteristic. Khandker (1988) estimates a search model with two types of jobs, those with some form of nonwage payment (e.g., a bonus) and those without such payments. The method used in this article allows for a continuum of job types.

tracts between risk-averse workers and risk-neutral firms with access to capital markets provide smooth consumption paths for workers. Hedonic models of labor market equilibrium often treat hours of work as a non-pecuniary job characteristic that is fixed for a given job but varies across jobs and for which a compensating wage differential may exist in equilibrium (Rosen 1986). Labor supply models treat hours of work as subject to choice by the worker, given the hourly wage offered by the firm (e.g., Pencavel 1986). The results presented below can be interpreted within the context of any of these models, although it is not possible to use my results to test competing models of hours determination. Thus, this article shows that job search behavior and hours of work can be treated within a consistent empirical framework.³

In the remainder of the article I describe the model (Sec. II), discuss econometric issues (Sec. III), describe the data used (Sec. IV), present and discuss the estimates and tests (Sec. V), and summarize the article (Sec. VI).

II. The Model

The model I present here is based on the model estimated by Wolpin (1987), extended to incorporate nonwage job characteristics. The model considers the behavior of an unemployed worker who, by paying an exogenous cost C (measured in utility), can contact one firm each period and receive a job offer with known, exogenous probability λ_t , where t indexes the duration of search.⁴ Financial constraints are assumed to limit the search horizon to T periods, after which the searcher, if still unemployed, must accept the next offer received. Thus, if the current duration of search is $t < T$, then $T - t$ periods remain in which the worker can set a nonzero probability of rejecting an offer. If $t \geq T$, the worker must accept any offer. There are no layoffs or quits once a job is accepted.

An explicit functional form for utility is necessary for estimation, and the Cobb-Douglas utility function is one of the few tractable forms for this problem:

$$U = W^{\alpha_1} H^{\alpha_2}, \quad \alpha_1 \geq 0, \quad \alpha_2 \leq 0, \quad (1)$$

³ Burdett and Mortensen (1978) present a thorough analysis of a model in which job-search and labor-supply decisions are integrated. Their model has the reservation-wage property because hours are assumed to be freely chosen by workers as a function of offered wages. In the model I present below, the reservation-wage property is a special case.

⁴ In the context of the specification discussed below, in which utility is a function of hours and wages, it is possible to model the optimal choice of time and money inputs to search, but such a model is too complicated to estimate in the present context.

where U is per-period utility when employed at earnings of W per period and hours of work of H per period.⁵ In the estimation, a period is taken to be a week, so W and H can be thought of as weekly earnings and hours of work, respectively. In the expected-wealth-maximization model, the restrictions $\alpha_1 = 1$ and $\alpha_2 = 0$ are imposed. Job offers are assumed to be independently and identically distributed (i.i.d.) random draws from the known, stationary, joint distribution $F(x, y)$, where $F(x, y) = \text{pr}(W < x, H < y)$. For estimation purposes I assume a joint lognormal distribution:

$$\ln W = \mu_w + \varepsilon_1, \quad (2)$$

$$\ln H = \mu_H + \varepsilon_2, \quad (3)$$

$$E(\varepsilon_1) = E(\varepsilon_2) = 0, \quad (4)$$

and

$$E(\varepsilon_1^2) = \sigma_1^2, \quad E(\varepsilon_2^2) = \sigma_2^2, \quad E(\varepsilon_1 \varepsilon_2) = \sigma_{12}, \quad (5)$$

where E is the mathematical expectation operator. In this model, firms are viewed as offering workers a job consisting of specified levels of weekly earnings and hours. Given the assumptions of the model, the optimal search strategy for workers has the reservation utility property: any offer with utility exceeding the reservation utility level is accepted.⁶ The reservation

⁵ Identification of the utility function parameters is discussed below. Workers are assumed to have identical preferences. The estimation method, described below, requires explicit solutions for the expected value of utility, given that an acceptable offer was received. This requirement limits the choice of functional form for utility to the class of Cobb-Douglas and linear functions. Kiefer (1987) presents a model of search for wage-hour packages that is similar to the model given here. He argues (p. 218) that, if the utility function defined over, say, weekly consumption and leisure is increasing, concave, and has a positive cross derivative, then the utility function defined over the hourly wage and weekly hours of work should allow for the marginal utility of hours of work to be positive or negative, depending on whether offered hours are less than or greater than optimal hours at the offered wage rate. Equation (1) does not allow for this; instead the marginal utility of H is assumed to be negative for any value of H . This form is therefore not well suited for constrained utility maximization subject to a budget constraint. However, as discussed below, job offers are assumed to consist of a take-it-or-leave-it wage-hours package, so maximization of (1) subject to a budget constraint is not part of the model. Alternative functional forms for utility are discussed in Sec. V below.

⁶ Rosen (1978) analyzes a consumer-search model with multiple goods, which is formally similar to the present model (although it is not dynamic) and also yields a reservation utility strategy for search. Wilde (1979) considers the case in which the nonwage characteristic of the job is revealed only by working on the job and cannot be ascertained before accepting the job. Altonji and Paxson (1988) model the behavior of employed workers who search from a wage-hours distribution. They assume no search costs and exactly one offer per period.

utility level changes with the duration of search because of the finite horizon and the possibly nonstationary offer probability. In principle, these two factors can interact to produce any pattern of reservation utilities that is consistent with the eventual decline of reservation utility to zero at T . No attempt is made here to solve for an equilibrium distribution of earnings and hours. The existence of the latter is taken as given.

The value of being unemployed in period $t < T$ is

$$V_t = \lambda_t E \max \{ \delta_t U, -C + RV_{t+1} \} + (1 - \lambda_t) E(-C + RV_{t+1}), \quad (6)$$

where $\delta_t = \sum_{j=t}^T R^j$, $R = 1/(1 + r)$, r is the rate of time preference, τ is the horizon for labor force participation, E is the expectations operator, and the search cost is paid in period t for the chance to receive an offer in period $t + 1$. The value function consists of a weighted average of the expected value of the best option, given that an offer is received, where the options are accepting or rejecting the offer and the expected value of continued search, given no offer is received. The weights are λ_t and $1 - \lambda_t$, respectively. The reservation level of utility in period t , denoted θ_t , is defined by

$$\delta_t \theta_t = -C + RV_{t+1} \quad (7)$$

since, from (6), $-C + RV_{t+1}$ is the expected present discounted value of searching in an optimal manner until period T . Once period T is reached, financial constraints are assumed to force searchers to accept the next offer, that is, set $\theta_T = 0$, so the value of entering period T unemployed is

$$V_T = \sum_{j=T}^{\tau} (R^{j-T} [\prod_{k=T}^{j-1} (1 - \lambda_k)] [\lambda_j \delta_j EU - (1 - \lambda_j) C]), \quad (8)$$

where $\prod_{k=T}^{T-1} (\cdot) \equiv 1$, and $EU = \exp(\gamma + \frac{1}{2}\sigma^2)$ is the expected utility per period of a random job offer, with $\gamma = \alpha_1 \mu_w + \alpha_2 \mu_H$, and $\sigma^2 = \alpha_1^2 \sigma_1^2 + \alpha_2^2 \sigma_2^2 + 2\alpha_1 \alpha_2 \sigma_{12}$.

The advantage of the functional forms specified for utility and the wage-hours distribution is that they yield a tractable solution for the value function. V_t can be written as

$$\begin{aligned} V_t &= \lambda_t [E(\delta_t U | \delta_t U \geq \delta_t \theta_t) \cdot \text{pr}(\delta_t U \geq \delta_t \theta_t) + \delta_t \theta_t \cdot \text{pr}(\delta_t U < \delta_t \theta_t)] \\ &\quad + (1 - \lambda_t) \delta_t \theta_t \\ &= \lambda_t \{ \delta_t EU [1 - \Phi((\eta_t/\sigma) - \sigma)] + \delta_t \theta_t \Phi(\eta_t/\sigma) \} + (1 - \lambda_t) \delta_t \theta_t, \end{aligned}$$

where Φ is the standard normal cumulative distribution function (CDF),

and $\eta_t = \ln \theta_t - \gamma$. The first term in the square brackets is the expected present discounted value of the utility of a job offer, given that the offer is acceptable, multiplied by the probability that a random offer is acceptable. The second term in square brackets is the expected present discounted value of rejecting an offer and continuing to search according to the optimal strategy, multiplied by the probability that a random offer is unacceptable. The final term accounts for the probability of not receiving an offer. Substituting (7) into (9) yields a nonlinear difference equation for V_t that can be computed recursively from T backward, given parameter values. The value function and decision rule each period depend on all future values of λ_t , which are assumed to be known. This can be seen by successive substitution of (7) (updated) into (9). Hence the model generates truly forward-looking behavior.

In the following section, identification and estimation of the parameters are discussed. In the remainder of this section, I point out the key difference between this model and its expected-wealth-maximization counterpart. In the latter version of the model, the optimal strategy has the reservation weekly earnings property. In figure 1, the log of reservation weekly earnings in period t , $\ln W'_t$, is a horizontal line in $\ln W - \ln H$ space. That is, hours are presumed not to matter in the job-acceptance decision. In the expected-utility-maximizing model, the reservation utility level, θ_t , defines an upward sloping straight line in $\ln W - \ln H$ space, with slope $= -\alpha_2/\alpha_1$, given the presumption that $\alpha_2 < 0$.⁷ The latter model predicts that any earnings-hours offer located above this line will be accepted, that is, a low-earnings job might be accepted if the hours were low also, and a high-earnings job might be rejected if the hours were also high. If the utility-maximizing model is correct, then the wealth-maximizing model would incorrectly predict that offers located in area A in figure 1 would be rejected, and offers located in area B would be accepted. The larger $-\alpha_2/\alpha_1$, the greater the probability of an incorrect prediction by the wealth-maximization model. In Section V below, I present estimates of the probabilities associated with areas A and B .

A possible objection to a test of the expected-wealth-maximization hypothesis based on the model described above is that the test depends on the validity of the model, which is highly structured. However, a test is also possible based on a substantially less structured version of the model. In this version of the model, which I denote the unrestricted model, utility and job offers are still defined by (1)–(5), and the assumption is maintained that the optimal search strategy is characterized by the reservation utility

⁷ The equation for the indifference curve is linear in logs because of the Cobb-Douglas utility function: since $\theta_t = W^{\alpha_1} H^{\alpha_2}$ defines the values of W and H that provide utility level θ_t , it follows that $\ln W = (\ln \theta_t - \alpha_2 \ln H)/\alpha_1$ along an indifference curve.

FIG. 1

property (which specializes to the reservation weekly earnings property when $\alpha_1 = 1$ and $\alpha_2 = 0$). The difference is that the determination of reservation utility each period is left unspecified instead of being forced to follow the path dictated by the solution to the dynamic programming problem, (6)–(9). The reservation utility is estimated as a free parameter each period in this version, while in the dynamic programming model, the path of reservation utilities is determined by C and T . As discussed below, the key parameters needed to test the reservation weekly earnings property remain identified in the unrestricted model, permitting a more robust test.

III. Econometric Issues

The model described above was estimated by full information maximum likelihood (FIML). Before describing the estimation procedure, I discuss identification of the parameters. The data available for estimating the model include the duration of search and weekly earnings and hours on accepted jobs. The assumption of homogeneous workers is maintained.

Wolpin (1987) shows that the parameters of the wealth-maximization version of this model are identified. The only new issue that arises in the utility-maximization model is identification of the utility function parameters, α_1 and α_2 . A normalization is required since monotonic transformations of the utility function specified in (1) will not alter the implications

of the model. I have chosen to set $\alpha_1 = 1$ since under this restriction the expected-utility-maximizing model still nests expected wealth maximization. With the restriction $\alpha_1 = 1$, α_2 is identified by the hours data. This is also true in the unrestricted model. The dynamic programming model (also referred to as the restricted model) is nested in the unrestricted model, so an explicit test of the restrictions implied by the former is possible.

To form the likelihood function for the model, two additional assumptions are required. First, it is assumed that the offer arrival rate is given by $\lambda_t = \exp\{\beta_0 + \beta_1 t\}$, allowing for duration dependence in the offer rate.

The second additional assumption is made necessary by the fact that the model implies that $U \geq \theta_t$ for any offer accepted in period t . There are two ways to impose this implication of the model in the estimation procedure. One is to maximize the likelihood function subject to this constraint for each period up to $T - 1$. This is the strategy followed by Jensen and Westergaard-Nielsen (1987) and by Flinn and Heckman (1982) in the stationary case, but the maximum-likelihood procedure then becomes non-regular since the parameter estimates may be on the boundary of the parameter space. An alternative procedure, similar to one implemented by Wolpin (1987) and Stern (1989), allows for measurement errors in observed wages and hours. For given parameter values, observing a value of $U < \theta_t$ is then attributed to measurement error. This helps reduce the influence of outliers on the parameter estimates since without measurement error the job with the smallest value of U in the whole sample will have a major effect on the parameter estimates.⁸ I assume $\ln W_0 = \mu_w + \epsilon_1 + e_1$ and $\ln H_0 = \mu_H + \epsilon_2 + e_2$, where W_0 and H_0 are observed wages and hours, and e_1 and e_2 are i.i.d. normally distributed, mean zero measurement errors with variances $\sigma_{e_1}^2$ and $\sigma_{e_2}^2$, and zero covariances with each other and with the ϵ 's. These variances are identified by the fact that the offer-acceptance decision involves a comparison of true utility (the expected value of which depends on the true variances) with reservation utility, while the contribution of observed wages and hours to the likelihood function includes both the true variances and the measurement-error variances.

An individual (i) who accepts a job in period t_i contributes a term to the likelihood function for the probability of remaining unemployed for $t_i - 1$ periods, and a term for the joint probability of becoming employed in period t_i and the observed value of utility on the accepted job. An

⁸ For evidence that an unusually low wage can have a significant impact on parameter estimates in this context, see Flinn and Heckman (1982, p. 149), who infer a very low job offer arrival rate (one offer per 5–7 months) due to a low reservation-wage estimate derived from the smallest accepted wage in their sample (\$1.50 per hour). The rationale for the use of measurement error here is similar to the rationale for its use in the kinked budget constraint literature, which is to account for observations in theoretically inadmissible regions. See, e.g., Moffitt (1986).

individual who remains unemployed after being observed for t_i periods contributes a term like the first one above (but for t_i periods instead of $t_i - 1$). Let $\varepsilon = \varepsilon_1 + \alpha_2 \varepsilon_2$, $e = e_1 + \alpha_2 e_2$, $\sigma_e^2 = \sigma_{e1}^2 + \alpha_2^2 \sigma_{e2}^2$, and $\rho^2 = \sigma^2 / (\sigma^2 + \sigma_e^2)$.

The likelihood function is

$$L = \prod_{i=1}^{I_1} \left\{ \prod_{j=1}^{t_i-1} [\lambda_j \Phi(\eta_j/\sigma) + (1 - \lambda_j)] \right\} \cdot \left\{ \lambda_t \left[1 - \Phi \left(\frac{\eta_t - \rho^2(\varepsilon + e)}{\sigma(1 - \rho)^{.5}} \right) \right] \phi \left(\frac{\varepsilon + e}{(\sigma^2 + \sigma_e^2)^{.5}} \right) \cdot \frac{1}{(\sigma^2 + \sigma_e^2)^{.5}} \right\} \quad (10)$$

$$\cdot \prod_{i=1}^{I_2} \left[\prod_{j=1}^{t_i} (\lambda_j \Phi(\eta_j/\sigma) + (1 - \lambda_j)) \right],$$

where I_1 is the number of completed spells, and I_2 is the number of incomplete spells.⁹ The joint probability of observing an offer being accepted $\text{pr}(\varepsilon > \eta_t)$, and the observed value of utility of the accepted offer $(\varepsilon + e)$ is decomposed into the conditional probability of $\varepsilon > \eta_t$, given the observed $\varepsilon + e$ (the term in square brackets), times the marginal density of $\varepsilon + e$, both of which are normal given the assumed normality of ε_i and e_i , $i = 1, 2$. As noted above, at each iteration of the likelihood function the value function is computed recursively from period T backward in order to obtain estimates of η_t to include in the likelihood function. In the unrestricted model, η_t is a parameter to be estimated in each period in which any offers were accepted.

Exogenous variables can be included in the model as determinants of any or all of the parameters. However, no attempt has been made to incorporate unobserved heterogeneity because of the complexity of doing so, the arbitrariness of limiting the sources of such heterogeneity, and the fact that, in some cases, the parameters of the distributions of unobservables would be unidentified.

IV. Data

Data from the Employment Opportunity Pilot Project (EOPP) baseline household survey were used to estimate the model. This survey collected data in 20 sites in the United States during 1980 to serve as a baseline for

⁹ A number of individuals in the sample described below had missing data on earnings. The likelihood function was modified to permit these cases to be used, assuming randomly missing data. For an individual who accepts a job in period t_i but does not report weekly earnings, the term $\lambda_t(1 - \Phi(\eta_t/\sigma))$ replaces the second line of (10). The sample proportions of cases with missing data were used to weight the different likelihood terms.

Table 1
Descriptive Statistics on Unemployment Spells

	Mean	Standard Deviation
Duration (weeks)	12.7	12.0
1 = complete spell	.64	.48
Accepted weekly earnings	249	146
Log of accepted weekly earnings	5.37	.55
Accepted weekly hours	40.1	10.2
Log of accepted weekly hours	3.66	.28

NOTE.—The sample size is 329. Sample size for wages and hours is 194. Wages have been deflated to a January 1979 basis using the monthly consumer price index.

evaluating the effects of the EOPP program, which was intended to provide intensive job search assistance and training to low-income individuals in selected sites. The program was canceled shortly after it was initiated, but the baseline survey provides a rich source of data on preprogram job search behavior. Low- and middle-income households were oversampled, but the sample was not truncated on income.¹⁰ I use a subsample of 329 white men aged 25–35 who graduated from high school but did not attend college and who experienced a spell of unemployment during the period covered by the survey, January 1979–October 1980. The sample has been restricted to a relatively homogeneous group in order to minimize the inclusion of explanatory variables, which increase the cost of estimation substantially. Retrospective labor market histories from the date of the survey (April–October 1980) back to January 1979 provide data on search activity during unemployment spells and earnings and hours on all jobs.

In table 1, descriptive statistics on the variables used to estimate the model are presented, and in table 2 the frequency distribution of duration and the pattern of hazard rates are given. The average duration of a spell of unemployment is about 13 weeks and 65% of all spells are 13 weeks or less, while 73% of all completed spells are 13 weeks or less. The hazard rate appears to decline after about 13–15 weeks of duration. There is considerable dispersion in accepted hours of work as well as in earnings, so the potential for the earnings-hours model to provide a better fit than the earnings-only model exists.

V. Results

A. Parameter Estimates

Parameter estimates for the expected-utility-maximizing (EUM) and expected-wealth-maximizing (EWM) versions of the model without any

¹⁰ See Keeley and Robins (1985), Blau and Roberts (1986, 1990), and Blau (1989) for further discussion of the data.

Table 2
Distribution of Unemployment Spells by Duration

Duration (Weeks)	Number of Spells	Number of Complete Spells	Average Weekly Hazard Rate
1-3	75	52	.058
4-6	61	48	.070
7-9	37	25	.043
10-12	24	15	.031
13-15	39	28	.050
16-20	24	16	.032
21-24	17	8	.026
25-73	52	17	.010
All	329	209	.050

NOTE.—In the estimation each week is treated as a separate period. The data are reported for groups of weeks here and in other tables to save space.

exogenous variables are presented in table 3.¹¹ The estimates were obtained by maximizing the likelihood function with T , the search horizon, fixed at alternative values and then picking the value of T that yielded the largest likelihood.¹² Estimates of unrestricted versions are presented as well.

The estimates in table 3 indicate that both the cost of search and the rate of time preference are zero. A rate of time preference close to zero was also found by Wolpin, but his estimated cost of search is nonzero. The results here could indicate that C and r are statistically unidentified or could simply indicate that searchers are not impatient and have little or no opportunity cost for the resources devoted to search.¹³ Some of the other parameters are imprecisely estimated, though generally of reasonable magnitudes. However, α_2 is estimated to be close to -1 , and the estimate is significantly different from zero in both versions of the EUM model, suggesting rejection of the wealth-maximizing model. The value of the χ^2 statistic from the likelihood-ratio test of the restrictions implied by the

¹¹ Several specifications of the model were estimated with exogenous variables such as age and location in a standard metropolitan statistical area (SMSA) as determinants of mean wages and hours. In every case, likelihood ratio tests indicated that the fit of the model was not improved by including these variables, so they were dropped from the final version of the model.

¹² The NMSIMP method in the GQOPT package was used to reach the neighborhood of the maximum, and GRADX was used to generate the final estimates and standard errors. The working horizon, τ , was set at 35 years in calculating V_T .

¹³ When the model was reestimated with r fixed at alternative values, C was still estimated to be zero, and the likelihood value was always lower than when r was unconstrained. A possible reason for the estimates of C and r being zero is that the search horizon, T , could capture the effect of discounting and search costs. That is, a short horizon has the same impact as a high discount rate and high search cost.

Table 3
Maximum-Likelihood Parameter Estimates

	Restricted Models		Unrestricted Models	
	(1)	(2)	(3)	(4)
C	0	0		
μ_w	5.48(2.96)	5.38(.04)	4.26(1.72)	5.38
$\sigma^2_{\epsilon_1}$	.39(.43)	.002(.003)	.13(.65)	.00
$\sigma^2_{\epsilon_2}$	.14(.06)	.31(.02)	.14(.16)	.32
β_0	-2.71(.18)	-2.72(.15)	-2.47(.17)	-2.66
β_1	-.024(.009)	-.022(.008)	-.026(.009)	-.02
r	0	0	0	0
μ_H	3.77(3.14)	...	2.55(1.89)	...
$\sigma^2_{\epsilon_1}$	.48(.72)	...	.16(.16)	...
$\sigma^2_{\epsilon_2}$	.16(.08)	...	.09(.46)	...
α_2	-.93(.20)	...	-.95(.22)	...
σ_{12}	.43(.07)	...	.10(.04)	...
T	25	25	-1,038.39	-1,056.06
$\ln L$	-1,052.43	-1,062.00		
$\sigma^2_1/(\sigma^2_1 + \sigma^2_{\epsilon_1})$	.73	.005	.48	.00
$\sigma^2_2/(\sigma^2_2 + \sigma^2_{\epsilon_2})$	.75	...	.64	...
$\sigma_{12}/\sigma_1\sigma_2$	.998	...	.712	...
$E(W)$	291	217	76	218
$SD(W)$	201	10	28	0
$E(H)$	55	...	14	...
$SD(H)$	43	...	6	...

NOTE.—Estimated asymptotic standard errors are in parentheses. These should be viewed with caution since they were generated using numerical derivatives and may be unreliable. The standard errors for C and r were very small and are probably unreliable, so are not reported here. Standard error estimates could not be obtained for the unrestricted model, which also included estimates of the reservation utility or wage in each period. The estimates are not reported here, but see n. 21. E = mathematical expectations operator; W = wages; H = hours; SD = standard deviation.

expected-wealth-maximizing model is 19.1 using the estimates from the restricted models in columns 1–2. The critical value of a $\chi^2(5)$ variable is 11.1 at the 5% level and 16.7 at the .5% level, so the restrictions are clearly rejected.

It is interesting that the restriction $\alpha_2 = -1$ cannot be rejected, so a model in which the goal is to maximize the expected hourly wage (W/H) is consistent with the data. Also, as shown in the lower part of table 3, the estimated correlation between weekly earnings and weekly hours is essentially one in the restricted model (.71 in the unrestricted model).¹⁴ The joint distribution of earnings and hours, therefore, is estimated to degenerate to a univariate distribution of hourly wages. This may

¹⁴ The correlation was constrained to fall between -1 and 1. Part of the explanation for the high correlation may be that part of the total variance of wages and hours is being attributed to measurement error. If the correlation is calculated using the total variances (true plus measurement error), the correlation falls to .74, closer to the observed correlation (.19) of accepted earnings and hours.

be consistent with hourly wage maximization by workers since, if workers are indifferent among jobs offering the same hourly wage and different weekly hours, then employers will not be constrained to offer hours that maximize workers' utility, and job offers need only consist of a specified hourly wage. However, this result is also consistent with a model in which workers maximize utility by choosing hours of work, given the hourly wage offer accepted. These alternative models cannot be distinguished empirically in the present context. It is important to stress that the results indicate that workers are clearly not indifferent to alternative combinations of weekly hours and weekly earnings.

The other parameters that are estimated precisely are those of the offer arrival rate (β_0, β_1). The estimates in column 1 imply a weekly offer arrival rate of .065 in the first week of search and a rate of .037 by the twenty-fifth week. The estimate of $T = 25$ weeks is very close to the length of the period of eligibility for unemployment insurance (UI) benefits. This may be a coincidence, but it certainly seems plausible that search behavior could become more constrained on expiration of UI benefits.¹⁵

Some of the parameters of the joint distribution of earnings and hours are poorly determined in the EUM model results, although the point estimates do not appear highly unreasonable.¹⁶ It is interesting to note that the EUM model results in column 1 indicate that accepted earnings are truncated from above, in contrast to the usual result of truncation from below in the EWM model (compare the mean of accepted earnings in table 1 to the estimated untruncated means in table 3). This is due to the fact that accepted hours of work are also estimated to be below the mean on average. Measurement error is estimated to account for about one-quarter of earnings and hours variation, respectively, in the column 1 results.¹⁷ The most peculiar result is probably the very high proportion of

¹⁵ About 55% of the sample received UI benefits. I attempted to incorporate these benefits in the cost of search, C , but with poor results. The results reported in table 3 do not incorporate the UI data.

¹⁶ One reason for the imprecise estimates of the earnings-hours distribution may be the assumption of joint lognormality. Taking weekly wages and hours separately, χ^2 goodness-of-fit tests reject the lognormal specification for wages and, especially, hours. The distribution of accepted weekly hours appears to be unimodal and symmetric with a very high concentration around 40 (73% between 35 and 40). The only tractable alternative in this problem to the assumption of joint lognormality is joint normality together with a linear utility function ($U = W + \alpha_2 H$). The estimates for this version of the model were highly unreasonable and are therefore not reported. Another specification was estimated in which hours of leisure enters the Cobb-Douglas utility function directly and leisure hours are assumed to be distributed lognormally. This specification also yielded unreasonable results.

¹⁷ Duncan and Hill (1985) present measurement error variance estimates for earnings and hours based on comparing survey responses of workers to company records. Their results are for annual earnings and hours and are therefore not directly comparable to the estimates in table 3. Their estimates of the share of

earnings variance estimated to be accounted for by measurement error in the wealth-maximization estimates in columns 2 and 4.

A formal test of the restricted models is discussed below, but an informal comparison of the restricted and unrestricted results is informative. The estimates of α_2 are virtually identical, providing strong confirmation that rejection of the reservation weekly earnings property is not an artifact of a poorly specified structural model. The unrestricted model produces less reasonable estimates of the parameters of the earnings-hours distribution, except for the correlation between earnings and hours, which is .71 instead of .99. The restricted and unrestricted models produce very similar estimates for the EWM model.

B. Testing the Model

A likelihood-ratio test of the fit of the restricted model was performed. Reservation utility each week is a free parameter in the unrestricted model. The longest observed duration of search in the data was 73 weeks, so the number of parameters to be estimated is $73 + 11$ (all of the previous parameters except T and C) = 84.¹⁸ The restricted model has 13 parameters and is nested in the unrestricted model so a likelihood ratio test of the restrictions of the dynamic programming model can be performed, with degrees of freedom equal to 71. The likelihood-ratio test statistic value is 28.1, which is less than the critical value of a $\chi^2(71)$ variable at conventional levels of significance. Thus, the restrictions implied by the dynamic programming EUM model cannot be rejected. Note also that when the EWM model was tested against the unrestricted version of the EWM model, the restrictions of the former could not be rejected, but the unrestricted EWM model is strongly rejected when tested against the unrestricted EUM model.¹⁹ The results clearly indicate that EWM is inconsistent with the data in either the restricted or unrestricted versions of the model.

Several other methods were used to evaluate the fit of the restricted EUM model and to compare the predictions of the fitted utility and wealth-

measurement error variance in total variance are 15%–25% for annual earnings and 32%–46% for annual hours (hourly workers only) (Duncan and Hill 1985, table 3, cols. 3–4). Hence, the results in cols. 1 and 3 in table 3 for the EUM models seem reasonable.

¹⁸ For periods in which no transitions to employment were made, a reservation utility of infinity provides a perfect fit to the data. In the restricted version of the model, the estimated reservation utility for such periods is finite, so a degree of freedom is used up for each such period in the unrestricted model. See Wolpin (1987) for further discussion.

¹⁹ The χ^2 value for a test of the EWM model against the unrestricted version of the EWM model is 11.9 with 71 degrees of freedom, and the χ^2 value for a test of wealth maximization against utility maximization with both models unrestricted is 35.3 with 5 degrees of freedom.

Table 4
Comparison of Observed and Predicted Values from Expected Utility Maximization Model

Duration	A. Average Weekly Hazard Rate		B. Per-Period Utility, Given a Job Is Accepted		C. Log (Weekly Earnings), Given a Job Is Accepted		D. Log (Weekly Hours), Given a Job Is Accepted	
	Observed	Predicted	Observed	Predicted	Observed	Predicted	Observed	Predicted
1-3	.058	.061	8.53	7.12	5.33	5.59	3.59	3.89
4-6	.070	.058	7.90	7.10	5.42	5.58	3.70	3.88
7-9	.043	.055	7.01	7.09	5.21	5.58	3.69	3.88
10-12	.031	.051	10.59	7.09	5.72	5.58	3.71	3.88
13-15	.050	.048	8.63	7.09	5.53	5.58	3.73	3.88
16-20	.032	.043	7.13	7.09	5.24	5.58	3.71	3.88
21-24	.026	.039	8.73	7.09	5.33	5.58	3.61	3.88
25-73	.010	.024	6.84	7.00	5.10	5.48	3.57	3.77
Average	.050	.052	8.15	7.09	5.38	5.58	3.67	3.88

maximization models. Table 4 displays the observed hazard rates and accepted earnings, hours, and utility and their predicted counterparts from the estimated EUM model (col. 1 estimates in table 3) by duration. The predicted hazard rates are generally close to the observed rates, and the model appears to capture the eventually declining hazard. The predicted decline in the hazard rate is due to the decline in the offer rate, offsetting the declining reservation utility. The model predicts a roughly constant level of utility of accepted offers (which is approximately average hourly earnings) with duration, and the data appear to support this, although the level of accepted utility is underpredicted.²⁰ The model overpredicts both earnings and hours on average, probably due to the fact that utility is estimated to depend approximately on their ratio.

In table 5, I compare predicted job acceptance probabilities by duration for the restricted EUM and EWM models. I also compare the proportion of accepted offers that exceed the reservation utility or wage level by duration for the restricted EUM and EWM models. Recall that with measurement error included in the model the value of accepted offers is not constrained to exceed reservation levels. There is little in table 5 to distinguish the two models. The job acceptance probabilities are quite high and quite close in the two models, and the proportion of offers with a value exceeding the reservation value is identical in the two models in most periods.²¹

Table 6 reports the results of a Monte Carlo experiment in which 5,000 random offers were drawn from the estimated earnings-hours distribution, using the column 1 results from table 3. The reservation utility and weekly earnings estimates (from the col. 1 and 2 models, respectively, in table 3) were then used to predict which of these offers would be accepted in each week of search, according to the EUM and EWM models. The proportion of offers that would be mistakenly predicted to be rejected and accepted, according to the EWM model (corresponding to areas *A* and *B*, respectively, in fig. 1), is shown in table 6. Over 40% of offers would be mistakenly predicted to be rejected according to the EWM model in the first few

²⁰ The observed value of accepted utility is computed using the estimated value of α_2 together with actual wages and hours. The unrestricted model produces much poorer predictions of accepted utility, wages, and hours because of the low estimated means of wages and hours (see table 3, col. 3). The predicted hazards from the unrestricted model are slightly more accurate than those from the restricted model.

²¹ The reservation utilities estimated as part of the unrestricted model fluctuate erratically with duration and are all statistically insignificant but generally decline with duration. The job-acceptance probabilities are much lower in the unrestricted model because of the low estimated means of wages and hours. The proportion of accepted offers with estimated utility greater than estimated reservation utility is generally much higher in the unrestricted models, due to reservation utility being treated as a free parameter each period.

Table 5
Comparison of Predictions from Expected Utility- and
Wealth-Maximization Models

A. Expected-Utility-Maximization Model

Duration	Reservation Weekly Utility	Job Acceptance Probability	Proportion of Accepted Offers with Estimated Utility Greater than Estimated Reservation Utility
1-3	6.54	.95	.58
4-6	6.44	.98	.59
7-9	6.32	.99	.47
10-12	6.20	1.00	.85
13-15	6.06	1.00	.73
16-20	5.86	1.00	.67
21-24	5.62	1.00	.75
25-73	0	1.00	1.00

B. Expected-Wealth-Maximization Model

Duration	Reservation Weekly Earnings	Job Acceptance Probability	Proportion of Accepted Offers with Weekly Wage Greater than Estimated Reservation Weekly Earnings
1-3	201	.97	.51
4-6	198	.99	.61
7-9	195	1.00	.53
10-12	191	1.00	.85
13-15	187	1.00	.81
16-20	181	1.00	.67
21-24	174	1.00	.88
25-73	0	1.00	1.00

weeks, with the proportion dropping in later periods. The mistaken predictions are for offers with relatively low weekly earnings but also relatively low hours. Since the EWM model places no weight on hours in the utility function, such offers would generally be rejected, according to this model, but would often be accepted according to the EUM model. Almost no offers would be mistakenly accepted according to the EWM model.²²

VI. Conclusions

This article has demonstrated that the reservation weekly earnings hypothesis can be tested in the context of a job-search model. This hypothesis has been maintained in the growing literature on structural estimation of search models but has not previously been tested. The results of this study lead to rejection of the hypothesis and indicate that imposing it could lead to a fairly high proportion of incorrect predictions. There are many possible

²² The misclassification probability from the unrestricted models is lower in most periods and is due entirely to offers being mistakenly accepted rather than rejected, except in the first week.

Table 6
Monte Carlo Results on the Proportion of Offers Misclassified
by the Expected-Wealth-Maximization Model

Duration	Mistakenly Reject	Mistakenly Accept	Total Misclassification Probability
1-3	.38	.04	.44
4-6	.37	.02	.39
7-9	.36	.01	.37
10-12	.36	0	.36
13-15	.35	0	.35
16-20	.33	0	.33
21-24	.31	0	.31
25-73	0	0	0

reasons in theory why the reservation weekly earnings property could fail to hold, and this article has investigated only one of these causes, hours of work in the utility function. Empirical investigation of other possible sources of failure of the reservation wage property, such as other nonwage job characteristics in utility, risk aversion, and an unknown wage-offer distribution, would be useful extensions. It has also been assumed that a nondegenerate earnings-hours distribution could exist in equilibrium, but there are a number of conditions that must be satisfied for this to be possible, and it would be desirable to test whether these conditions are met. For example, heterogeneity of preferences may be important but has been assumed away here.²³

The results obtained in this study suggest that an hourly wage maximization model fits the data well and that job offers can be viewed as consisting of an hourly wage, with either the employer or the worker choosing hours. Whether this is a plausible description of the labor market can be determined only by attempting to replicate the results for other groups and other samples. However, whether or not hourly wage maximization is the best model to describe search behavior, the results clearly indicate that wealth maximization is not the best model.

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²³ See Mortensen (1986, pp. 897-913) for a survey of the literature on equilibrium wage dispersion, and Eckstein and Wolpin (1990) for an empirical market equilibrium search model.

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