

DIRECT TESTS OF THE RESERVATION WAGE PROPERTY*

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The theory of optimal job search focuses on reservation wages. Thus, comparative dynamic properties such as effects of changes in search subsidies (e.g. unemployment insurance benefits), etc. are usually stated in terms of changes in the reservation wage path. The principal difference between infinite and finite search horizon models is that the reservation wage is constant in the former and decreasing in the latter. Also, a central concern in models of search from an unknown distribution is identifying conditions under which reservation wages exist.¹ There have been no previous direct tests of the reservation wages predicted by finite horizon search models.² One reason is that reservation wages are not observed in field labour markets.³ In addition, previous experimental tests of search theory have used observations of search duration, search income, and accepted wages, not reservation wages. The results of such tests generally do not imply rejection of (the implications of) the risk neutral search model.

Some previous experimental tests of job search theory are reported in Braunstein and Schotter (1981, 1982), Cox and Oaxaca (1989), Harrison and Morgan (1990), and Hey (1987). Search theory in the context of consumer search for the lowest price in the absence of complete information about the price offer distribution is discussed in Hey (1981), and experimental results are reported in Hey (1982).⁴ Cox and Oaxaca (1989) presents a discrete wage, finite horizon version of the theory of sequential search that focuses upon the opportunity costs associated with the foregone earnings from rejecting an offer when it is received. The risk neutral model is a special case of the general concave search model in which income preferences can be represented by some strictly increasing, concave utility function. The reservation wages of a risk

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¹ Mortensen (1986) surveys the theoretical literature on job search.

² Braunstein and Schotter (1981, p. 20) report on one experimental treatment in which they elicited reservation wages. Their subjects' reservation wages were found to be decreasing, and it was reported that this finding was inconsistent with the constant reservation wage property of infinite horizon search models. It is not known if their subjects' reservation wages were consistent with the predicted decreasing reservation wages of the relevant finite horizon model.

³ Feldstein and Poterba (1984) use 'reservation wage' data from a special supplement to the May 1976 CPS. The 'reservation wage' question from the CPS asks unemployed workers to state the lowest wage they would accept for the kind of job they are seeking. However, there is no basis for interpreting the answers to this question as corresponding to the theoretical notion of reservation wages. In their actual job acceptance decisions, workers are in no sense bound by their answers to the 'reservation wage' question.

⁴ See Kogut (1990, 1992) for some results of experimental tests of search theory in the context of consumer search for the lowest price from a known price offer distribution.

averse agent never exceed those of a risk neutral agent. Hence, numerical solutions for the risk neutral special case of the model can be used to test both that special case and the general concave (risk averse or risk neutral) search model.

Tests of the search model reported in Cox and Oaxaca (1989) are based on search duration and search income. In addition to the baseline trials, those experiments include treatments that test for the effects on subject behaviour of variations in the interest rate, search costs and subsidies, riskiness of the wage offers distribution, the probability of receiving an offer, and the length of the search horizon. Several parametric and non-parametric tests are applied to search duration and search income data from the baseline and various treatment trials. The risk neutral model survives these tests and the general concave model survives these tests remarkably well.

Hey (1981, 1982) has argued that the more complicated the search environment, the more reliance searchers may place on naive rules. Hey's observations about the possible importance of naive rules may apply to the experiments described in Cox and Oaxaca (1989) and to the experiments with observed reservation wages reported below.

This paper advances our understanding of the performance of finite horizon job search theory by subjecting the theory to direct tests with observed reservation wages and by comparing the performance of the theory with that of a naive rule. We show that a naive rule performs as well as the risk neutral model in (indirect) tests that use search duration data. In contrast, (direct) tests using observed reservation wages imply rejection of both the naive rule and the risk neutral model but not the general concave model. Our interpretation of this finding is that indirect tests based on search duration are weak tests of the theory.

I. EXPERIMENTAL DESIGN

The finite horizon model that we test is developed in Cox and Oaxaca (1989). To induce observable reservation wages, as required for direct tests of the theory, one needs to conduct experimental trials in which the subject responses consist of stated minimum acceptable offers for which they are willing to make binding pre-commitments of acceptance. Framing search decisions in this way may be psychologically different from framing them as acceptance or rejection responses to known offers, although economic theory does not make such a distinction.⁵ In order to test for the presence of a 'pre-commitment effect' on search decisions, we pair experimental trials involving pre-commitment with trials in which subject responses are acceptance or rejection of known wage offers.

Each experiment for a single subject is divided into two parts. In part I, during each period in which a trial is in progress, a subject is asked to record either an *S* (for 'stop') or a *C* (for 'continue'). If a subject chooses *C* during any period (except the last one) in a trial then the trial continues on to the next

⁵ See Slovic and Lichtenstein (1983) for a discussion of 'framing effects' and a list of references.

period. That is, the *C* response indicates that the subject has decided to continue the search, which means that the offer, if any, in that period is rejected. The *S* response indicates that the subject has decided to stop the search and accept the offer, if any, received in that period. Of course, the first *S* recorded in a trial ends it, and the subject then begins the next trial in the experiment. In contrast, in part II a subject is asked to record the minimum acceptable offer during each period in which a trial is in progress. The figure recorded is the pre-committed reservation wage for that period. If the subject receives an offer that equals or exceeds the recorded reservation wage, the trial is terminated and the income earned in that trial is added to the subject's accumulated earnings in the experiment. If the subject does not receive an offer that equals or exceeds the recorded reservation wage, he is permitted to continue the search (but is not allowed to accept the offer, if any).

Each of the two parts of an experiment consists of eight trials. The first two are baseline trials in which the interest rate and net search subsidy are both zero. Other features of the baseline trials are that the probability of receiving an offer in any period is $\frac{1}{2}$ and the conditional probability that the amount of an offer is any one integer from 1 to 10 is $\frac{1}{10}$. The third and fourth trials in each part are the same as the baseline trials except that they include a net subsidy to search of 5 cents per period; this is the 'subsidy treatment'. The fifth and sixth trials in each part are baseline trials. Finally, the seventh and eighth trials in each part are the same as the baseline trials except that the probability of receiving an offer is decreased from $\frac{1}{2}$ (in the baseline) to $\frac{1}{4}$ (in the seventh and eighth trials); this is the 'probability treatment'.

This experimental design has the following features. The second pair of baseline trials is included in each part of the experiment so that we can test for possible confounding of the subsidy and probability treatment effects with learning or other sequencing effects on search behaviour. The entire sequence of baseline and treatment trials in part I (without pre-commitment) is repeated in part II (with pre-commitment) so that we can test for the presence of a pre-commitment treatment effect on search decisions. Thus all of part I is a baseline control for part II.

Procedures for conducting these experiments are as follows. Each trial consists of 20 periods (the finite horizon). During each period in which a trial is in progress, a subject first draws a realisation of a random variable that determines whether he receives an offer. If an offer is received, the amount of the wage is determined by the realisation of a second random variable. The wage is then multiplied by the (pre-specified) annuity factor that converts it into the end-period capital value of the income stream implied by receiving the wage each period until the end of the horizon. The capital value is then added to the (zero or positive) pre-specified earnings (or search subsidy) for the period to determine the total earnings from stopping the search at that time. Further details on procedures for conducting search experiments of this type are contained in Cox and Oaxaca (1989). Complete subject instructions and sample record sheets for the experiments reported in the present paper are contained in an appendix available upon request to the authors.

There were 30 distinct subjects. Each subject participated in an experiment at a distinct time and had no contact with other subjects that is known to the experimenters. The discrete wage, finite horizon search model in Cox and Oaxaca (1989) can be used to calculate the expected payoff to a risk neutral, perfectly-optimising subject from participating in one of these experiments. The unconditional expected payoff was \$24.06. The expected payoff conditional on the actual draws of the random variables was \$22.44. The actual average subject payoff was \$21.44, with a range from \$17.56 to \$24.54. Experiments lasted about one hour. The subjects were University of Arizona undergraduates with no known previous experience with manually-run, individual choice experiments. Some of the subjects did have experience with computerised laboratory market experiments.

II. TESTS FOR A PRE-COMMITMENT TREATMENT EFFECT

The pre-commitment-induced observable reservation wages are a central feature of the experiments reported in this paper. An important question is whether these observed reservation wages are the same as the implicit reservation wages subjects use when they are not required to pre-commit to a minimum acceptance wage. Of course one cannot merely assume that the two types of reservation wages are the same. Therefore, we have employed a variety of tests to address this question. The experimental design question is whether the pre-commitment requirement itself is a treatment that influences subject behaviour.

Cox and Oaxaca (1992) reports the results of our tests for a pre-commitment treatment effect. Both parametric means tests and non-parametric median (Fisher sign) tests are reported. The basis for both tests is a comparison of the difference between search duration in the pre-commitment and no-pre-commitment trials and the difference between the theoretically-predicted risk neutral search duration (given the actual draws) in the pre-commitment and no-pre-commitment environments. This comparison of differences is necessitated by the fact that when we use each subject as his own control, the draws will vary for that subject across trials. Thus, we are able to control for variation in the draws by comparing deviations from theoretically-predicted search duration conditional on the actual draws.

The tests reported in Cox and Oaxaca (1992) lead to the conclusion that the pre-commitment requirement seems to affect subject search duration for the first two experimental treatments and then to be 'shaken off' for the remaining treatments. This interpretation is strengthened by two factors. First, the third treatment in the experimental sequence is a repeat of the first (baseline) treatment. Second, we performed the means test and Fisher sign test for the null hypothesis of a return to baseline behaviour after the intervening subsidy treatment. The results showed relatively high p values for the no-pre-commitment baseline experiments and relatively small p values for the pre-commitment baseline experiments. Consequently, one would not reject return

to baseline for the no-pre-commitment experiments but would reject return to baseline for the pre-commitment experiments. This is consistent with subjects 'shaking off' the influence of the pre-commitment requirement by the time they reach the second baseline treatment. The fact that the same baseline treatment is used when a pre-commitment effect is detected and when it disappears makes it difficult to argue that it is merely the sequential arrangement of the four basic treatments that somehow has caused a pre-commitment effect to appear and then disappear.

III. PREDICTED SEARCH DURATION: SEARCH MODELS AND A NAIVE RULE

Table 1 presents a summary of subject conformance with search duration predictions for all of our experiments to date. In the first row of Table 1, we see

Table 1
Consistent Search Terminations in All Experiments

Model	Ratio	%
Concave model	1,014/1,080	93.9
Risk neutral model	822/1,080	76.1
Naive rule	808/1,080	74.8

that 1,014 out of the total of 1,080 (or 93.9% of the) observed search terminations are consistent with the concave model. Perhaps even more surprising, 76.1% of the observations coincide with the point predictions of the risk neutral model. The conclusions suggested by Table 1 are supported by several parametric and non-parametric tests reported in Cox and Oaxaca (1989). Most of those tests do not imply rejection of the risk neutral model. In addition, authors of other experimental papers that report indirect tests, based on data such as search duration, have also not rejected the risk neutral model (e.g. Braunstein and Schotter, 1981, 1982). These results caused us to ask whether successful prediction of search duration in our earlier paper and others in the literature might be a fairly easy test for the theory to pass. Perhaps some naive rule might do nearly as well as the risk neutral model.

Consider the following simple naive rule. Let the reservation wage meet the requirement of minimal rationality by being equal to zero (or, equivalently, one) in the last period of the search horizon. For other periods, let the reservation wage be the mean and median of the conditional wage offer distribution (5.5), rounded to the closest admissible integer wage rate (6). The last row in table 1 reports that 74.8% of the search terminations observed in all of our experiments are consistent with this naive rule. Thus the naive rule is, on average, almost as accurate in predicting search duration as is the risk neutral model.

Table 2 reports the search-duration predictive accuracy of the concave and

Table 2
Consistent Search Terminations in the New Experimental Treatments

Treatment	Concave model			Risk neutral model			Naive rule					
	No pre-commitment		No	No pre-commitment		No	No pre-commitment		No			
	Ratio	%	Ratio	%	Ratio	%	Ratio	%	Ratio			
First base line	53/60	88.3	58/60	96.7	46/60	76.7	43/60	71.7	50/60	83.3	49/60	81.7
Subsidy	52/60	86.7	58/60	96.7	41/60	68.3	36/60	60.0	36/60	60.0	45/60	75.0
Second base line	56/60	93.3	57/60	95.0	46/60	76.7	52/60	86.7	43/60	71.7	54/60	90.0
Probability	56/60	93.3	59/60	98.3	47/60	78.3	48/60	80.0	42/60	70.0	43/60	71.7
Total	217/240	90.4	232/240	96.7	180/240	75.0	179/240	74.6	171/240	71.2	191/240	79.6

risk neutral models and the naive rule for each of the treatments in the no-pre-commitment/pre-commitment experiments. The concave model is consistent with the highest percentage of observations in every treatment. The risk neutral model is more accurate than is the naive rule in three out of the four treatments with no pre-commitment. In contrast, the naive rule is more accurate in three out of the four pre-commitment treatments. Overall, the risk neutral model is consistent with 359 out of 480 (or 74.8%) of the search terminations whereas the naive rule is consistent with 362 out of 480 (or 75.4%) of the search terminations.

We have found that the naive rule does about as well as the risk neutral model in predicting search duration. We now proceed to report direct tests using observed reservation wages.

IV. DIRECT TESTS OF PREDICTED RESERVATION WAGES

Parametric and non-parametric tests of the risk neutral and concave models and the naive rule can be conducted separately for each individual period of a particular experimental treatment. As one can well imagine, such tests are likely to produce a mixture of outcomes across periods. This is of course what we found. A more concise procedure is to test the entire reservation wage path in terms of its consistency with the models. This strategy is in effect a joint test across all periods in which search has taken place. We have adopted a large sample likelihood ratio test for this purpose. It must be borne in mind, however, that joint tests can be quite sensitive to the behaviour of only one or two remaining searchers in the later periods of the search horizon.

The mean reservation wage time path for a particular (baseline, subsidy, or probability) treatment can be represented by

$$w_{ijt} = \sum_t \beta_t X_{ijt} + e_{ijt}, \quad (1)$$

where w_{ijt} is the observed pre-commitment wage for period t of the j th trial for subject i ; X_{ijt} is a dummy variable that takes on the value 1 for period t , and 0 otherwise; β_t is the coefficient on the t th dummy variable; and e_{ijt} is a random disturbance term. It is easily shown that the OLS estimator $\hat{\beta}_t$ is the mean reservation wage for period t , \bar{w}_t . For test specification purposes it will be more convenient to express (1) in observation matrix form:

$$w = X\beta + e. \quad (2)$$

The number of columns in the X matrix is equal to the maximum number of periods searched by any subject. A period searched in a trial by a subject yields an observation; hence the number of rows in the X matrix is equal to the total number of periods in all trials searched by all subjects.

The test specification for the risk neutral model is given by

$$H_0: \beta = \beta^n, \quad H_1: \beta \neq \beta^n, \quad (3)$$

where β^n is the vector of risk neutral reservation wages. The test specification

for the naive rule is derived from statement (3) by replacing the vector β^n by a vector with sixes as the first $T-1$ elements and a zero as the last element. The test specification for the concave model is given by

$$H_0: \beta \leq \beta^n, \quad H_1: \beta_t > \beta_t^n \quad \text{for at least one period } t. \quad (4)$$

Joint inequality tests of the type specified by (4) are discussed in Judge and Yancey (1986, pp. 149-65).

The joint tests considered here can be very sensitive to data in the later periods of search in which very few searches take place. For example, in the last 7 periods of the pre-commitment, first baseline treatment there was only a single searcher left. The pre-commitment reservation wages for the lone searcher in these periods were above the corresponding risk neutral wages. The differences are statistically significant and would therefore tend to lead to rejection of the concave model in a joint test over all periods. To address this issue, we also conducted tests with data confined to periods with at least 2 searches. This size cutoff still leaves from 97% to 100% of the samples intact.

Table 3
*P Values for Likelihood Ratio Tests of Mean Reservation Wage Paths**

Treatment	Concave model	Risk neutral model	Naive rule
First base line	0.006 (0.430)	0.000 (0.000)	0.035 (0.005)
Subsidy	1.000 (1.000)	0.000 (0.000)	0.010 (0.005)
Second base line	0.620 (0.620)	0.000 (0.000)	0.000 (0.000)
Probability	0.992 (0.992)	0.000 (0.000)	0.000 (0.000)

* The p values in parentheses were computed from subsamples that include only data from periods in which at least 2 subjects were still searching.

Table 3 presents the p values corresponding to the likelihood ratio tests of the risk neutral and concave models and the naive rule. Both the risk neutral model and the naive rule are overwhelmingly rejected. Except for the first baseline treatment results utilising less than 2 observations in the later periods, the concave model would not be rejected. Therefore, the concave model comfortably survives the joint inequality tests for all treatments.⁶

V. CONCLUSION

Although the theory of optimal job search focuses on reservation wages, the typical message space of naturally-occurring labour markets consists of statements of job offer acceptance and rejection. Perhaps as a consequence, previous tests of search models have been indirect, in the sense that they were based on the implications of reservation wages for variables such as search

⁶ Because of the panel data nature of the observations from the pre-commitment experiments, we investigated the fixed effects/least squares dummy variable (LSDV) and random effects (RE) model specifications. We were able to reject OLS when tested against the LSDV model. We were also able to reject OLS when tested against the RE model. Finally, we could not reject the RE model when tested against the LSDV model. None of the inferences about the linear and concave models are changed when using the RE model.

duration, search income, and accepted wages. The results of such indirect tests have generally not implied rejection of the risk neutral search model.

In this paper, we report an experiment that is designed to elicit (binding) reservation wage messages from the subjects and thus to make possible direct tests of the reservation wage path. Our data analysis begins with an informal inspection for consistency of observed search terminations with the predictions of a naive rule and the risk neutral and concave (risk averse or risk neutral) search models. Table 1 reports the aggregate consistency ratios and percentages for all of the search experiments that we have run. About 94% of the search terminations are consistent with the concave model. Furthermore, 76% of the search terminations are consistent with the risk neutral model and 75% of them are consistent with the naive rule. Table 2 reports disaggregated consistency figures for the no-pre-commitment/pre-commitment experiments that elicited the subjects' reservation wages. Once again, the naive rule has about the same success rate in predicting search duration as does the risk neutral model. One interpretation of this finding is that indirect tests, based on reservation wage implications such as predicted search duration, are weak tests of search models. The results of the direct tests of reservation wages support this interpretation.

Table 3 reports likelihood ratio tests of mean reservation wage paths. The risk neutral model and the naive rule are rejected for every experimental treatment in both tests using all the data and tests using data for periods in which there were at least two searches. In contrast, the concave model is not rejected in any test using the at-least-two-searches subsample of the data. It is rejected only for the first baseline in the tests using all of the data.

We have found that it is necessary to postulate that experimental subjects may be risk averse in order to maintain consistency between reservation wage data and theoretical reservation wage paths. This suggests the question as to whether there are any independent data that support the conclusion that many of our subjects are risk averse. Cox *et al.* (1988) report auction market experiments for more than 200 subjects from the same subject pool of University of Arizona (UA) undergraduate students that we use in our search experiments. They report that almost all of their subjects' bidding behaviour is consistent with a risk neutral or risk averse (i.e. 'concave') bidding model and, furthermore, that the bids of 68% of them are significantly risk averse. This risk aversion explanation of bidding behaviour is corroborated by the experiments reported by Harlow and Brown (1990*a, b*) using subjects from the same UA subject pool. They report results for more than 100 subjects who bid in auctions, completed two psychological survey tests, and submitted to biochemical blood tests. Harlow and Brown conclude that the psychological survey tests support the risk aversion explanation of bidding and, furthermore, that there is a measurable biochemical basis for their interpretation of subjects' experimental economic behaviour.

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