DISCUSSION PAPER SERIES

OPTIMAL ECONOMIC SEARCH AND LABOR MARKET POLICY: AN EXPERIMENTAL STUDY

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No. 79-22 August 1979

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The economics of optimal economic search has become a topic of intense interest over the past ten years. On the policy side of the field, the questions being investigated have dramatic implications for the definition of the natural rate of unemployment, the position of the Phillips curve, the impact of unemployment insurance, and a variety of other macro-policy and labor market questions. Despite the importance of this literature, a great majority of the theoretical results remain untested. Schotter and Braunstein (1979) performed a series of laboratory experiments whose aim was to test a large number of hypotheses existing in the theoretical search literature. Their results showed that the searchers in their experiments behaved in a manner that was remarkably consistent with the way searchers should behave if they were following an optimal sequential reservation wage search strategy.

This paper presents some further results not reported in Schotter and Braunstein (1979), all of which attempt to answer a set of more applied policy type questions.

These results were not reported before in an attempt to separate the theoretical from the applied results of that experiment.

Before proceeding, let us pause and state our methodological position clearly at the outset so as not to be misunderstood about what we feel our results prove. First, as was stated in Schotter and Braunstein (1979), experiments can only be useful in economics as a tool to falsify theory. What we mean is that if a behavioral hypothesis is deduced from a formal model, the behavior predicted should be able to be produced in the laboratory if the proper experiment could be performed. If no acceptable experiment produces that hypothesized result, then the result, although not negated, is at least open to suspicion. On the other hand, the verification of certain kinds of behavior in one experiment cannot be considered proof of the theorem predicting it. It is only through the repeated verification of this behavior in a series of experiments that one can begin to have some faith in the theory.

When it comes to making policy on the basis of experimental results, their validity is even more tenuous. It is not contended here that the results we report can be expected to be (or should be) the basis upon which social policy is made. Rather our results should be taken as the

outcome of an exercise which very well may be consistent with the way things work in the real world, but which certainly requires replication elsewhere before actual decisions can be made on the basis of them. In any case, it is our feeling that experimentation in economics is mainly of use when applied to the testing of well established theoretical results as opposed to furnishing the basis upon which to make policy prescriptions. Although the later will be what we are engaged in here, it is hoped that you recognize the limitations of such an exercise.

In this paper we will proceed as follows. In Section I we will state the hypotheses that will be tested in this paper. These will be presented after a short description of the Basic Search Paradigm which depicts the most basic search situation studied in the literature.

In Section II we will present a description of the experimental design used to test these hypotheses.

In Section III we will present the results of our experiment.

Finally, in Section IV we will state our conclusions and impressions.

Section I

The Basic Search Paradigm

and Optimal Economic Search

Before we proceed to outline the experimental procedure used in our experiments, let us review the types of hypotheses we will investigate here. To do this, let us briefly characterize the "Basic Search Paradigm," which the theory of optimal economic search uses as its starting point and which was used by us in devising our experimental design. To do this, consider the following situation. Assume that you are a worker looking for a job and that you only care about the wage of the job--no other characteristic is important. Each day you venture out in search of a job and generate one and only one job offer offered to you from a stationary distribution that is known to you. You can search as many times as you like (infinite horizon) and once a job is offered to you it is always available for you to accept (perfect recall). Each time you search, you incur a constant search cost of c, and you are assumed to be risk neutral.

The characteristics of this scenario--perfect knowledge of the wage distribution, constant search costs, infinite horizons, perfect recall, risk neutrality, etc.--

furnish us with the archetypal search situation for the literature and it is safe to say that the literature has developed by relaxing these characteristics and investigating how the optimal behavior of the searcher should change. The "optimal behavior" is a myopic type of behavior which is characterized by the reservation wage property such that if a searcher were placed in the Basic Search Paradigm, optimal behavior for that searcher would dictate that he set a reservation wage ε and keep on searching as long as the wages he is offered were less than ε, but stop as soon as he received a wage of ε or greater. The rule is mypoic in that all a searcher need do is compare his most recent offer to ε and follow the dictates of the strategy. He stops as soon as he gets a wage greater than or equal to ε.

ε has two explanations. First, it is that reservation wage which, if set, would equate the constant search cost faced by the searcher to the marginal expected gain from one more search. In other words, it equates the expected cost of one more search (c) to its expected gain. Another explanation of ε, and one that we will exploit later, is that ε is equal to the expected net gain (net of search costs) that a searcher can expect to get before he even searches for the first time, if he contemplates searching optimally.

B. Hypotheses Tested

The hypotheses that we tested primarily involved a comparison of the behavior of our searchers before and after a change was made in the Basic Search Paradigm. Since the theory predicts which direction these changes will take, we can evaluate our subject's behavior in the light of the theory and see if they behave in the predicted manner.

Hypothesis 1: Unemployment Insurance

The effect of unemployment insurance on the duration of unemployment is a strongly debated issue. For an overview of the subject as of 1975, see Marston (1975). Critics of the system of unemployment insurance look upon it as an intervention in the labor market which prolongs the duration of unemployment over what it would normally be and consequently lengthens an unproductive and therefore wasteful spell of unemployment. Chapin (1971) in an interstate comparison concludes that the mean duration of unemployment is greater in those states where unemployment insurance is greater. Gramlich (1974), in a study that controls for demographic characteristics, finds a similar result. Holen and Horowitz (1974) build a multi-equation

model of state unemployment and find no significant effect of unemployment insurance benefits on unemployment duration. Felstein (1972) has compared the search behavior of insured and uninsured workers. He notes that insured workers drew an average of 14.2 weeks of unemployment insurance in 1971, while uninsured workers only averaged an employment search duration of 8 weeks, and attributes this difference to the disincentive effects inherent in the system. Marston (1975), using a more sophisticated procedure, found that the expected duration of unemployment for insured workers does significantly exceed that of uninsured workers, but the differences between the two groups was rather small.

In order to state our hypothesis in as formal a manner as possible, we will first characterize unemployment insurance as a subsidy to the searcher which is in effect for a specific period of time and, in essence, reduces his cost of search for that period. With this characterization, we can state the following two additional hypotheses.

Hypothesis 1: Unemployment Insurance. When a searcher searches in the Basic Search Paradigm and knows that his first k searches are subsidized (an insured worker), he will tend to search longer, accept a higher wage,

increase his reservation wage, and be more selective of wages than a searcher who is searching under identical circumstances without the k period subsidy (an uninsured searcher).

Hypothesis 2: Exhaustion of Benefits

Another issue that is raised in the literature is whether or not searchers will exhaust their benefits before accepting or even looking for a new job. This is especially important when unemployment benefits are approximately equal to the wages of the worker's previous job. This leads to our next hypothesis.

Hypothesis 2: Searchers who are searching with recall in the Basic Search Paradigm and whose first k searches are subsidized will tend not to accept any job until period t = k.

Hypotheses 3 and 4: Risk, Risk Aversion and Search

Our next set of hypotheses concern the effect of risk aversion and increases in risk on the search behavior of unemployed workers. Search theory very clearly indicated that risk averse searchers should search less, set lower

reservation wages, and accept lower wages than their risk neutral counterparts (or less risk averse cohorts). In addition, it predicts, at least in the case of risk neutral searchers, that an increase in the riskiness of the distribution searched from should increase search duration. Robert Feinberg (1977) presents one of the few empirical studies on the issue and confirms that 1) according to his data, as the standard deviation of the distribution of potential wage offers increases, an individual's expected duration of unemployment will increase and 2) an individual who is more risk averse than another will have a shorter expected duration of unemployment. These hypotheses can be stated as follows and are presented in detail in Schotter and Braunstein (1979).

Hypothesis 3: Risk Aversion and Search. Risk averse searchers who are searching in the basic search paradigm situation with or without recall tend to search less and are less selective of wages than are risk neutral searchers searching under the same circumstances.

Hypothesis 4: Increases in Risk (Mean Preserving Spreads). If a searcher is searching under the conditions specified by the basic search and is searching from a stationary distribution $F(\cdot)$, then if $F(\cdot)$, is transformed by a mean preserving

spread (becomes more risky in the Rotschild-Stiglitz sense) into F'( ), all else remaining the same, the reservation wage of the searcher will tend to increase. (Remember, searchers in the BSP are risk neutral.)

Hypothesis 5: Minimum Wage Legislation

Probably one of the most emotional economic and political issues of the past 25 years is that of minimum wage legislation. The typical question that is investigated revolves around whether minimum wage legislation actually benefits the group it is trying to help or whether the artificial imposition of wage standards leads to a factor substitution that reduces employment levels not only in the affected industries but also related industries. From our perspective, however, the minimum wage debate involves the question of whether minimum wages tend to increase the duration of search unemployment for those workers who are affected. To depict this phenomenon we characterize minimum wage legislation as follows: Assume that you are a worker searching in the Basic Search Paradigm and are searching from a stationary symmetric triangular wage distribution defined over the interval $a \leq w \leq b$. Now assume that the distribution is truncated at some $\bar{a}$, $a < \bar{a} < \mu$ (μ is the mean of the distribution), and that all wages less than $\bar{a}$ cannot (by law) be offered to you. Consequently, when you search you will know that

you will never be offered a wage less than $\bar{a}$. The question we ask is: will this lower end truncation (imposition of a minimum wage) increase the expected number of periods that you search as well as your reservation wage, average accepted wage, etc. This hypothesis is more formally phrased as follows.

Hypothesis 5: If a searcher in the Basic Search Paradigm searches from a wage distribution F(W) defined over the interval $a \leq w \leq b$, and if the distribution is truncated at the lower end, then the searcher will tend to set a higher reservation wage, search longer, and be more selective of wages than a searcher searching under identical circumstances but whose wage distribution F(w) is not truncated.

Hypotheses 6, 7 and 8: Information and the Labor Market

All markets are information mechanisms and labor market policy has long been concerned with facilitating the exchange of information within the labor market. One extremely interesting consequence of the optimal search literature was pointed out by Gastwirth (1976), and deals with the robustness of the optimal search rule. More

precisely, Gastwirth (1976) demonstrates that while the optimal search rule (i.e., the myopic reservation wage policy rule specified before) does indeed maximize expected income when the searcher is fully and correctly informed about the exact wage distribution he is searching from, if the distribution is misspecified so that he has a mistaken impression as to what the real distribution is, the optimal search rule may lead to extremely inappropriate and inefficient behavior. Consequently, if unemployed workers in a labor market have poor information about the true distribution of available wages, this misspecification could lead to extended periods of search unemployment for those workers and hence higher levels of unemployment overall.

Another related question is whether it is worthwhile for workers to actually pay to get better information. In other words, are the private benefits of accumulating information in markets with incomplete information greater than the private costs. Both of these hypotheses were tested as follows.

Hypothesis 6: Searchers who think that they are searching with a constant search cost of c from a wage distribution $F(w)$ with density function $f(w)$ and an associated optimal reservation

> wage of ε_F but are actually searching from a distribution G(w) with density function g(w) whose associated optimal reservation wage is ε_G with $\varepsilon_G < \varepsilon_F$, tend to search longer than they would if they had known that they were searching from G(w) and receive final payoffs which are worse than they would receive if they had known that they were searching from G(w) to begin with.

Another related issue was raised by Telser (1973), where he reports the results of a stimulating computer simulation. What Telser did was to simulate, in a monte carlo study, various naive and sophisticated (i.e., optimal) search strategies which he used to search from various wage distributions. The naive rule was one in which the searcher merely accepted the first wage offered to him. What Telser found was that the additional payoff that resulted when his simulated searchers searched optimally as opposed to accepting the first wage offered was negligible. This he interpreted as indicating that the return from optimal search could be quite low. In our paper we test a closely related question. First, if we assume that our agents did, in fact, use a variety of different search strategies,[1] then if there was no meaningful payoff differences attributable to those strategies (as Telser's

results would lead us to believe), we would expect that the variances in the payoffs that we observe should be quite low. In addition, we can investigate whether the profitability of various types of searching strategies was conditional on the informational conditions of the search. For instance, it may be that when searchers are fully informed about the distributions from which they are searching, the variance in the payoffs is significantly less than that which results when they are searching from either a misspecified distribution an unknown distribution. These considerations lead to the following hypotheses.

Hypothesis 7: The variance of payoffs of searchers in the Basic Search Paradigm is low relative to the mean of the payoffs.

Hypothesis 8: The variance of payoffs of searchers searching from identical distributions is greater when the searchers are not informed at all about the distribution they are searching from than when they are fully informed.

What hypothesis 8 says is that even if there is no benefit from using different search strategies when

searchers are fully informed about the distribution being searched from, there may indeed be benefits when searchers are not so fully informed.

With this background let us now turn to a description of the experimental design we sued to test these results.

Section II

Experimental Design[2]

The experimental design used to test the hypotheses stated in Section I was created to emphasize the characteristics of the basic search paradigm and its modifications. To that end, a total of 56 undergraduate males and females were recruited over a three week period from three separate undergraduate economics principles courses at New York University and divided into three groups without their knowledge. The three groups can be identified by nicknames as follows: Group I, Basic Search Paradigm Group or Risk Neutral Group; Group II, the Risk Averse Group; Group III, the Uncertainty Group. Each group came totally from a separate class. To fully explain the experimental design, let us look at the separate experiments performed by these three groups.

Group I: The Basic Search Paradigm
or Risk Neutral Group

Students in Group I were scheduled for hour-long appointments and brought into an enclosed room one at a time. In the room was a principal investigator, a desk upon which was an interactive computer terminal, and two chairs. The subject was then given a 10 page set of instructions and told to read them. These instructions explained 12 experimental search trials that he would partake in, so that each subject knew he would perform twelve search trials, some of them identical to each other, but most of them different. They were told that the instructions would be gone over in detail by the principal investigator and a practice period performed before the actual experiment took place. The instructions (available from the authors upon request) contained the following information.

The subject was told that he was going to participate in an experiment whose purpose it was to investigate how people go about searching for wages and prices. He was told that if he wanted to, he could think of himself as a worker looking for a job for which the only characteristic of the job of interest was its wage. Two facts were

relevant. First, the exact wages existing were not known with certainty but rather were random and described by some probability distribution to be told to him. Consequently, in order to obtain a satisfactory wage, it was necessary to search. In addition, each time he searched, he would incur a cost and his final payoff would consist of the wage accepted minus the total search costs incurred. The actual searching procedure was simple. The student would sit in front of the computer terminal and, to start searching, would type the word SEARCH into the terminal. The computer would then offer him a wage by typing back "$\underline{w}$ is my offer," where $\underline{w}$ would be some wage derived from a given probability distribution which the searcher always knew or at least thought he did. The wages offered were denominated in points which in all cases, except two, ranged from 0 to 200 points. Each search cost c points, where c varied from trial to trial (always known by the searcher). If the subject was satisfied by the wage offered, he would type STOP into the terminal and his final payoff would be his accepted wage $\underline{w}$, minus c points. If the wage was not satisfactory, the subject would again type SEARCH into the terminal and another offer would be tendered. Again, the searcher could either accept or reject by typing SEARCH or STOP into the terminal. If the searcher

searched n times and then accepted a wage of $\underline{w}$ points, the final point payoff would be $\pi = (\underline{w} - nc)$ points and in Group I all subjects were given one penny for each point they earned. Since each subject performed this searching procedure under 12 different circumstances, it is best to stop and explain each circumstance separately--i.e., explain each experimental trial. Before the experiment was performed an extended 1/2 hour practice session was held in which subjects drew wages from all of the distributions searched from and practiced searching until they felt they were ready to start. Consequently, the behavior observed in the experiment was that of fairly experienced subjects and we felt that most, if not all, of the learning done by our subjects was done before the experiment started in earnest.

Experimental Trial 1. In experimental trial 1, the searcher was informed that he was searching from a symmetric triangular wage distribution p(w) with mean 100 and range 0 to 200 points. The formula for the function used was

$$p(w) = \begin{cases} \frac{w}{10,000} \text{ for } 0 \leq w \leq 100 \\ \frac{100 + (100 - w)}{10,000} \text{ for } 100 \leq w \leq 200 \end{cases}$$

In this trial he could search as many times as he wanted to and each search cost 5 points. In addition, any wage offered was always available so that all searchers here had perfect recall and by typing STOP at any time t, the final point payoff of any searcher in this trial was $\pi = \max(w_1, \ldots, w_t) - tc$.

This trial, then, contains all of the characteristics of the Basic Search Paradigm--i.e., a known distribution of wages, constant search cost, and perfect recall. In addition, if the reader is willing to grant that the utility functions of all subjects are approximately linear in dollars over the range of payments made for these trials (0 to $2.00), then having a linear conversion function of points into pennies and paying one penny for every point, we can take these searchers to behave as if they were risk neutral and this characteristic can be added to the list above. If one is not willing to assume that these subjects have linear utility functions over the range of payoffs offered them, then we could call this group the "less risk averse" group when compared to Group II as we will see. This conversion (of 1 penny for each point) was preserved for all 12 trials in Group I, so that this group was risk neutral in every trial. The theoretically optimal reservation wage in this trial was $\varepsilon = 133.00$.

Experimental Trial 2. As far as the subjects were concerned, experimental trial 2 was identical to experimental trial 1. It in fact was, except that unknown to them we had preselected a sequence of wages that we drew previously from the symmetric triangular distribution. This sequence was given to all Group I subjects in Trial 2 and was also given to subjects in Groups II and III. The first five numbers in this sequence were 80.292, 78.657, 115.641, 110.747 and 146.348, presenting the searcher with four wages below the theoretically optimal reservation wage of 133. Clearly, the theory would dictate that the subject wait for the 146.348 wage offer to appear.

Experimental Trial 3. In experimental trial 3 all search rules were identical to the rules used in Trial 1, i.e., perfect recall, constant search costs, known distributions, etc., except that the subjects in this trial searched from a rectangular distribution in which all wages were equally likely--i.e., $p(w) = 1/200$, $0 \leq w \leq 200$. This rectangular distribution can be obtained from the triangular by a series of mean preserving spreads and hence was a "more risky" distribution than the triangular one, in the Rothschild-Stiglitz (1970) sense.

Experimental Trial 4. In experimental trail 4, all conditions were identical to experimental trial 1, i.e.,

search from a symmetric triangular distribution with perfect recall, except that each search cost 10 points and not 5 points as before. Clearly this trial tried to isolate the effect of increased search costs.

Experimental Trial 5. This trial was identical again to trial 1, except that the distribution searched from was a truncated symmetric triangular distribution in which the searchers were told that they were searching from a symmetric triangular distribution but one in which they would never be offered a wage below 50 points. In other words, the computer program operating here was choosing wages from a symmetric triangular distribution but if a wage below 50 points ever arose, it would be ignored and not offered. Consequently, subjects knew that they would never have to spend 5 points and obtain a wage below 50 points. This truncation had a certain similarity to the imposition of a minimum wage on experimental trial 1 and represented our attempt to simulate that social institution.

Experimental Trial 6. All subjects were told that they were simply repeating experimental trial 3, where they searched from a rectangular distribution $p(w) = 1/200$, $0 \leq w \leq 200$. In actuality, the computer was giving

them wages from a right triangle distribution $p(w) = (1/100 - (1/20,000)w)$ so that they were deliberately misinformed about the distribution of wages. This trial represented our attempt at evaluating the issue raised by Gastwirth (1976) concerning the robustness of reservation wage search strategies since, as far as the subjects were concerned, they were acting in a situation identical to what would occur if they had misspecified the distribution they were searching from.

Experimental Trials 7, 8 and 9. These three trials represented attempts to simulate the impact of time horizons and time preference. Since we do not report on these results here, we refer you to Schotter and Braunstein (1979) for a description of them and the associated results.

Experimental Trial 10. In this trial all conditions were identical to those specified in experimental trial 1, except for the fact that for the first five times a subject searched he would receive a 3 point subsidy, making the net marginal cost of the first five searches only two points each. From search 6 onward, the marginal cost of search returns to 5 points. This trial attempted to simulate conditions existing under the institution of

unemployment insurance in which the benefit period was 5 periods. The effects of this institution will be discussed in a later paper.

Experimental Trial 11

In Experimental Trial 11 all conditions existing in Trial 1 were recreated, except that no recall was allowed. Consequently, each wage was a take-it-or-leave-it offer and at any time only current wage offers were available. This was identical to Experimental Trial 7, except for the fact that in Trial 7 a seven search horizon (or limit) was imposed.

Experimental Trial 12

Experimental Trial 12, as far as the subjects knew, was identical to Trials 1 and 2. However, in this trial we again pre-selected the sequence of wages that each subject would get. This clearly controlled for the sequences received by the subjects and comparisons of the behavior of subjects in Group I receiving this sequence could be compared to the behavior of subjects in other groups receiving identical sequences. The first six offers of the trial sequence were 93.945, 43.578, 65.862, 82.865, 74.881, 147.764, making it a "worse" sequence than the period 2 sequence and one in which the subject

had to wait 6 periods to receive a wage above the theoretically optimal reservation wage.

Before each subject performed these twelve trials, he practiced on a practice program in which he was allowed to draw as many wages as he wanted to from all distributions used in the experiments. In addition, the properties of these distributions were explained to him, and then he was allowed to practice in searching circumstances identical to those in which he would soon be searching. These practice sessions continued until the principal investigators felt that the subjects were totally familiar with all distributions and search procedures. The final payoff of each subject was the sum of his payoffs in each trial and in Group I final payoffs average approximately $13.30, a one hour session. The incentives in the experiment were very considerable as they were for each individual trial. A total of 20 subjects participated in Group I, and they were paid as they left.

Group II: The Risk Averse Group

Subjects in Group II performed all experimental trials that subjects in group I performed. However, in each trial their final dollar payoff was

calculated using a different conversion function to transform a subject's final point payoff into a final dollar payoff. More specifically, instead of the linear one penny for one point function used in Group I, subjects in Group II were given a final dollar payoff calculated by taking their final point payoff and converting it into a dollar payoff by the following formula:

$$\$ = \frac{(\Pi)^{1-\lambda}}{1 - \lambda}$$

where $\lambda = .05$. This function is concave with

$$\frac{d\left(\frac{-\$''(\Pi)}{\$'(\Pi)}\right)}{dw} < 0 .$$

$-\$''(\Pi)/\$'(\Pi)$ is a measure we can call relative point aversion which is comparable to the Arrow-Pratt measure of risk aversion. The effect of this conversion function is to simulate risk averse behavior since if the function

$$\$(\Pi) = \frac{(\Pi)^{1-\lambda}}{1 - \lambda}$$

is a concave function mapping points into dollars, and if all subjects have a utility function for dollars

$u = U(\$)$ which is linear over the range of payoffs defined in our experiment, then the composite function, $h = g(n) \times U(\$)$, mapping points into utility, is concave thereby simulating a concave utility function exhibiting decreasing risk aversion. As a matter of fact, even if they do not have linear dollar utility functions Group II subjects would still be more risk averse than Group I subjects. Consequently, Group II is called the risk averse group and since they perform the exact same trials as Group I, we hope to explain differences between these groups on the basis of the concavity of the conversion function used. Trials 8 and 9 were omitted in an effort not to compound the risk aversion and discount rate effects which work in the same direction. Because of the conversion function and the smaller number of trials, subjects in Group II had an average payoff of $10.00 which is still quite substantial for a one hour experiment. Consequently, incentives in this group, we feel, were comparable to those in Group I. Group II then presents risk aversion as a treatment variable. A total of 21 subjects participated in Group II, and they were paid as they left.

Group III: The Uncertainty Group. Experimental Group III contained a total of 8 experimental trials

designed to treat various forms of uncertainty not contained in the experimental design for Groups I and II.

Experimental Trial 1

Subjects were told that they were searching from one of four distributions of wages chosen with equal probability by the computer. The distributions were the symmetric triangular, the rectangular, the right triangular and the left triangular, all defined over the inverval 0 to 200 points. They could search as many times as they wished, search costs per search were 5 points, and they had perfect recall. Consequently, all conditions were identical here to Experimental Trial 1 in Group I except that there they knew the distribution they were searching from, while here they are told it could be any one of four. Actually, in Experimental Trial 1 the distribution that they searched from was the symmetric triangular so that this trial isolated knowledge of the distribution searched from as a treatment variable when compared to Trial 1 of Group I, the Basic Search Paradigm group. Subjects were given one penny for each final point profit they obtained in all Group III experimental trials.

Experimental Trial 2

All conditions in Experimental Trial 2 are identical to Experimental Trial 1, except that unbeknownst

to them they were actually searching from a right triangular distribution.

Experimental Trial 3

All conditions in Experimental Trial 3 were identical to Trials 1 and 2, except that unbeknownst to the subjects they were actually searching from a rectangular distribution.

Experimental Trial 4

In Experimental Trial 4, subjects were told that they were searching from the symmetric triangular distribution, that each search cost 5 points, and that they could search as many times as they wanted, as is true of all subjects in Group III. In addition, their final dollar payoff was derived by offering the subjects one penny for each point earned. In short, they searched under identical conditions as did the subjects participating in Trial 1 of Group I. One major difference did exist, however. In Trials 4 and 5 of Group III, subjects did not have perfect recall of past wage offers. They had what may be called "uncertain recall" in which at any time the only wage that was definitely available for them was their currently offered wage. However, they could go back and find out if a wage offered to them in the past

was still available for them by typing the period that that wage was offered to them into the computer. This "backward solicitation" of wages cost 5 points, just as if it were a new search. The computer would tell them whether this previous wage was still available. The subjects were informed that the probability that a wage offered to them k periods ago had a 1/k chance of still being available and a (k - 1)/k chance of not being available, making the probability of past wages not being available a decreasing function of the time past since they were offered. This is actually how their availability was determined. Once a past solicitation was made and a wage found to be available, the subject could either accept it, search again, or solicit some other previously offered wage. This trial, then, isolated the existence of "uncertain recall" as a treatment variable and the behavior of the subjects on this trial can be compared to the perfect and no recall cases to study the effect of this variable.

Experimental Trial 5

Trial 5, as far as the students were concerned, was identical to Trial 4. This is true in fact, except that in this trial the preselected sequence used in Experimental Trials 2 of Groups I and II whose first 5 offers were 80.292, 78.657, 115.641, 110.747, 146.348

was given to all subjects. This, of course, further controlled the experimental environment in trying to isolate the effect of uncertain recall by holding the actual sequence offered subjects constant across groups.

Experimental Trial 6

In Trial 6 subjects searched in circumstances identical to the ones existing in trial 1 of Group I (the Basic Search Paradigm Group), except here they were (and knew it) searching from a right triangular distribution whose formula is

$$p(w) = [\frac{1}{100} - \frac{1}{20,000} w]$$

Experimental Trial 7

In this experimental trial all of the conditions existing in Trial 1 of Group I existed here. However, here subjects were (and knew it) searching from a rectangular distribution.

Experimental Trial 8

In Experimental Trial 8, as far as the subjects knew, all of the conditions existing in Trials 1, 2 and 3 also existed here. In actuality, all subjects were given the sequence used in Experimental Trial 12 in Group I (also Trial 10 of Group II), in which the first six offers were 93.945, 43.578, 65.862, 82.865, 74.881, 147.764.

Fifteen subjects participated in Group III and they were paid as they left. The average payoff in this group was $9.10 for 3/4 hour of time, preserving roughly the same incentive structure as Groups I and II.

Qualitative Procedures. As the subjects in each group searched they were asked a series of questions whose aim was to try to solicit some unobservable qualitative information about their searching strategies. In Group I this was done by asking each subject before each trial what was the minimum amount he would accept (hypothetically) that would make him indifferent between searching and simply accepting the amount requested. In short, he was asked the minimum bribe he would accept not to search. This answer, if the searcher behaved rationally and was capable of making all of the proper calculations, should be equal to the optimal reservation wage as we have shown before in Section II (equation 8). Therefore in an indirect manner we were able to find out how different their answers were from those that would be given if indeed they searched optimally. In Experimental Trial 12 we not only asked this question but also before each search we asked the subjects if they would continue to search and, if so, what would be the minimum wage offer that they could get on the next search that would cause

them to stop searching and accept that wage. Finally, when all of the trials were finished, each subject was asked to write a one paragraph summary of what he felt was the best or optimal way to search, as well as to describe how he searched.

Group II subjects were asked the identical questions and again asked to report on their searching strategies.

Group III subjects were asked the same questions. However, in Trials 1, 2, 3 and 8 they were also asked to tell us the maximum amount of money they would be willing to pay to find out which one of the four "equally probable" wage distributions they would actually be searching from. This was done in an effort to find out if they had an accurate estimate of the value of such information since this can be useful in understanding whether workers correctly evaluate the value of labor market information when unemployed.

Having explained our experimental procedure in detail, we can now proceed to discuss the tests of our hypotheses.

Section III

Results

Hypothesis 1: Unemployment Insurance

In testing the impact of our simulated unemployment insurance, we compared the behavior of searchers on trials 1 and 10 in Group I and trials 1 and 8 in Group II (i.e., the trials before and after the five period subsidization). This was our attempt to simulate the major effects of unemployment insurance by altering the cost of certain searches. In the "control" trial (Trial 1 in Groups I and II), the cost per search was set at five points each. However, for the "experimental" trial (Trial 10 in Group I and Trial 8 in Group II), there was a three point subsidy for each of the first five searches. This had the effect of lowering the search cost to two points for five periods, after which the cost per search returned to five points.

The results are generally as expected and are quite similar to those we found in a test of the effects of changes in search costs in our earlier paper (Schotter and Braunstein, 1979). With the "unemployment insurance" reducing the costs of early searches, the subjects search longer on average. This is true for both the risk neutral and risk averse groups and is statistically significant in

both cases. Furthermore, both groups set higher average reservation wages when the insurance is in effect. But the statistical significance of these differences varies, and the findings with respect to the average highest rejected wage and average accepted wage are inconclusive. The results are presented in Table 1, below.

Notice that the searchers who were in the risk averse group were most dramatically affected by the imposition of unemployment insurance. For instance, they tended to search an average of 4.71 times which was significantly greater than their risk neutral counterparts. This is understandable, however, since in utility terms, due to the concavity of their simulated utility functions, the reduction in their search costs (in utility terms) was greater than the reduction in the search costs of the risk neutral searchers. Consequently, we would expect such a reaction from risk averse searchers.

Hypothesis 2: Search Duration and Benefit Exhaustion

In testing Hypothesis 2 we were interested in seeing whether the institution of unemployment insurance tended to stretch the average duration of search out until benefits were exhausted. Consequently, we tested the

TABLE 1

TESTS OF H^1 (UNEMPLOYMENT INSURANCE)

Group and Parameter Tested	Condition: With/Without Unemployment Insurance	Condition: With Unemployment Insurance	Difference
Risk Neutral:			
Reservation Wage	134.50	140.00	5.50
Highest Rejected Wage+	123.17	107.42	-15.75
Accepted Wage	146.45	148.88	2.43
Number of Searches	2.70	3.80	1.10*
Risk Averse:			
Reservation Wage	109.71	123.52	13.81*
Highest Rejected Wage+	107.27	125.80	18.53*
Accepted Wage	141.40	135.86	-5.54
Number of Searches	3.33	4.71	1.38*

*Significant at the 95% level.

+The "highest rejected wage" statistics reported here represent the average highest wage rejected by all searchers in a given trial before they accepted a wage. They are presented in an effort to present an operational and observable statistic with which to measure the reservation wages of our searchers.

hypothesis that the average search duration for both risk neutral (Group I) and risk averse (Group II) searchers under a system of unemployment insurance was five periods. Using the data presented in Table 1, we see that the mean search duration of the risk neutral searchers with unemployment insurance was 3.80 searches compared to 2.70 before, while the mean for the risk averse searchers was 4.71 as opposed to 3.3. When we tested the hypothesis that these durations were equal to five, we find that both 4.71 and 3.8 were not significantly different from 5 at the 99% level of significance. Consequently, in our experiment a simulated system of unemployment insurance did significantly extend the search duration to a length not significantly different from the period in which benefits were exhausted.

Hypotheses 3 and 4: Risk and Risk Aversion

Both hypotheses 3 and 4 were tested and reported on in Schotter and Braunstein (1979), and we refer the reader there for a full discussion of the results. Quite quickly, we found that risk averse searchers do, on average, search less, are less selective of wages, and accept lower wages than do risk neutral searchers. However,

the results on the accepted wage was statistically significant only when the sequence of wages offered was held constant (Groups I and II, Trial 2).

When the distribution of wages searched from became more risky (Hypothesis 4), we found that both risk neutral and risk averse searchers set higher reservation wages and accepted higher wages on average, in response to a mean preserving spread of the wages offered. (comparison of the behavior of our Group I and Group II searchers on Trials 1 and 3). Also, our searchers became more selective of wages (i.e., rejected higher wages--see "highest rejected wage" row on Table 1), and searched longer, but these changes were not significant.

As a result, our tests of both hypotheses 3 and 4 confirmed the econometric results of Feinberg (1977).

Hypothesis 5: Minimum Wage Legislation

These tests compare the results from two experimental trials in which all conditions were similar except that the distribution of wage offers was symmetric triangular (Trial 1 in Groups I and II) in one trial and truncated symmetric triangular (Trial 5 in Groups I and II), in the other. In the truncated distribution, all

wage offers below 50 points were suppressed. For this reason we consider this to be a reasonable simulation of a minimum wage standard.

The results shown in Table 2 are mixed. Both the risk neutral and the risk averse groups set higher reservation wages when facing a minimum wage, but the average highest rejected wage and average accepted wage are higher only for the risk averse group. Furthermore, in most of the comparisons the differences are not statistically significant. We find similarly mixed results in the comparisons of average number of searches. The risk neutral group searches, on average, a significantly longer time with the minimum wage than without the minimum wage. However, the difference in the risk averse group is not statistically significant and has the opposite sign.

Hypothesis 6: The Robustness of Optimal Search

Hypothesis 6 deals with the question of how robust the optimal search strategy is. Gastwirth (1976) theoretically derived the fact that the optimal search strategy is not very robust rule in the sense that it can lead to quite inefficient types of behavior when the distribution searched from is misspecified. Our interest was

TABLE 2

TESTS OF H^5 (MINIMUM WAGE)

Group & Parameter Tested	With/Without Minimum Wage	With Minimum Wage	Difference
Risk Neutral:			
Reservation Wage	134.50	150.00	15.50*
Highest Rejected Wage	123.17	115.31	-7.86
Accepted Wage	146.45	142.23	-4.22
Number of Searches	2.70	4.10	1.40*
Risk Averse:			
Reservation Wage	109.71	118.76	9.05*
Highest Rejected Wage	107.27	127.71	20.44*
Accepted Wage	141.40	155.94	14.54
Number of Searches	3.33	2.62	-0.71

*Significant at the 95% level.

in determining how real this problem is for actual flesh and blood experimental subjects, since it is only if the theoretical results derived have real world confirmation that we can employ them in our discussions of economic policy. As reported in Schotter and Braunstein (1979), risk neutral searchers who were tricked into thinking that they were searching from a rectangular distribution but were actually searching from a right triangular distribution (Group I, Trial 6), searched an average of 8.8 times while searchers who were informed that they were searching from a right triangular distribution (Group III, Trial 6), searched on the average of only 3.8 times. This huge difference is striking support for Gastwirth's theoretical predictions. A more important question, perhaps, is whether this difference in the mean search duration translates itself into a real difference in the searchers' payoffs. When we investigate this question, we see that searchers who were informed that they were searching from a right triangular distribution received an average payoff $1.008, while those who were misinformed and thought they were searching from a rectangular distribution received a payoff of only $.903. These differences, although impressive, are not significantly different at the 95% level of significance. Still, an almost 10% difference in payoffs exists and indicates that in labor markets a substantial investment in information dissemination may be justified

on a cost benefit calculation if it is thought that searchers are substantially misinformed about the characteristics of the wage distribution they are searching from. These results are summarized in Table 3.

Hypothesis 7: The Profitability of Various Search Strategies

In testing hypothesis 7, we proceed with the implicit assumption that each of our searchers are searching using a consistent, albeit unique, search strategy. According to Telser (1973), we might expect their payoffs to differ little from one another. This hypothesis was tested for both the risk averse and the risk neutral groups, both within each search trial and over all trial periods. The results are reported in Table 4.

As can be seen from the first part of Table 4 and Table 5, the variability of payoffs within each trial, both for the risk neutral and risk averse group, is quite small yet, on inspection, not unusually so. As a percentage of the mean, the standard deviation of the payoffs in each trial ranges from a low of 9% in Group I, Trial 2, to a high of 47% in Group I, Trial 6, but this was the trial in which we tricked our subjects. The typical percentage of the mean for the

TABLE 3

TEST OF H^6 (ROBUSTNESS OF THE OPTIMAL SEARCH RULE)

Group Tested	Mean Payoff	Mean Search Duration
Informed Group (Group III, Trial 6)	$1.008	3.8
Misinformed Group (Group I, Trial 6)	.903	8.8
Differences	.105 (.77)	5.0

Note: Numbers in parentheses are the t statistics.

*Significant at the 99% level.

TABLE 4

HYPOTHESIS H^7: PROFITABILITY OF VARIOUS SEARCH STRATEGIES

Group / Trial:	1	2	3	4	5	6	7	8	9	10	11	12	Sum
Risk Neutral (Group I)	.053	.011	.097	.098	.127	.182	NR	NR	NR	.092	.192	.043	1.13
Risk Averse (Group II)	.057	.017	.053	.038	.030	.076	NR	.059	.079	.037	--	--	1.652
Ratio of Group I & II	1.07	1.54	1.80	2.57*	4.2**	2.3*	2.7*	1.01	2.4*	1.1			1.53

*Significant at the 95% level.

**Significant at the 99% level.

NR = not reported

TABLE 5

MEANS AND STANDARD DEVIATIONS OF PAYOFFS

Trial	Mean	Standard Deviation	Standard Deviation / Mean
Group I:			
1	1.39	.231	.166
2	1.134	.104	.091
3	1.541	.311	.201
4	1.262	.314	.248
5	1.217	.357	.293
6	0.903	.427	.472
7	1.049	.407	.387
10	1.411	.303	.214
11	1.108	.438	.395
12	1.058	.207	.195
Group II:			
1	1.030	.239	.232
2	0.854	.130	.152
3	1.221	.230	.188
4	0.941	.194	.206
5	1.173	.174	.148
6	0.897	.275	.306
7	0.988	.305	.308
8	1.029	.242	.235
9	1.032	.280	.271
10	0.799	.193	.241

standard deviation was about 23%, which is not unusual. When we compare the variability of the payoffs in each trial across groups I and II, we find that the variance of payoffs in Group I was significantly higher than the variance of the payoffs in Group II on trials 4, 5, 6, 7 and 11. In essence, in these periods, we can say that however the search strategies differed amongst the searchers, these differences manifested themselves in the payoffs of the members of those two groups. Hence, risk aversion, or lack of it, does seem to introduce a variable that does account for some variability in the payoffs of searchers in some circumstances.

This finding is consistent with the type of behavior observed by risk averse searchers in Schotter and Braunstein (1979), where it was observed that risk averse searchers tended to exaggerate their level of risk aversion and set excessively low reservation wages. Such excesses tend to bunch the reservation wages of the searchers and can lead to lower variability in the payoffs of the searches as was discussed above.

In summation, one cannot say on inspection that these results are consistent with the simulation results presented by Telser (1973), since the payoff variances observed are not as low as one would have expected.

Hypothesis 8: Payoffs and Information States

In hypothesis 7 we investigated the variance of the payoffs of searchers who were primarily informed about the distributions of the wages they were offered. In hypothesis 8 we compare the variances of two groups of searchers whose information states varied in that in one group searchers were fully informed about the distribution of wages they were searching from, while in the other they were uninformed about their distribution. These results are reported in Table 6.

In Table 6 we compared the payoff mean and variance for searchers who were searching under identical circumstances but whose information about those circumstances differed. For instance, in comparing the payoff mean and variances for Group I, Trial 1 and Group III, Trial 1, we are comparing the behavior of agents who were searching from a symmetric triangular distribution in the Basic Search Paradigm and knew it (Group I, Trial 1), with those agents who were searching from a symmetric triangular distribution and knew only that they were searching from one of four possible distributions chosen at random (Group III, Trial 1). In comparing Group III, Trial 2 with Group III, Trial 6, we compared the behavior of agents both of

TABLE 6

HYPOTHESIS H^8: PAYOFFS AND INFORMATION STATES

Groups Compared	Comparison	Mean of Payoffs	Variance of Payoffs	Difference of Mean	Difference of Variance
Group I, Trial 1 vs. Group III, Trial 1	Informed vs. Uninformed Triangular Distribution	1.329 1.212	.053 .075	1.17 (1.35)	F = (1.42)
Group III, Trial 2 vs. Group III, Trial 6	Informed vs. Uninformed Fixed Sequence	1.327 1.008	.117 .127	.319 (2.78)*	F = (1.08
Group I, Trial 3 vs. Group III, Trial 3	Informed vs. Uninformed Rectangular Distribution	1.541 .834	.097 .128	.707 (6.51)*	F = (1.319)
Group I, Trial 12 vs. Group III, Trial 8	Informed vs. Uninformed Fixed Sequence	1.058 .954	.043 .046	.104 (1.52)	F = (1.06)

Note: Numbers in parentheses are t statistics.

*Significant at the 99% level.

whom were searching from right triangular distributions but one of whom (Group II, Trial 6) knew they were, while the other (Group III, Trial 2), again, only knew they were searching from one of four possible wage distributions.

As the results show, if our searchers were indeed searching with different search strategies, the variance of their payoffs were unaffected by the information conditions they were placed in. This is shown in Table 6 by the fact that although the means of the payoffs do vary across information states, better information always leading to higher mean payoffs as expected, none of the variances differed significantly, demonstrating that if indeed our searchers used different search strategies, these strategies did not, within any group, make their payoffs vary to any significant extent, even when information conditions varied. This limited set of observations does present some experimental support of Telser's (1973) simulation results.

Conclusions

The results of our experiment indicate that if searchers in the real world behave in a manner that is at all consistent with the behavior we have observed in

our experiment, there exists a wide scope of policy action available to the government which will allow it to dramatically affect the operation and efficiency of labor markets. In addition, it may be expected that many of the government's present actions (i.e., unemployment insurance, minimum wage legislation, etc.), do have significant effects on the behavior of unemployed workers in the labor market and that the effects are consistent with the type of behavior that is predicted by the theory of optimal economic search. Probably the one area in which the government can have the greatest impact in influencing the function of labor markets seems to be (on the basis of our results) in the provision of proper and correct information about the distribution of job offers existing in the economy. As was seen throughout our results, the misspecification of information can lead to prolonged periods of search unemployment and greatly increase what might be considered the natural rate of unemployment. Also, this prolonged period of search unemployment does not seem (at least on the basis of our results--see Table 3 and Hypothesis 6), to be productive in the sense of leading to a better net payoff for the searchers.

Finally, this paper, together with Schotter and Braunstein (1979), presents strong evidence of laboratory behavior that is strikingly consistent with the type of behavior we would expect to observe from economic agents who were searching for wages as if they were using an optimal sequential reservation wage strategy. If these results are reproducable elsewhere, they may furnish the government policy maker with a good theoretical basis upon which to construct a rational labor market policy and presents one of the rare situations in which theoretically derived economic results are first tested in the laboratory before being applied to the real world. It seems to us that this procedure might make sense more generally.

Notes

[1]This assumption is not inconsistent with the results of Schotter and Braunstein (1979), since their results simply indicated that as a group their subjects behaved as if they were searching optimally, yet within the group behavior could certainly have been varied, as indeed it was.

[2]This is an identical description as the one offered in Schotter and Braunstein (1979).

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