SEARCH THEORY; CURRENT PERSPECTIVES[1]

by Shouyong Shi

2006

Search Theory is an analysis of resource allocation in economic environments with trading frictions. These frictions include the difficulty of bringing potential traders together, coordinating agents' decisions, informing agents of trading opportunities, and keeping records of agents' trading histories. In the market, trading frictions appear in various forms of transactions cost and they generate important regularities in quantities and prices. For example, there are unemployed workers, under-utilized capital, and unsold goods in inventory, which indicate that markets are unable to exhaust all potentially desirable trades. Also, the law of one price predicted for a frictionless economy is at odds with the dispersion of prices often observed for similar goods.

Earlier models of search theory introduced two elements to capture search frictions (see Diamond, 1987). One element is a matching function, which generates the frequency of matches between agents. The other element is a mechanism to determine prices in individual trades. Two types of models incorporated these elements. One is sequential search models, in which agents on one side of the market post prices. Agents on the other side receive price quotes at an exogenous rate and decide sequentially whether to accept the quotes. The other type is random-matching models, in which the matching frequency is a function of the ratio of the numbers of agents on the two sides of the market. Such models determine price by Nash bargaining.

We will refer to these models as models of random search or undirected search, because agents in the models take the matching frequency as given. With undirected search, the

[1]This article is written as an entry to the Palgrave Dictionary of Economics. I thank the Social Sciences and Humanities Research Council of Canada for research support.

equilibrium is not able to internalize the externalities in the search process, and so the equilibrium is inefficient.

One recent development in search theory is the exploration of the mechanisms which can improve efficiency. A particular mechanism is directed search, which allows agents to use prices to directly affect the matching frequency. Directed search can enable the market to produce the efficient allocation under the constraint of the matching technology. This exploration has also led to the formulations of search as a strategic game. Another development uses search to construct a microfoundation for monetary theory.

This entry will focus on directed search. We will start with a random-matching model and illustrate the inefficiency of the equilibrium. Then, we will describe three models of directed search and related issues. After describing monetary search theory briefly, we will conclude. To simplify the description, we will treat the market as a labour market and let the time horizon be one period. The models can be adapted to the goods market and be extended to infinite horizon.

1. Random-Matching and Inefficiency

Consider a labour market with a large number of workers and firms. The number of workers searching for jobs is a fixed number u. All workers are the same and they are risk neutral. When employed, a worker produces goods whose value is $y > 0$. When unemployed, a worker enjoys leisure, the utility of which is normalized to 0. The number of vacancies is v, which is determined by competitive entry of firms. A potential firm can incur a cost c to create a vacancy, where $0 < c < y$. The technology of production has constant returns to scale so that a firm treats each vacancy separately. Normalize the production cost to 0.

Let us use a matching function, $M(u, v)$, to describe the total number of matches in the period. Let $\theta = u/v$ denote the "tightness" of the market. The matching probability for a worker is $p(\theta) = M(u, v)/u$ and the matching probability for a vacancy is $q(\theta) = M(u, v)/v$. Assume that M is increasing, concave and differentiable in each argument for all θ such that $p, q \in (0, 1)$. Moreover, the function has constant returns to scale. Thus, $p(\theta)$ is decreasing in θ, $q(\theta)$ is increasing in θ, and $q(\theta) = \theta p(\theta)$. Moreover, assume that $q(\theta)$ is concave, $q(0) = 0$, and $q(\infty) = 1$. The matching share of workers is defined as

$$s(\theta) = \frac{u}{M} \frac{\partial M(u, v)}{\partial u}.$$

Then, $s(\theta) = 1 + \theta p'(\theta)/p$. The matching share of firms is $(1 - s)$.

Once a worker and a firm are matched, the two choose the wage for the worker, w. Assume that this is done with Nash bargaining, which maximizes the geometrically weighted surplus of the two sides of the match: $w^{\sigma}(y - w)^{1-\sigma}$. Here, the worker's bargaining weight is $\sigma \in [0, 1]$. The solution for the wage share is $w/y = \sigma$.

The value of a vacancy is $J = q(\theta)(y - w)$ and the value of a worker's search is $V = p(\theta)w$. With competitive entry of firms, a firm's net profit is zero; i.e., $J = c$. This equilibrium condition can be rewritten as $(1 - \sigma)q(\theta) = c/y$. A unique solution for θ exists if $0 < c < (1 - \sigma)y$.

In the equilibrium, some workers are unemployed and some jobs are vacant. However, the existence of unemployment alone is not a sufficient indication of inefficiency. With the matching technology, not all resources can be fully utilized. The appropriate notion of efficiency must respect the constraint of this technology.

Let us measure efficiency with a social welfare function. Define social welfare as the weighted sum of expected values of agents in the economy, where all agents are given the same weight. This measure is also equal to the expected utility of an agent who is ignorant of whether he or she is a worker or a firm. Because firms earn zero net profit, the welfare level is equal to the sum of workers' values, uV. Using the condition of competitive entry to substitute w, we can express the welfare level as aggregate output minus the vacancy cost, i.e., $u[p(\theta)y - c/\theta]$. Because u is exogenous, the level of θ which maximizes welfare satisfies $-\theta^2 p'(\theta) = c/y$. Comparing this efficient outcome with the equilibrium outcome, we can see that the equilibrium is efficient if and only if:

$$\sigma = s(\theta).$$

This condition is the Hosios condition (see Hosios, 1990). It is required for efficiency for the following reason. The social value created by a marginal firm is $y[\partial M(u,v)/\partial v] = y(1-s)q$. In contrast, the firm's value in the equilibrium is $q(y-w)$. For the equilibrium to be efficient, the firm's value in the equilibrium must be equal to its social value. This requirement is met if and only if the wage share is equal to the matching share of workers, as the Hosios condition requires.

More specifically, a firm's entry into the market creates two externalities. One is positive – the presence of an additional firm increases the matching frequency of workers. The other externality is negative – an additional firm reduces the matching frequency of other firms. The Hosios condition ensures that the two externalities cancel out with each other. If $\sigma > s(\theta)$, a firm is under-compensated for its entry cost and the amount of entry is deficient; if $\sigma < s(\theta)$, a firm is over-compensated and the amount of entry is excessive.

With random matching, the equilibrium cannot satisfy the Hosios condition generically, because both sides of the condition involve exogenous elements of the model. In particular, when the matching function is Cobb-Douglas, the matching share s is a constant which is unrelated to the workers' wage share.

The inefficiency will remain if a sequential search model is used instead of a random-matching model. With sequential search, firms post wages. There can be a non-degenerate distribution of wage shares in the equilibrium. However, the matching share will still be independent of the wage share.

2. Directed Search and Efficiency

Directed search links the wage share to the matching share by explicitly modelling an agent's tradeoff between the wage and the matching frequency. To capture this tradeoff, suppose that all agents expect each wage level to be associated with a market tightness by a function $\theta(w)$. Search is "directed" in the sense that, by posting a particular wage, a firm expects to change the matching probability by affecting workers' applications. For a firm posting wage w, the matching probability is $q(\theta(w))$; for a worker who applies to wage w, the matching probability is $p(\theta(w))$. The functions $p(\theta)$ and $q(\theta)$ have the properties assumed above. Given the tightness function, each firm chooses a wage to post to maximize the expected value $J = q(\theta(w))(y - w)$, and each worker chooses to apply to a wage that maximizes the expected value $V = p(\theta(w))w$. The equilibrium tightness must be consistent with competitive entry and workers' application decisions.

Without restricting the function $\theta(.)$, there can be many equilibria. For example, take an arbitrary wage $w_0 \in (0, y)$, and let θ_0 satisfy: $q(\theta_0)(y - w_0) = c$. Suppose that workers believe that all firms will post only wage w_0. With this belief, workers will apply only to wage w_0. But if no worker applies to other wages, then all firms will indeed post only wage w_0. That is, the pair (w_0, θ_0), together with the particular belief, is an equilibrium. In this equilibrium, $\theta(w)$ is not well-defined for $w \neq w_0$, because there is no firm or worker at such wages.

One way to avoid this problem is to introduce a small measure of non-optimizing firms that post every feasible wage and to analyze the limit of the equilibrium when this measure approaches zero. Another way is to impose restrictions on the beliefs out of the equilibrium, as we do here. Let E be the set of equilibrium wages. For $w^* \in E$, denote the expected value of applying to w^* as $V^* = p(\theta(w^*))w^*$. We require that, for every $w^* \in E$, the function $\theta(.)$ must satisfy $p(\theta(w))w = V^*$ for w in a neighbourhood of w^*. That is, a firm believes that workers will apply to a deviating wage to such an extent that they will be indifferent between the deviating wage and the equilibrium wage.

The restriction implies the following features of the tradeoff between the wage level and the matching probability. First, because $p(\theta)$ is a decreasing function, a worker who applies to a wage higher than an equilibrium wage expects to face a tighter market and, hence, a lower matching probability. Similarly, a firm that posts a wage higher than an equilibrium wage expects to increase its matching probability. Second, because $p(\theta)$ is differentiable, the restriction implies that the function $\theta(.)$ is differentiable. Thus, the tradeoff between the wage level and the matching probability is smooth.

To characterize the equilibrium, suppose $w^* \in E$, with $V^* = p(\theta(w^*))w^*$. Each firm takes V^* as given and chooses w to solve the following problem:

$$\max \; q(\theta(w))(y - w) \text{ s.t. } p(\theta(w))w = V^*.$$

Under the earlier assumptions on the function $q(\theta)$, the problem above is a concave problem and the solution is interior for all $V^* \in (0, y)$. Using the relationship $q(\theta) = \theta p(\theta)$, we can derive the first-order condition of the problem as $w^*/y = s(\theta)$. The equilibrium satisfies the Hosios condition!

As before, we can determine the tightness in the equilibrium by the entry condition, $J = c$. Then, the worker's indifference condition recovers V^*. It is easy to see that the market tightness is identical to the efficient one. Thus, the equilibrium is efficient.

The reason why the equilibrium is efficient can be related to hedonic pricing. With directed search, the market functions as if there is a price (in terms of wage) for every level of tightness. The inverse of the function $\theta(.)$ serves as such a pricing function. Given this function, each worker chooses to apply to a wage level that maximizes his or her expected utility and each firm posts a wage to maximize expected profit. In the equilibrium, the market prices the tightness efficiently. That is, the increase in wage that a firm is willing to give for a marginal increase in the tightness is equal to the increase in wage that a worker asks for to compensate for a tighter market. As a result, the equilibrium internalizes search externalities. Because of this link to hedonic pricing, directed search is also called competitive search (see Moen, 1997).

Directed search can also induce the efficient amount of investment. Suppose that each firm chooses the level of capital before entering the labour market. Anticipating that the equilibrium wage will divide the match surplus efficiently, firms will choose the efficient level of capital.

3. Strategic Formulation of Directed Search

In the above analysis, the matching function is a black box – it is specified exogenously as in models of undirected search. Because the matching function is important for the analysis of efficiency, it is important to derive a matching function from agents' strategic behaviour. Peters (1991) and Burdett et al. (2001) formulate such a strategic game of directed search. The formulation also justifies the restriction above on the beliefs out of equilibrium. Let us describe the game where both u and v are fixed numbers greater than or equal to two. Competitive entry can be introduced in the same way as above.

The one-period game is as follows. First, all firms post wages simultaneously. Each worker observes all firms' posted wages. (The essence of the model is the same if each worker can observe only two wages that are randomly drawn from posted wages.) Then, all workers choose the firms to which they apply. Assume that a worker can apply to only one job in the period, but the worker can use mixed strategy in the application. After receiving applicants, a firm randomly chooses one to be employed. Production takes place immediately and an employed worker is paid the posted wage. Then, the game ends.

There are many equilibria of this game that are asymmetric in the sense that identical agents do not use the same strategy. When $u = v = 2$, for example, one asymmetric equilibrium is that one worker applies only to one firm and the other worker applies only to the other firm, while the two firms post zero wage. In this equilibrium, there is no unemployment – unemployment is eliminated by implicit coordination between the two workers. That is, a worker believes that the other worker will not apply to the same job as he or she does. Other asymmetric equilibria involve trigger strategies that also feature implicit coordination. Such coordination is unlikely to be attainable when there are many agents in the market.

To emphasize the lack of coordination, we focus on the symmetric equilibrium, where all (identical) workers use the same mixed strategy to apply to the jobs. In this equilibrium, it is probable that two or more workers will apply to the same job, in which case some workers will be unemployed.

To characterize the equilibrium, consider a particular firm, called firm A. Suppose that other firms post wage w, but firm A posts wage x. If x is close to w, some workers will apply to firm A: if no other worker applied to firm A, a lone applicant to firm A would be employed with certainty, which would generate higher expected utility than applying to w. In fact, workers will increase the probability of applying to firm A until the expected utility from this application is the same as that from applying to other firms. Let a be the probability with which a worker applies to firm A. Then, firm A will receive one or more workers with probability $[1 - (1 - a)^u]$, and the expected number of applicants received by the firm will be ua. A worker who applies to firm A will be employed with probability $\left[1-(1-a)^u\right]/(ua)$. Because a worker's application probabilities across the firms must add up to one, a worker applies to each firm other than firm A with probability $\pi(a) = (1-a)/(v-1)$. The probability of employment in such a firm is $\left[1-(1-\pi(a))^u\right]/(u\pi(a))$. For a worker to be indifferent between firm A and other firms, the expected payoff must be the same from these firms. That is,

$$\frac{1-(1-a)^u}{ua}x = \frac{1-[1-\pi(a)]^u}{u\pi(a)}w.$$

This equation defines a smooth function $a = f(x, w)$. This function serves the same role as the tightness function did in the above formulation of directed search – it describes how a firm's wage offer will affect workers' application, given other firms' wage offers. Note that f is an increasing function of x. Taking other firms' wage offers as given, firm A chooses x to solve:

$$\max\ (y-x)\left[1-(1-a)^u\right] \quad \text{s.t. } a = f(x, w).$$

Denote the solution to this problem as $x = g(w)$.

A symmetric equilibrium is a wage level w such that $w = g(w)$. In this equilibrium, $a = \pi(a) = 1/v$. The first-order condition of the above maximization problem, evaluated in the equilibrium, yields:

$$w = y\left[\frac{(1-1/v)^{-u}-1}{u/v} - \frac{1}{v-1}\right]^{-1}.$$

The formulation above reveals two features of a market with a finite number of agents. First, the number of matches generated in the equilibrium is $v[1-(1-1/v)^u]$. This matching technology exhibits decreasing returns to scale. The reason is that when the number of agents increases, the coordination failure becomes more severe, and so the number of matches per agent falls. Second, when a firm chooses its wage offer, it cannot take as given the payoff which a potential applicant can get by applying elsewhere. We have made this interdependence explicit with the notation $\pi(a)$. That is, when firm A raises the offer, it will attract all workers to apply to it with a higher probability, which will increase the probability of employment at other firms. For any given offer by other firms, a worker's payoff of applying to those firms will increase as a result of the wage increase by firm A. These two features complicate the analysis.

Fortunately, the complexity disappears in the limit when the market becomes infinitely large. Suppose that u and v approach infinite, with a fixed ratio $\theta = u/v$. Then, the matching probability is $(1 - e^{-\theta})$ for a firm and $(1 - e^{-\theta})/\theta$ for a worker. These matching probabilities have all the properties assumed above and, in particular, they are independent of the scale. Moreover, $u\pi(a) \to \theta$, which is independent of an individual firm's offer, x. The payoff to a worker who applies to a firm other than firm A is $w(1 - e^{-\theta})/\theta$, which is also independent of x. In the limit economy, the equilibrium satisfies the Hosios condition and it is efficient.

4. Other Pricing Mechanisms and Price Dispersion

Price-posting is not the only mechanism to direct search. There are other mechanisms of directed search which can generate efficiency as well. Auction is an example (e.g., Julien et al., 2000). In contrast to price-posting, auction induces price dispersion. Thus, efficiency is not necessarily linked to a uniform price in an economy with risk-neutral agents.

Consider the following game with first-price auctions. Each firm announces a reserve wage and the following scheme. If two or more workers participate in the firm's auction, the participants bid on the wage and the lowest bidder is employed at the bid wage; if two or more workers have the lowest bid, one of them is chosen randomly by the firm; if only one worker participates, the worker is paid the reserve wage. After observing all firms' announcements, workers choose the auction in which they will participate. A worker can participate in only one firm's auction, although the choice can be a mixed strategy.

Choose an arbitrary firm and call it firm A. Let x be the reserve wage announced by firm A and a the probability with which a worker participates in this firm's auction. For a worker who participates in firm A's auction, there are two possible outcomes. The first is that the worker is the only participating worker, in which case the worker gets wage x. This outcome occurs with probability $(1-a)^{u-1}$. The other possibility is that the firm receives one or more other participants. In this case, the participants bid the wage down to 0. Thus, by participating in firm A's auction, a worker expects to obtain a value $(1-a)^{u-1}x$. For firm A, there are also two cases. If only one worker participates in the firm's auction, profit is $(y-x)$. This case occurs with probability $ua(1-a)^{u-1}$. If two or more workers participate, profit is y. The probability for this case is $[1-(1-a)^u - ua(1-a)^{u-1}]$. Thus, the expected value (profit) of firm A is:

$$ua(1-a)^{u-1}(y-x) + \left[1-(1-a)^u - ua(1-a)^{u-1}\right] y.$$

For a firm other than firm A, let r be the reserve wage announced by the firm, $\pi(a)$ the probability of a worker's participation in the firm's auction, and $V(r,a)$ the expected value for a worker from such participation.

In order for a worker to be indifferent between firm A's auction and other firms' auctions, the expected value must be the same; i.e., $(1-a)^{u-1}x = V(r,a)$. Taking this condition as a constraint and taking other firms' auctions as give, firm A chooses x to maximize the expected profit above. Let $x = g(r)$ be the optimal choice. Then, a symmetric equilibrium is a reserve wage r such that $r = g(r)$.

As in the case of wage-posting, the characterization of the equilibrium is simplified in the limit economy where $u \to \infty$ and $\theta = u/v \in (0,\infty)$. In such a limit, we have $\pi(a)v \to 1$. Hence, $\pi(a)$ and $V(r,a)$ are independent of a. Solving the above maximization yields $r = y$. Thus, in contrast to directed search with wage posting, auction generates a wage differential. Some employed workers are paid their productivity but others are paid their reservation wage, 0.

Despite the dispersion of wages, the equilibrium is efficient. With risk-neutral agents, it is expected wage, rather than the actual wage, that is important for efficiency. With auction, the expected payoff is $ye^{-\theta}$ to a worker and $y\left[1-(1+\theta)e^{-\theta}\right]$ to a firm. These expected payoffs are the same as those in directed search with wage posting.

5. Related Issues

(1) Risk aversion and asymmetric information. When workers are risk averse, different mechanisms of directed search can differ in efficiency. For example, price-posting generates lower risks in workers' income than auction. If the insurance market is imperfect, then wage-posting may give higher expected utility to workers than auction. Moreover, unemployment insurance, financed by lump-sum taxes, can improve welfare in this case (see Acemoglu and Shimer, 1999). On the other hand, price-posting is unlikely to be efficient when there is asymmetric information about the quality of goods in sale or workers' productivity. Auction is a better mechanism to allocate resources in the presence of private information.

(2) Heterogeneity and assortative matching. Directed search models can be extended to allow workers to be heterogeneous. To achieve efficiency in such an extension, firms must rank different types of workers in addition to announcing wages. Heterogeneity can also appear on both sides of the market. In this case, an interesting question is whether the matching pattern is assortative, that is, whether similar attributes are matched with each other. In a frictionless economy, the efficient matching pattern is positively assortative, provided that the attributes on the two sides of the market are complementary. Moreover,

the competitive equilibrium can implement the efficient matching outcome. When search frictions are introduced through undirected search, neither is the equilibrium pattern of matches assortative nor is it efficient (e.g., Sattinger, 1995, and Shimer and Smith, 2000). Introducing directed search can restore efficiency. However, the efficient matching pattern may be non-assortative when utility is transferable (e.g., Shi, 2001). There is a tradeoff between the matching quality and the matching rate.

(3) Multiple applications. Most search models assume that an agent on one side of the market can visit only one agent on the other side of the market in a period; for example, a worker can apply only to one job at a time. This assumption may not be realistic. When workers can apply to multiple jobs simultaneously, there is a new source of the failure of coordination among firms: two firms may select the same worker and one of them will fail to obtain the worker. If the left-out firm has no recourse to other applicants it received, then the equilibrium is inefficient even with directed search. However, there are rules of selection, such as the one described by Gale and Shapley (1962), that can eliminate this difficulty of coordination and restore efficiency.

(4) On-the-job search. Search on the job is rarely examined in directed search models; sequential (undirected) search models have dominated the analysis on this topic. See Mortensen, 2003, for the references. These models are constructed typically in continuous time. They assume that each worker, employed or not, receives a wage offer according to a Poisson process. While an unemployed worker receives one offer at a time, an employed worker effectively receives two offers – his current wage and the new offer from another firm. In this environment, the equilibrium must have a continuous distribution of wages with no mass point in the interior of the support; otherwise, a firm's payoff function would be discontinuous on the right side of the mass point. These models yield strong predictions on the shape of the wage distribution, some of which are counter-factual.

6. Search as a Microfoundation for Monetary Theory

A surprising development of search theory is its use in monetary theory. For monetary economics, a fundamental question is why intrinsically useless objects, such as fiat money, can have a positive value in the equilibrium. A familiar but informal answer is that such objects relieve the difficulty of exchange by acting as media of exchange. To capture this role of money, traditional monetary theory has used shortcuts while keeping the assumption of frictionless (Walrasian) markets. Examples include the requirement that agents must hold cash in advance of purchases and the assumption that money yields direct utility which cannot be generated by other assets. These shortcuts seem incompatible with the Walrasian markets in the model and they are unable to explain why different media of exchange can have different values. To formalize the difficulty of exchange, Kiyotaki and Wright (1993) abandoned the shortcuts and replaced the Walrasian exchange with random bilateral matches. The resulting model is a value theory of money, which gives money a role in improving efficiency of the market. Shi (1995), and Trejos and Wright (1995), integrated this value theory of money with a theory of price.

Monetary theory has gone one step further to analyze optimal trading mechanisms. Using the method of mechanism design, the theory characterizes the set of allocations that are compatible with agents' incentives in the presence of search frictions. Next, the theory examines the efficient allocations and asks whether the implementation of these allocations entails particular types of trade, such as the use of money, banking, or a payments system, e.g., Green and Zhou (2005). This analysis has clarified the relationship between optimal trading mechanisms and different components of search frictions, such as the difficulty for agents to meet, the difficulty for the society to keep record of agents' transactions, and the difficulty of enforcing trades.

7. Conclusions

Search theory was initially formulated to understand price dispersion and unemployment. Recent research has shifted the focus to the pricing mechanism and efficiency in frictional economies. Directed search is formulated to allow agents to explicitly make a tradeoff between prices and matching frequency. The main finding is that directed search can restore efficiency that failed in earlier search models. However, even the efficient allocation cannot fully utilize all resources, because of the constraint of the matching technology. Moreover, the efficient allocation may not have the assortative pattern that emerges in a frictionless economy. The literature has explored different pricing mechanisms of directed search and used search to develop a microfoundation for monetary theory.

This entry has omitted the empirical work of using search models to explain wage distribution and inequality. For this literature, see Mortensen (2003).

By focusing on pricing mechanisms and efficiency, the research has brought search theory close to the task of analyzing the interactions between trades inside economic organizations and outside in the market. These interactions are important for explaining the observed forms of contracts and trading institutions. Monetary search theory has already taken up this task by using the approach of mechanism design. Other fields can also benefit from incorporating search frictions. An example is the literature on optimal dynamic contracts. This literature characterizes optimal contracts that a firm can provide to workers who repeatedly receive shocks to their tastes and productivity that are unobservable to the firm. The typical assumption is either that agents can fully commit to the contracts or that they cannot commit at all. This assumption has produced unrealistic predictions on the time profile of agents' utilities. To improve the predictions, it seems important to allow agents in a contractual relationship to search for other contracts. This allowance will endogenize the duration in which an agent will stay in a particular contract. In general, the integration of search theory and contract theory awaits future research.

References

Acemoglu, Daron and Robert Shimer, 1999, "Efficient unemployment insurance," *Journal of Political Economy* 107, 893-928.

Burdett, Kenneth, Shi, Shouyong and Randall Wright, 2001, "Pricing and matching with frictions," *Journal of Political Economy* 109, 1060-1085.

Diamond, Peter, 1987, "Search theory," in: Eatwell, John, Milgate, Murray and Peter Newman (eds.), *The New Palgrave Dictionary of Economics*, Macmillan Press, London.

Gale, David and Lloyd Shapley, 1962, "College admissions and the stability of marriage," *American Mathematical Monthly* 69, 9-15.

Green, Edward and Ruilin Zhou, 2005, "Money as a mechanism in a Bewley economy," International Economic Review 46, 351-371.

Hosios, Arthur, 1990, "On the efficiency of matching and related models of search and unemployment," *Review of Economic Studies* 57, 279-298.

Julien, Benoit, Kennes, John, and Ian King, 2000, "Bidding for labor," *Review of Economic Dynamics* 3, 619-649.

Kiyotaki, Nobuhiro and Randall Wright, 1993, "A search-theoretic approach to monetary economics," *American Economic Review* 83, 63-77.

Moen, Espen R., 1997, "Competitive search equilibrium," *Journal of Political Economy* 105, 385-411.

Mortensen, Dale, 2003, *Wage Dispersion: Why Are Similar People Paid Differently.* MIT Press, Cambridge.

Peters, Michael, 1991, "Ex ante price offers in matching games: non-steady state," *Econometrica* 59, 1425-1454.

Sattinger, Michael, 1995, "Search and the efficient assignment of workers to jobs," *International Economic Review* 36: 283-302.

Shi, Shouyong, 1995, "Money and prices: a model of search and bargaining," *Journal of Economic Theory* 67, 467-496.

Shi, Shouyong, 2001, "Frictional assignment. i. efficiency," *Journal of Economic Theory* 98, 232-260.

Shimer, Robert and Lones Smith, 2000, "Assortative matching and search," *Econometrica* 68, 343-370.

Trejos, Alberto and Randall Wright, 1995, "Search, bargaining, money and prices," *Journal of Political Economy* 103, 118-141.