

Gehrig, Thomas

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Discussion Paper No. 1058

INTERMEDIATION IN SEARCH MARKETS

by

Thomas Gehrig*

August 1993

revised version

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*Department of Managerial Economics and Decision Sciences, J.I. Kellogg Graduate School of Management, Northwestern University, 2001 N. Sheridan Road, Evanston, Illinois 60208, USA.

Abstract

In markets, in which exchange requires costly search for trading partners, intermediaries can help to reduce the trading frictions. This intuition is modelled in a framework with heterogeneous agents, who have the choice between intermediated exchange and search accompanied by some bargaining procedure. The equilibria of such a game are characterized. In the case of a monopolistic intermediary the tradeoff between the bid-ask spread and the costs of delay during private search determine the intermediary's clientele. In equilibrium the monopolist charges a positive spread. Traders with large gains from trade prefer to deal with him, whereas traders with relatively low gains from trade engage in search. In case of competition among intermediaries the classical Bertrand result obtains and bid and ask prices converge to the (unique) Walrasian equilibrium price. Thus in the confines of the model the Walrasian auctioneer of the market under consideration can be replaced by competing intermediaries. In addition a multiplicity of subgame perfect Nash equilibria emphasizes the coordination problems inherent in models of intermediation.

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Intermediation in Search Markets

1. Introduction

Price-setting mechanisms vary considerably across markets. It is useful to distinguish between intermediated markets and search markets. In intermediated markets, products are purchased and sold by the intermediary who posts bid and ask prices. Intermediaries include wholesalers, retailers and financial institutions. Intermediated markets also include organized auction markets, such as stock, bond and commodity futures markets, and auction houses such as Christie's or Sotheby's. In search markets, buyers and sellers meet and negotiate prices. These markets include bazaars, real estate markets, and markets for contracted services. Since the services of intermediaries are costly to traders, the question arises why intermediaries are necessary. This paper attempts to answer the question by allowing buyers and sellers the choice between entering a search market or an intermediated market. It is shown that by posting prices, intermediaries reduce the costs of search for buyers and sellers.

By publicly posting prices, intermediaries reduce the costs of matching and the likelihood of disagreement in bargaining. As Demsetz (1968) observes, intermediaries offer the service of immediacy. However, intermediaries, typically, buy at a lower buying (bid) price and sell at a higher selling (ask) price, thus generating positive revenue for any commodity bought in the input market and sold again on the output market. Traders, with little gains from trade may not be willing to pay this transaction cost, implicit in the bid-ask spread, and prefer to trade in the frictional market. It will emerge that, typically, both markets co-exist whenever the bid-ask spread in the intermediated market is positive, and when there is enough heterogeneity among traders. So, intermediaries, when designing their pricing strategies, need to take into account the characteristics of the underlying search market. An increasing search efficiency in the underlying frictional

market generally drives optimal bid-ask spreads down. In fact, this result even obtains in the case of a monopolistic intermediary whose market power is largely determined by the ability of traders to bypass him by trading in the frictional market. As these frictions vanish, so does his market power. Furthermore, it will emerge that intermediaries' profits depend quite sensitively on widely held beliefs of traders about intermediaries' ability to deliver.

Immediacy is particularly important in financial markets since prices react continuously upon arrival of new information, which may affect the value of the underlying security. Since this information generally is revealed only gradually to market participants, either via direct communication or indirectly through the movement of prices, financial markets may face serious problems of asymmetric information. This is manifested in recurring debates about insider dealing as well as in the growing literature on optimal market micro structures (Milgrom, Glosten (1985), Kyle (1985), Roell (1987)). This literature concentrates on the design of optimal bid-ask-spreads for market makers in situations of "informed dealing". To prevent a market break down, additional trading motives are necessary. Typically, these are modelled as "noise traders", who may be considered as traders dealing for reasons unexplained by the model. Undoubtedly, asymmetric information will affect the design of the intermediaries' price schedules. Yet, there has to be a prior motive for trade, which keeps the "noise" or "liquidity" traders in the market. It is this motive we concentrate on, sidestepping the impact of insider information.

In his seminal article "The Cost of Transacting", Harold Demsetz (1968) develops the idea of immediacy to explain actually observed transaction costs at the New York Stock Exchange (NYSE). In his view, the exchange's specialists provide the service of immediate order execution by maintaining inventories of shares. In markets with large price fluctuations such services might be of great value to customers. Intermediaries can recoup any opportunity costs and positioning risks they incur, by charging positive bid-ask spreads. He develops a model, in which transaction costs are entirely determined by the costs of providing the service of immediacy.

Although the “specialists” for a particular stock at the NYSE are regulated monopolists, Demsetz argues verbally that there should be enough competitive pressure from related and rival markets so as to avoid excessive spreads. “Competition of several types will keep the observed spread close to cost. The main types of competition emanate from (1) rivalry for the specialist’s job, (2) competing markets, (3) outsiders who submit limit orders rather than market orders, (4) floor traders who may bypass the specialist by crossing buy and sell orders themselves, (5) and other specialists” (Demsetz, 1968, p.43). Thus, competitive pressure should guarantee fairly competitive pricing of the specialist. Observed positive bid-ask spreads therefore are reliable measures of the cost of intermediation. So, while leaving the confines of his model, Demsetz implicitly relies on the beneficial effects of price competition.

The recent literature on two sided price competition however contests such a view. It demonstrates the sensitivity of equilibria of price setting games on the exact nature of competition. Stahl (1988) and Yanelle (1989a) offer examples of two sided price competition, in which non-Walrasian equilibria with positive bid-ask spreads emerge, even when the intermediation technology is costless. These examples hinge on the impossibility of short sales. In such a non-Walrasian equilibrium intermediaries offer attractive bid prices and hence virtually attract all sellers. This gives them a monopoly position towards buyers. Furthermore, even the existence of equilibrium may be problematic in intermediated markets. (Yanelle, 1989a).

This calls for a rigorous treatment of the intuition developed above. In such a framework then also the question can be addressed, to what extent an intermediary’s liberty to set prices will be constrained by the various sources of competition. In particular, how will bid-ask spreads and the nature of competition among intermediaries depend on frictions in the underlying market for direct transactions between buyers and sellers?

Our model formalizes Demsetz’s central insight: organized markets reduce the impact of trading frictions. Therefore, these frictions which give rise to the intermediated market are modelled explicitly in the direct exchange market. It

takes time to find a suitable trading partner and to negotiate the price. Intermediaries, by offering fixed prices, stand ready to speed up the process of exchange. Their price quotes are widely visible and therefore allow traders to trade without delay, provided the intermediary can satisfy the order at all. To provide this service, intermediaries are guided by the principle of gain in charging bid and ask prices. However, they are bound by competition from rival intermediaries as well as from the search market. In fact, we shall see that the presence of this search market qualitatively changes the nature of competition among the intermediaries. In addition, they have to compete against the search market and cannot exploit a monopoly position as in the examples discussed above. Competition among several intermediaries is shown to result in Walrasian outcomes. It depresses bid-ask spreads down to zero. Consequently, buyers and sellers can transact at Walrasian prices and zero transaction costs via the intermediaries. In the absence of any costs for the intermediation services the Walrasian auctioneer can be replaced by competing intermediaries.

If, however, there are fixed costs of entry into the intermediation business, the natural industrial structure is that of a natural monopoly in the sense of Shaked and Sutton (1983). In their definition an industry is a natural oligopoly, when the number of firms entering the industry is bounded independently of the size of the economy. Thus, in a natural oligopoly the convergence to a fragmented industrial structure is explicitly prevented, as the economy grows large. Here, in equilibrium only one intermediary enters. He charges positive spreads. In the choice of prices, however, he is constrained by competition against the search market. In equilibrium, typically, the search market is active. Buyers and sellers with large gains from trade prefer intermediated trade, whereas traders with lower gains engage in search.

Several aspects of intermediation are discussed in the literature. One line of thought argues that intermediation may help to complete the market system in situations, in which asymmetric information causes market failure otherwise (Garella, 1989). Another line stresses economies of scale in the provision of incentive schemes (Diamond, 1984, Yanelle, 1989b). Intermediaries might save on

transaction (monitoring) costs to the benefit of society and could be considered as part of an efficient mechanism minimizing the impact of informational costs.

In their paper about “middlemen” (1987), Rubinstein and Wolinsky pursue a totally different route. They incorporate intermediaries in a bargaining and matching framework. Intermediaries enjoy the advantage that their probabilities of meeting customers is higher than for customers meeting customers. In equilibrium all agents may interact with each other. A buyer might happen to bargain either with an intermediary or a seller. In this sense both direct and indirect trade take place in equilibrium. However, neither buyers nor sellers can affect their matching probabilities by deliberately dealing with the intermediary. So the model is silent about explaining the advantages of intermediation.

Also, the work of Yavas (1992) and Moresi (1991) is closely related. Yavas distinguishes between market-makers, who are committed to trade any quantity at the quoted prices, and match-makers, who are committed to their price quotes only. He analyses how the different commitment assumptions affect search incentives of buyers and sellers and aggregate welfare. However, his model is set up such, such that after unsuccessful search, ultimately traders are matched by intermediaries with probability one. Therefore, the search market essentially provides a chance to get a better deal than a monopolistic intermediary is prepared to offer. There is no chance of trading opportunities being lost. Moresi analyzes “market equilibria with exogenous intermediation” in a dynamic framework, where intermediaries are market makers, and hence committed to trade any quantity requested at the quoted prices.

The paper is organized as follows. Section 2 introduces the general model. Section 3 analyzes the case of a monopolistic intermediary, competing against the search market. Section 4 also allows for competition among intermediaries. Finally, section 5 concludes.

2. The Model

In an unorganized market, buyers and sellers meet randomly and negotiate about the terms of trade. In such an environment, there are two sources that may cause delay of trade. There can be delay in the search for trading partners and there may be delay or even breakdown in bilateral negotiations. If delay is costly to traders an opportunity arises for intermediaries to provide a trading post and to commit to fixed prices. Thus, they provide an opportunity for traders to reduce the transactions costs associated with search and bargaining. Typically, intermediaries will charge traders implicit fees by offering different buying and selling prices. So, traders ultimately have to decide whether to deal through an intermediary or to search for trading partners in the unorganized search market.

Section 2.1 explains traders' characteristics, while section 2.2 gives details about the unorganized search market. Section 2.3 describes intermediaries, and section 2.4 lays out the market environment and defines the market equilibrium.

2.1 Buyers and Sellers

Assume that there is a continuum of ultimate traders, i.e., of buyers and sellers, who want to trade at most one unit of an indivisible product.

Buyers' preferences are described by reservation prices $r \in [0, 1]$. If the product sells at the price p , a buyer with reservation price r attains utility of $U_\beta(r) = r - p$. Let the reservation values be uniformly distributed on $[0, 1]$. The distribution of reservation prices generates an aggregate demand schedule, which can be interpreted as the Walrasian market demand. When reservation values are uniformly distributed, Walrasian demand is linear, and reads $D(p) = 1 - p$ for prices $p \in [0, 1]$.

Symmetrically, sellers' preferences are described by reservation prices $s \in [0, 1]$. So if the product sells at p seller s 's utility reads $U_\sigma(s) = p - s$. Let s also be uniformly distributed on $[0, 1]$. So, Walrasian supply is $S(p) = p$, for prices $p \in [0, 1]$.

Buyers' and sellers' preferences are private information. Only the aggregate distributions of types, and, therefore, aggregate demand and supply are common knowledge. So, in principle, all traders can calculate the unique Walrasian equilibrium price and the corresponding allocations. However, since there is no auctioneer quoting market clearing prices and coordinating the trading activities, the agents are forced to establish the equilibrium allocation by their own actions, which does imply costly search for trading partners and some sort of price bargaining.

Alternatively, they may trade with intermediaries, who, in contrast to the auctioneer, will quote prices with the purpose of generating profits. Typically, these prices will not be market clearing in the Walrasian sense, and inefficient allocations do result.

2.2 The Search Market

When buyers and sellers choose to enter the search market assume that they are matched at random by some matching technology. The number of agents on the two sides of the market may differ. The technology is such that each market participant on the short side of the market is matched with some probability $\lambda \in [0, 1]$ with an agent of the opposite type. The matching probabilities of agents on the long side consequently are adjusted by the relative numbers and therefore less than λ . The probability of being matched to a particular subset of trading partners is the same for all subsets of the same size (i.e. with the same Lebesgue measure) on the same market side. In the symmetric case of equally many sellers and buyers in the search market λ is simply the probability of being matched for any participant. This is the continuous analog of assuming that the probability of being matched to a particular partner will be constant for all possible partners. Such a technology can easily be shown to exist for the discrete case.

Once a match is established, the traders engage in negotiations about the price of the product. Since they do not know their counterpart's reservation price, sequential bargaining may become quite complex. Therefore, a highly simplified

version of the bargaining process is chosen. Nature selects one of the partners at random to announce a take-it-or-leave-it offer, which the counterpart may accept or reject. Upon acceptance trade is accomplished. After rejection however, the trading opportunity is lost, and all traders leave the market.

For technical reasons assume further that only traders who expect positive utility from trading will enter the market. This prevents the market from being overcrowded by agents unwilling or incapable of trading, i.e., with an expected value from trade of zero. These superfluous traders would only affect the matching probabilities. Alternatively, a (negligibly) small entry cost for the search market could have been introduced.

Let $F(r)$ and $G(s)$ be the distribution functions of buyers and sellers active in the search market. Buyer r 's utility $U_\beta(r)$ when entering the search market consists of three components. If he is lucky, he finds a trading partner and receives the right to supply a take-it-or-leave-it bid. Otherwise, he may still find a matching partner and respond passively by accepting or rejecting a bid. In the worst case, he might not even find a partner on the search market. His utility therefore consists of the value of the bidder's game plus the value of the respondent's game weighted by the appropriate probabilities. The same applies to the seller's utility $U_\sigma(s)$.

In order to determine the value of the search game for a bidder define his optimal bid for given conditional distributions of sellers $G(s)$ and buyers $F(r)$ active in the search market. Let $x(r)$ and $y(s)$ denote the buyer's and the seller's bid. In case buyer r 's bid is accepted, he receives utility $r - x(r)$. So he has an incentive to bid a low price. On the other hand, by lowering the bid, he also reduces the probability of the bid being accepted, because only sellers with reservation prices $s \leq x(r)$ might accept. This trade-off between maximal surplus and a high probability of trade determines the actual offer.

A passive matching partner will accept a bid only as long as his utility gain is positive. So buyer r 's utility is $\max\{0, r - y(s)\}$ in case seller s has the right to bid. Likewise, seller s 's utility is $\max\{0, x(r) - s\}$ when it is buyer r to bid.

Define the expected utility from search as the sum of the expected value from bidding and the value of the subform, in which the matching partner offers a bid. This will be done for the special case, in which the total numbers of sellers and buyers in the search market are equal, since the general case is readily established by adjusting the respective utilities by the relative measure of traders on the long side of the market. Buyer r expects the following utility from search:

$$U_{\beta}(r) = \frac{\lambda}{2} \int_{s \leq x(r)} (r - x(r)) dG(s) + \frac{\lambda}{2} \int_{y(s) \leq r} (r - y(s)) dG(s). \quad (1.1)$$

Likewise, the sellers' utility attainable from search can be written as

$$U_{\sigma}(s) = \frac{\lambda}{2} \int_{r \geq y(s)} (y(s) - s) dF(r) + \frac{\lambda}{2} \int_{x(r) \geq s} (x(r) - s) dF(r). \quad (1.2)$$

Essentially, the implicit cost of search for traders consists of the probability of disagreement in a particular match, which urges them to delay trade by one period. In a richer model of search, traders could be matched more than once, and by affecting their search intensities they would typically affect the number of expected matches. The crucial aspects of search, however, the possibility of mismatches and costly delay, are captured in this stylized version.

2.3 Intermediaries

As an alternative to the search markets, traders may choose to deal immediately with the intermediaries at the quoted prices. Assume that the intermediaries $i = 1, \dots, I$ quote fixed ask- and bid prices (a_i, b_i) , which are publicly observed by the whole market. For the period in question, intermediaries are committed to these prices for any transaction they engage in.

As long as they face the same number of buyers and sellers at the prices quoted they can easily match their clients and service all deals. In case of a

mismatch, however, they cannot serve all customers on one side of the market. In this case, they randomly ration the long side of the market. So, intermediaries' price commitments are limited to the intermediaries' ability to match the two market sides. Intermediaries cannot go bankrupt. At this stage, the possibility of intermediaries entering the search market in order to satisfy remaining customers is ruled out. In fact, it will not be optimal for intermediaries to do so. Let q_{bi} be the number of buyers and q_{si} the number of sellers that intermediary i attracts. Then the intermediary's profits are:

$$\pi_i = \min(q_{bi}, q_{si})(a_i - b_i). \quad (2)$$

Unsuccessful traders are allowed to enter the search market after they have been rejected by the intermediary. Accordingly, unsuccessful applications to an intermediary are not costly for the traders, except for the trading opportunity with the intermediary foregone.

Buyers' and sellers' value of an intermediated transaction will depend on the surplus which can be attained at a given price quote of the intermediary, and on the probability of actually obtaining this surplus. When the intermediary can match the request of a particular client, this value is simply the difference between the client's reservation price and the intermediary's quote. In case the intermediary i cannot match all clients, there is a chance of $\alpha_{\beta i} = \min(\frac{q_{si}}{q_{bi}}, 1)$ or $\alpha_{\sigma i} = \min(\frac{q_{bi}}{q_{si}}, 1)$ that a buyer or a seller has to be rationed. Then the value of trade with intermediary i for buyer r and seller s , $W_{\beta i}(r)$ and $W_{\sigma i}(s)$, are determined by:

$$W_{\beta i}(r) = \alpha_{\beta i}(r - a_i). \quad (3.1)$$

$$W_{\sigma i}(s) = \alpha_{\sigma i}(b_i - s). \quad (3.2)$$

In equilibrium, clearly $\max(\alpha_{\beta i}, \alpha_{\sigma i}) = 1$, i.e., at most one market side will be rationed.

In the present setup, intermediaries differ from traders in two important respects. First, they have access to some information technology which allows

them to communicate prices to everybody, and second, they are committed to the prices quoted. In this respect, intermediaries resemble dealers at the National Association of Security Dealers' Automated Quotation System (NASDAQ) or the specialist at the New York Stock Exchange (NYSE).

2.4 Market Equilibrium

While markets typically operate in a dynamic environment the essential features of timing and commitment can be discussed best by analyzing the details of a single trading period in isolation. The length of such a period can be viewed as the minimal time period for which an intermediary's price quotes are fixed.

At the beginning of the period, intermediaries quote a selling (ask) and a buying (bid) price. During the period they are committed to sell or buy at this price. Observing the price quotes, customers decide which intermediary to visit. Alternatively, they can enter the search market or even remain inactive in case they cannot profitably engage in trade. However, they can only choose one action. So, either they search, visit an intermediary, or remain inactive. Buyers will search only if $U_{\beta}(r) \geq W_{\beta i}(r)$, for all i , and sellers will search only if $U_{\sigma}(s) \geq W_{\sigma i}(s)$, for all i . Having observed the incoming orders, intermediaries may ration the long side and send unsuccessful traders back to the search market. Accordingly, in assessing their utility from trade with the intermediary, buyers and sellers have to take into account the probability of being serviced.

In summary the stages of a trading period can be described as follows:

stage 1: Intermediaries select prices;

stage 2: Buyers and sellers select an intermediary or the search market;

Intermediaries may ration the long side of the market and send unsuccessful traders back to the search market;

stage 3: The matching market clears.

Buyers' and sellers' market choice will depend on their expectations of intermediary i 's trades (q_{bi}^e, q_{si}^e) , for all i and accordingly on their estimates $(\alpha_{\beta i}^e, \alpha_{\sigma i}^e)$, for all i . Typically, a buyer cannot expect any gain from trading with intermediary i if he expects $q_{si}^e = 0$. So the market equilibrium has to be defined as a perfect Bayesian equilibrium.

Definition 1.

A perfect Bayesian equilibrium consists of intermediaries' pricing strategies (a_i^*, b_i^*) , the market choice of buyers and sellers given their common beliefs (q_{bi}^e, q_{si}^e) , for all i such that:

- (i) Intermediaries choice of prices (a_i^*, b_i^*) maximizes intermediaries profits (2) for all i ;
- (ii) buyers' and sellers' market choice maximizes their expected gains from trade, either (1.1),(1.2) or (3.1),(3.2), given their beliefs (q_{bi}^e, q_{si}^e) , for all i ;
- (iii) buyers' and sellers' beliefs on the equilibrium path, (q_{bi}^e, q_{si}^e) , are consistent with Bayes' rule and the intermediaries' equilibrium strategies.

Typically, there will be many market equilibria in the given context. However, weak dominance arguments will select a single equilibrium.

3. A Monopolistic Intermediary

Traditionally, monopolistic firms are viewed with suspicion by public policy makers because of their dominant position in the market place. All customers need to purchase from the monopolist endowing him with a strong degree of market power which he can exploit strategically. In the presence of a search market, the situation is different, however, since traders may trade directly and circumvent the monopolistic intermediary. There are still costs of trading involved in the search market, such as delay and breakdown of bargaining, and these frictions may render some market power to the intermediary. Nevertheless, the

monopolistic intermediary's market power now is closely related to the efficiency of the underlying search market and the magnitude of the search frictions or costs. The search market acts like a competitor to the intermediary and disciplines him accordingly. So, one would expect that the intermediary's spreads will be related to the degree of inefficiency of the search market. In stock markets, for example, Demsetz (1968) argues that social losses associated with the specialist system in stock trading may be rather small because of precisely this disciplining role of the search market, or because of implicit competition from related markets. The purpose of this section is to substantiate and qualify this claim.

So, consider the monopolist's decision problem. Since he moves first and remains committed to the prices quoted for the rest of the trading period he needs to anticipate the (likely) decision of ultimate traders. In particular, he needs to assess the reaction of traders on his price quotes (a, b) . (The subscript i is suppressed for the rest of this section, since a single intermediary is analyzed only.)

As a first observation note that for any positive bid ask spread, $a - b > 0$, there will always be some traders actively participating in the search market, since sellers with valuations above the intermediary's bid price b and buyers with valuations below the ask price a can obtain a gain from trade only in the search market. In other words, as long as the intermediary is active and generates positive revenues, the search market is active as well. So, the intermediary's decision problem cannot be analyzed independently of the search market.

Furthermore, buyers with a valuation of exactly a and sellers with a valuation of exactly b will acquire zero surplus when trading with the intermediary. When entering the search market with some probability, a match with positive potential surplus is generated and actually succeeds in splitting the surplus. So by continuity, in close neighborhoods the respective buyers and sellers will enter the search market. So these buyers and seller will search as well. But where exactly is the cut-off and will anybody deal with the intermediary at all? Proposition 1 provides an answer by characterizing the decision of buyers and sellers. The proof is given in the appendix.

Proposition 1

- a. *There are critical reservation values \underline{r} and \bar{r} with $\underline{r} < \bar{r}$, such that the set of buyers can be partitioned into three subsets. Buyers with valuations in the interval $[0, \underline{r})$ remain inactive. Buyers with valuations in the interval $[\underline{r}, \bar{r}]$ enter the search market. Buyers with valuations in the interval $(\bar{r}, 1]$ trade with the intermediary.*
- b. *There are critical reservation values \underline{s} and \bar{s} with $\underline{s} < \bar{s}$, such that the set of seller can be partitioned into three subsets. Sellers with valuations from the interval $[0, \underline{s})$ trade with the intermediary. Sellers with valuations from the interval $[\underline{s}, \bar{s}]$ enter the search market. Sellers with valuations from the interval $(\bar{s}, 1]$ remain inactive.*

Proposition 1 is based on a strong monotonicity property. Take a buyer with valuation r , for example. If he prefers to enter the search market, any buyer with higher valuation will either search or trade with the intermediary, but not remain inactive, since otherwise he simply could imitate the buyer with lower valuation in the search market and enjoy positive gains from trade.

Likewise, if buyer r prefers to enter the search market, it can be shown that no buyer with lower valuation prefers to buy from the intermediary. The reason is that this hypothetical buyer by imitating the bidding strategy of buyer r could already achieve a utility from search which is higher than the corresponding utility from direct trade.

For small bid-ask spreads centered around the Walrasian price, high valuation buyers will achieve a surplus of $W_\beta(r) = r - a$ when trading with the intermediary, while the utility from search can be quite small, especially for small λ . So high valuation buyers will trade with the intermediary, provided he charges low enough ask prices.

Completely symmetric arguments apply for sellers. Sellers with potentially high gains from trade will trade with the intermediary, sellers with intermediate valuations will prefer search, and high cost sellers with no expected gains from trade remain inactive.

The number of traders dealing with the intermediary define his respective demand and supply at given price quotes. Proposition 2 describes the monopolist's profit maximizing choice and is proved in the appendix:

Proposition 2

a) *The intermediation game has a market equilibrium in which buyers with valuation $r > \frac{3}{4}$ and sellers with costs $s < \frac{1}{4}$ will trade with the intermediary for any $\lambda \in [0, 1]$. Buyers and sellers with valuations $r \in [\frac{1}{4}, \frac{3}{4}]$ and $s \in [\frac{1}{4}, \frac{3}{4}]$ will enter the search market. Buyers with valuations $r < \frac{1}{4}$ and sellers with valuations $s > \frac{3}{4}$ remain inactive.*

b) *The monopolist's price quotes are symmetric around the Walrasian price. His selling price (ask) is decreasing and his buying price (bid) is increasing in λ .*

$$a^*(\lambda) = \frac{3}{4} - \frac{\lambda}{8} \quad , \quad b^*(\lambda) = \frac{1}{4} + \frac{\lambda}{8}. \quad (4)$$

c) *The traders equilibrium beliefs are $q_b^e = q_b^* = q_s^e = q_s^* = \frac{1}{4}$.*

One of the remarkable features of the model is the presence of an active search market in equilibrium. Since match specific prices may be established there, a distribution of prices, at which trade takes place, can be observed. This is in contrast to a unique market clearing price in the Walrasian theory or Cournot's monopoly theory.

In equilibrium only traders with large gains from trade will prefer to trade with the intermediary. For them the chances to meet inadequate matching partners on the search market is particularly high. Hence search may prove relatively more expensive for them.

Note that in the given model the amount of intermediation is endogenously determined under the presence of trade frictions (search costs) on the underlying market for direct exchange. It takes time to find a good matching partner and as

long as time is valued by the agents they may be willing to pay for intermediation services. The intermediary provides immediacy and, thus, helps traders to economize on search costs. On the other hand, as long as he charges a positive spread, he imposes another transaction cost which not all market participants are willing to pay. So the tradeoff between the gains from immediacy and the transactional costs will determine the amount of trading activity via the intermediary and the importance of the search or shadow market.

The total number of active market participants in both markets exceeds the equilibrium number of traders in the Walrasian equilibrium. Clearly, in some matches on the search market no trade may take place. However some traders, who in Walrasian theory cannot participate in the markets, may engage in profitable trade. This is illustrated in figure 1.

In the case of the monopolist, the result is particularly interesting. In the absence of a search market ($\lambda = 0$), a classical monopolist would trade with the same types of buyers and sellers at a higher margin, however. Since the intermediary's economic role is purely to reduce the impact of trade frictions in the market, in choosing prices he is therefore bound by the size of these frictions. We may interpret λ as a partial measure of search market efficiency. An efficient search market which matches the short side with certainty (i.e. $\lambda = 1$) will restrain the intermediary's choice of prices most severely. In the model under consideration it will not render him totally redundant because the search market cannot achieve full efficiency. As the efficiency of the search market vanishes, however, the monopolist can afford to set prices, which correspond to his monopoly prices. So, the introduction of a market which allows agents to circumvent the monopolist will weaken his market power and depress his margins. This is restated in the following corollary.

Corollary

The classical monopolist charges $\hat{a}(0) = \frac{3}{4}$ and $\hat{b}(0) = \frac{1}{4}$. The minimum prices a monopolist charges are $\hat{a}(1) = \frac{5}{8}$ and $\hat{b}(1) = \frac{3}{8}$.

The parameter λ can also be interpreted as a measure of the competitive pressure on the intermediary from a competing market. Even protected monopolists may have to face the competition of shadow markets in which trade takes place on an unobservable individual level. Especially in financial markets such a dual structure of operation is found. So stocks are commonly traded on organized exchanges. However, quite, frequently there are also well established search markets in which prices are set by bilateral agreement. Often, even such search markets are organized by financial intermediaries who, therefore, also compete with the organized exchanges.

Returning to Demsetz's example at the New York Stock Exchange NYSE the question of competition off-market dealing is vital for the exchange, which is organized as a specialist system. The exchange grants exclusive rights to specialists to make the market in a specific stock. This gives the specialist the exclusive right to quote the prices for this stock. On the other hand the specialist has to comply with the rules of the exchange, which somewhat restrain his freedom in pricing and more importantly commit him to deal any normal quantity of stock at the price quoted. Only for large imbalances in the specialist's books due to large orders this commitment may be suspended. Therefore, particularly for large deals, an "upstairs dealer market" has developed, in which large trades, typically block trades, are matched. The participants in this upstairs market are a few large intermediary houses, which due to their large customer base can accommodate large deals better than the exchange. Obviously, as the efficiency of the upstairs market increases and small transactions are collected and bundled into larger blocks, there is concern about the viability of the specialist exchange.

Also observe that the equilibria for alternative measures of search market efficiency λ cannot be Pareto-ranked. Increasing λ will reduce equilibrium spreads and the participation in the search market as is seen in figure 1. Increasing efficiency of search may leave out market participants with rather low gains from trade.

Finally, note that the market equilibrium of proposition 2 is not unique. If buyers and sellers maintain the beliefs that the monopolist will not attract any

buyer or seller, i.e., $q_b^e = q_s^e = 0$ there is no value in trading with the intermediary. In this case, unintermediated trade is another equilibrium.

Since beliefs could depend on prices, a wide variety of equilibria are possible in fact. Essentially the multiplicity stems from a fundamental coordination problem between buyers and sellers which affects the intermediary's service probabilities. The attraction of the equilibrium singled out in proposition 2 is that it weakly dominates the no-trade or any other equilibrium, since sending requests to the intermediary is costless.

4. Price Competition among Intermediaries:

While the focus so far has been on indirect competition between differently organized market segments, there are several alternative sources of competition for a monopolistic intermediary. Demsetz (1968), for example, mentions specialists in related markets as another source of competition. While specialists in related markets provide another source of indirect competition, this section analyses the case of direct competition between intermediaries in the same market. Is it true that Bertrand competition among intermediaries drives down spreads such that intermediaries cannot recover any fixed costs of their operation? It will emerge that such an outcome is likely. However, due to coordination problems between buyers and sellers that are impertinent to models of intermediation, constellations are possible which allow several intermediaries to be active in the market.

Proposition 3:

In case of two competing intermediaries there is a market equilibrium, in which all intermediaries charge the Walrasian prices $a_i^ = b_i^* = \frac{1}{2}$, for $i = 1, 2$ and buyers and sellers correctly expect $q_{bi}^e = q_{bi}^* = q_{si}^e = q_{si}^*$, such that $\sum_i q_{bi}^* = \frac{1}{2}$. In this equilibrium the search market remains inactive.*

Proof:

It is easy to identify the Walrasian equilibrium as a perfect Bayesian equilibrium. Given that intermediary 1 charges $a_1 = b_1 = \frac{1}{2}$, the optimal reply for intermediary 2 is the same price quote. Charging a lower bid and a higher ask would not generate any positive trading volume, while charging a higher bid and a lower ask would at best cut into intermediary 2's profits.

Hence it remains to consider deviations, in which either intermediary 2's ask and bid prices are higher or in which both are lower than those of intermediary 1. Without loss of generality assume $a_2 > a_1$ and $b_2 > b_1$, while $a_2 \geq b_2$. Let $b_2 = b_1 + \epsilon$ and $\epsilon > 0$. It will be shown that there are quite "rational beliefs", which support the market equilibrium. At the bid b_2 , sellers $s < \epsilon$ will trade with intermediary 1, since they expect a surplus of $\frac{1}{2} - s$ which is larger than the maximal surplus they can achieve from trading with intermediary 2, $\alpha_2(\frac{1}{2} + \epsilon - s)$, where $\alpha_2 = \frac{1-b_2}{b_2} = \frac{\frac{1}{2}-\epsilon}{\frac{1}{2}+\epsilon}$, provided that they expect buyers $r > 1 - \epsilon$, who would rather trade with intermediary 1 than intermediary 2, will actually do so. Now, by the same reasoning, sellers with valuations in $]\epsilon, 2\epsilon]$ and buyers in $]1 - \epsilon, 1 - 2\epsilon]$ will trade with intermediary 1. This reasoning can be repeated and ultimately the deviant 2 will not be able to sell any product. Therefore, he does not attract any customers in the first place, and the deviation is unprofitable for the believe structure outlined.

Q.E.D.

The proof of proposition 3 reconfirms the sensitivity of intermediated markets with respect to widely held beliefs and participation decisions of potential clients. In addition to the causes of multiplicity of equilibrium in the monopoly case, also the degree of competition among intermediaries may be affected by the general belief structure. If, for example, all traders believe $q_{b_2}^\epsilon = q_{s_2}^\epsilon = 0$, there is an equilibrium, in which intermediary 2 remains inactive. So despite the potential competition from rivals, and possibly despite narrower spreads of rivals, the monopoly result of proposition 2 might emerge as an equilibrium outcome in this framework. Such an outcome is undesirable, since some (informed) outside observer might convince subsets of buyers and sellers to trade with the interne-

diary offering lower spreads. Obviously, no such institution exists in the present framework, and therefore the equilibrium outcome described here is perfectly sensible.

The Walrasian outcome of proposition 3, however, is stable with respect to the above thought experiment. The outside observer could not convince any subset of traders to trade with an intermediary deviating from the Walrasian equilibrium in an attempt to earn positive profits. Rather, in this equilibrium, Bertrand like undercutting is effective. In this sense the emergence of equilibrium prices can be explained without resorting to the coordinating function of an auctioneer, but by exclusively relying on the rational choice of prices by the market participants.

5. Conclusion

The preceding analysis has centered around a model of trade in which a role for intermediation arises endogenously. Intermediaries can help to reduce the impact of trading frictions. The analysis suggests that the industrial structure of the intermediation industry has the likely features of a natural monopoly, when the business of intermediation requires some fixed costs. Nevertheless, there are also combinations of beliefs and strategies, that can support several intermediaries in the market.

But even a monopolistic intermediary is constrained in his conduct, since the degree of market power is closely related to the efficiency of the underlying trading environment. Whenever the monopolistic intermediary charges positive spreads, an active search market arises and attracts market shares from the intermediary. As the monopolist charges higher spreads, he progressively loses market shares to the search market. Typically, the monopolistic intermediary specializes on the upper end of the market, i.e., he tends to attract the customers whose gains from trade are largest.

Appendix

Proof of Proposition 1:

The proposition is proved in a sequence of three lemmas.

Lemma 1:

For any positive bid ask spread, $a - b > 0$, there will be some traders actively trading in the search market.

Proof:

Buyers with valuations $r < a$ and seller with valuation $s > b$ can only expect positive gains from trade, when matched in the search market.

Q.E.D.

Denote the set of inactive buyers by Z_β and the set of inactive sellers by Z_σ .

Lemma 2

In equilibrium the sets of inactive buyers Z_β and inactive sellers Z_σ are closed and convex sets such that $0 \in Z_\beta$ and $1 \in Z_\sigma$.

Proof:

Suppose buyer r remains inactive. Then any buyer $\tilde{r} < r$ remains inactive. Otherwise buyer r could imitate buyer \tilde{r} and secure at least his payoff. Symmetrically this argument applies to sellers. Finally, buyer 0 and seller 1 remain inactive since they never expect a positive gain from trade.

Q.E.D.

Denote the set of buyers active in the search market by S_β and the set of buyers trading with the intermediary by I_β . Define S_σ and I_σ analogously for sellers. The Lebesgue measure of these sets is denoted by $\nu(S_\beta)$, $\nu(I_\beta)$, $\nu(S_\sigma)$ and $\nu(I_\sigma)$ respectively.

Lemma 3

In equilibrium $r_0 \in S_\beta$ and $s_0 \in S_\sigma$ imply $r \notin I_\beta$ and $s \notin I_\sigma$ for all buyers $r < r_0$ and all sellers $s > s_0$.

Proof:

1) In equilibrium at most one side of the market will be rationed. So either $\alpha_\beta = 1$ and $\alpha_\sigma \leq 1$ or $\alpha_\beta < 1$ and $\alpha_\sigma = 1$. In 2 the monotonicity property is established for the first case while the latter case will be proved next.

As $\alpha_\beta = 1$ there may be fewer buyers on the search market than sellers and therefore the intermediary might have to ration buyers with probability $\gamma_\beta \leq 1$.

Consider buyer $r < r_0$. By assumption $W_\beta(r_0) < \gamma_\beta U_\beta(r_0)$. Recall

$$U_\beta(r) = \frac{\lambda}{2} \int_{s \leq x(r)} (r - x(r)) dG(s) + \frac{\lambda}{2} \int_{y(s) \leq r} (r - y(s)) dG(s), \quad (A.1)$$

$$W_\beta(r) = \alpha_\beta(r - a). \quad (A.2)$$

Imitating the bidding strategy $x(r_0)$ of buyer r_0 in general is not optimal for buyer r and his utility from bidding his best bid $x(r)$ will certainly not be lower. Therefore

$$\begin{aligned} U_\beta(r) &\geq \frac{\lambda}{2} \int_{s \leq x(r_0)} (r - x(r_0)) dG(s) + \frac{\lambda}{2} \int_{y(s) \leq r} (r - y(s)) dG(s) \\ &= \frac{\lambda}{2} \left(\int_{s \leq x(r_0)} (r_0 - x(r_0)) dG(s) + \int_{y(s) \leq r_0} (r_0 - y(s)) dG(s) \right. \\ &\quad \left. - \int_{s \leq x(r_0)} (r_0 - r) dG(s) - \int_{y(s) \leq r} (r_0 - r) dG(s) \right. \\ &\quad \left. - \int_{r \leq y(s) \leq r_0} (r_0 - y(s)) dG(s) \right). \end{aligned} \quad (A.3)$$

Thus the first two integrals equal $U_\beta(r_0)$. Since by assumption $\alpha_\beta = 1$ it follows $\gamma_\beta U_\beta(r_0) > r_0 - a$, which implies:

$$\begin{aligned}
\gamma_\beta U_\beta(r) &\geq \gamma_\beta U_\beta(r_0) - \frac{\lambda}{2} \left(\int_{s \leq x(r_0)} (r_0 - r) dG(s) + \int_{y(s) \leq r_0} (r_0 - r) dG(s) \right) \\
&\geq \gamma_\beta U_\beta(r_0) - \lambda(r_0 - r)\nu(S_\sigma) \\
&\geq \gamma_\beta U_\beta(r_0) - (r_0 - r) \\
&> r - a \\
&= W_\beta(r).
\end{aligned} \tag{A.4}$$

Consequently r will not trade with an intermediary.

2) If $\alpha_\beta < 1$ necessarily $\alpha_\sigma = 1$. By symmetry a result analogous to 1) holds for sellers. In this case for $s_0 \in S_\sigma$ implies $s \notin I_\sigma$ for all $s > s_0$. Hence, buyers with valuations $r \in I_\sigma$ cannot expect any profitable trade and remain inactive. Accordingly, $\nu(I_\sigma + S_\sigma) = \nu(I_\beta + S_\beta)$, which implies $\gamma_\beta = 1$ in this subcase.

As in the previous step consider an imitation strategy, in which buyer r attempts to imitate the search strategy of buyer r_0 . Accordingly the following relations hold:

$$\begin{aligned}
U_\beta(r) &\geq \frac{\lambda}{2} \int_{s \leq x(r_0)} (r - x(r_0)) dG(s) + \frac{\lambda}{2} \int_{y(s) \leq r_0} (r - y(s)) dG(s) \\
&= U_\beta(r_0) + \frac{\lambda}{2} (r - r_0) \left(\int_{s \leq x(r_0)} dG(s) + \int_{y(s) \leq r_0} dG(s) \right)
\end{aligned} \tag{A.5}$$

Depending on the sign of $\frac{\lambda}{2} \left(\int_{s \leq x(r_0)} dG(s) + \int_{y(s) \leq r_0} dG(s) \right)$ two cases have to be considered.

i) Consider the case $\frac{\lambda}{2} \left(\int_{s \leq x(r_0)} dG(s) + \int_{y(s) \leq r_0} dG(s) \right) \geq \alpha_\beta$.

In this case choose $r > r_0$. Then using the imitation strategy buyer r can get:

$$\begin{aligned} U_\beta(r) &\geq U_\beta(r_0) + \alpha_\beta(r - r_0) \\ &= U_\beta(r_0) - \alpha_\beta(r_0 - a) + a_\beta(r - a). \end{aligned} \tag{A.6}$$

Now $r_0 \in S_\beta$ implies $r \in S_\beta$ for any $r > r_0$. In equilibrium $W_\beta(a) = 0$ and $U_\beta(a) > 0$. This statement clearly holds for $a > b$ since then buyer a will be able to generate positive surplus with a positive probability. Also if $a = b$ seller b will have positive search utility $U_\sigma(b) > 0$ as long as $\nu(I_\beta) > 0$. Accordingly, S_σ includes a positive measure of sellers with reservation prices less than b . This implies $U_\beta(a) > 0$. Accordingly with the above result $\nu(I_\beta) = 0$ which contradicts the assumption $\alpha_\beta < 1$. Therefore, this case cannot occur in equilibrium.

ii) Now, let $\frac{\lambda}{2} \left(\int_{s \leq x(r_0)} dG(s) + \int_{y(s) \leq r_0} dG(s) \right) < \alpha_\beta$.

Consider some buyer $r < r_0$. For him the following relation holds:

$$\begin{aligned} U_\beta(r) &\geq U_\beta(r_0) - \alpha_\beta(r_0 - r) \\ &= U_\beta(r_0) - \alpha_\beta(r_0 - a) + a_\beta(r - a). \end{aligned} \tag{A.7}$$

Accordingly, $r_0 \in S_\beta$ implies $r \notin I_\beta$ for any $r < r_0$, the monotonicity property.

3) Finally by a completely symmetric argument the monotonicity property also holds for sellers.

Q.E.D.

Lemmas 1 to 3 state that the sets of inactive buyers and sellers and the sets of buyers and sellers active on the search market are convex sets and directed sets. Hence, only buyers with high valuations and sellers with low costs can potentially trade with intermediaries. This completes the proof of proposition 1.

Q.E.D.

Proof of Proposition 2:

By virtue of lemma 1 above, if in equilibrium $a > b$, then the search market will be active and the sets of buyers and sellers trading with the intermediary can be written as intervals $I_\beta = [\bar{r}, 1]$ and $I_\sigma = [0, \underline{s}]$, unless $I_\beta = \emptyset$ or $I_\sigma = \emptyset$. This immediately implies $Z_\beta = I_\sigma = [0, \underline{s}]$. Buyer $r < \underline{s}$ will find no trading partner on the search market since all potential sellers with lower valuations prefer intermediated trade. In equilibrium r cannot deal profitably with the intermediary either and therefore remains inactive. Likewise $Z_\sigma = I_\beta = [\bar{r}, 1]$. Consequently, the sets of agents active in search are identical $S_\beta = S_\sigma =]\underline{s}, \bar{r}[$. So in equilibrium $\gamma_\beta = \gamma_\sigma = 1$. Moreover, in equilibrium $\underline{s} < \bar{r}$ since otherwise the monopolist quotes prices that generate losses. We shall see that indeed in equilibrium $a > b$. So the intermediary can earn positive revenues.

This characterization of the search market allows a simple representation of the optimal bid schedule for any trader considering entry into the search market. In 1) the optimal bid schedule is derived, while in 2) the utility from search is determined. This allows to explicitly calculate the critical valuations \bar{r} and \underline{s} as functions of the monopolist's price quotes in 3). 4) establishes that in equilibrium the intermediary quotes symmetric prices $a = 1 - b$ and finally in 5) the optimal spread is determined.

1) For buyers $r \in S_\beta$ the optimal bid can be calculated as follows:

$$\begin{aligned}
 x(r) &:= \operatorname{argmax} \int_{s \leq x(r)} (r - x(r)) dG(s) \\
 &= \operatorname{argmax} \int_{\underline{s}}^{x(r)} \frac{1}{\bar{r} - \underline{s}} (r - x(r)) ds \quad (A.8a) \\
 &= \frac{r + \underline{s}}{2}.
 \end{aligned}$$

Likewise for $s \in S_\sigma$:

$$\begin{aligned}
y(s) &:= \operatorname{argmax} \int_{y(s) \leq r} (y(s) - s) dF(r) \\
&= \frac{\bar{r} + s}{2}.
\end{aligned} \tag{A.8b}$$

2) Using the optimal bid schedule in equilibrium the utility of participation in the search market can be calculated for $r \in S_\beta$ and $s \in S_\sigma$

$$\begin{aligned}
U_\beta(r) &= \frac{\lambda}{2} \int_{s \leq x(r)} (r - x(r)) dG(s) + \frac{\lambda}{2} \int_{y(s) \leq r} (r - y(s)) dG(s) \\
&= \frac{\lambda}{8} \frac{1}{\bar{r} - \underline{s}} \left((r - \underline{s})^2 + (2r - \bar{r} - \underline{s})^2 \right),
\end{aligned} \tag{A.9a}$$

$$\begin{aligned}
U_\sigma(s) &= \frac{\lambda}{2} \int_{r \geq y(s)} (y(s) - s) dF(r) + \frac{\lambda}{2} \int_{x(r) \geq s} (x(r) - s) dF(r) \\
&= \frac{\lambda}{8} \frac{1}{\bar{r} - \underline{s}} \left((s - \bar{r})^2 + (2s - \bar{r} - \underline{s})^2 \right).
\end{aligned} \tag{A.9b}$$

In particular the utility levels of the critical traders \bar{r} and \underline{s} are identical and can be determined as

$$U_\beta(\bar{r}) = U_\sigma(\underline{s}) = \frac{\lambda}{4} (\bar{r} - \underline{s}). \tag{A.10}$$

3) For given prices (a, b) the value of intermediated trade can be determined for the critical buyers and sellers \bar{r} and \underline{s} by $W_\beta(\bar{r})$ and $W_\sigma(\underline{s})$. Since these critical agents are defined by indifference between search and intermediated trade and since W_j and U_j , $j = k, v$ are continuous functions their valuations have to satisfy the following equation system:

$$U_\beta(\bar{r}) = W_\beta(\bar{r}), \tag{A.11a}$$

$$U_\sigma(\underline{s}) = W_\sigma(\underline{s}). \quad (A.11b)$$

Since at most one side of the intermediated market has to be rationed at most one of α_β and α_σ is less than 1. Without loss of generality, assume $0 < 1 - r \leq \underline{s}$. This implies:

$$\begin{aligned} \frac{\lambda}{4}(\bar{r} - \underline{s}) &= \bar{r} - a \\ &= \frac{1 - \bar{r}}{\underline{s}}(b - \underline{s}). \end{aligned} \quad (A.12)$$

The second equation implies $b(1 - \bar{r}) = (1 - a)\underline{s}$. Given $\underline{s} \geq 1 - \bar{r}$ this implies further $b \geq 1 - a$ or equivalently $a \geq 1 - b$. In equilibrium sellers can only be rationed if the ask price a is more distant from the hypothetical Walrasian equilibrium price of $\frac{1}{2}$ than the bid price b . Solving for \underline{s} yields

$$\begin{aligned} \underline{s} &= (1 - a) \frac{4(1 - a) - \lambda}{(4 - \lambda)(1 - a) - \lambda b} \\ &= b \frac{4b - \lambda}{(4 - \lambda)b - \lambda(1 - a)}, \end{aligned} \quad (A.13)$$

4) Next, the symmetry of equilibrium prices relative to the hypothetical Walrasian equilibrium price is established, i.e., $a^* = 1 - b^*$. In order to prove this claim assume to the contrary $a^* > 1 - b^*$, which according to step 3 implies $\underline{s}^* > 1 - \bar{r}^*$. The following deviation (\tilde{a}, \tilde{b}) is profitable for the monopolist for small enough ϵ , $\tilde{a} = a^* - \epsilon$ and $\tilde{b} = b^* - \epsilon$.

The deviation does not affect the spread, $\tilde{a} - \tilde{b} = a^* - b^*$ but increases trading volume. In order to establish $1 - \tilde{r} > 1 - r^*$ the following inequality has to be satisfied:

$$(1 - \tilde{a}) \frac{4(1 - \tilde{a}) - \lambda}{(4 - \lambda)(1 - \tilde{a}) - \tilde{b}\lambda} > (1 - a^*) \frac{4(1 - a^*) - \lambda}{(4 - \lambda)(1 - a^*) - b^*\lambda}$$

In fact this inequality is true, whenever $b^* < a^*$. Therefore, (\tilde{a}, \tilde{b}) is a profitable deviation which demonstrates that the maintained hypotheses is wrong.

5) Finally, the optimal choice of prices has to be determined. Given optimal prices are symmetric $a^* = 1 - b^*$ trading volume is given by $\underline{s}^* = \frac{4(1-a^*)-\lambda}{2(2-\lambda)}$. In equilibrium the monopolist's profits are $\underline{s}^*(a^* - b^*) = \underline{s}^*(2a^* - 1)$. The optimal choice of a^* is

$$\begin{aligned}
 a^* &= \operatorname{argmax} \underline{s}^* (2a^* - 1) \\
 &= \operatorname{argmax} \frac{4(1 - a^*) - \lambda}{2(2 - \lambda)} (2a^* - 1) \\
 &= \frac{3}{4} - \frac{\lambda}{8}.
 \end{aligned} \tag{A.14}$$

Consequently, the optimal choice of b is

$$b^* = 1 - a^* = \frac{1}{4} + \frac{\lambda}{8}. \tag{A.15}$$

and trading volume is given by

$$\underline{s}^* = 1 - \bar{r}^* = \frac{1}{4}. \tag{A.16}$$

This implies that the monopolist can earn positive revenues for any λ . By quoting prices $a^* \geq b^*$ he can earn non-positive revenues only. Therefore, the described allocation is an equilibrium.

Q.E.D.

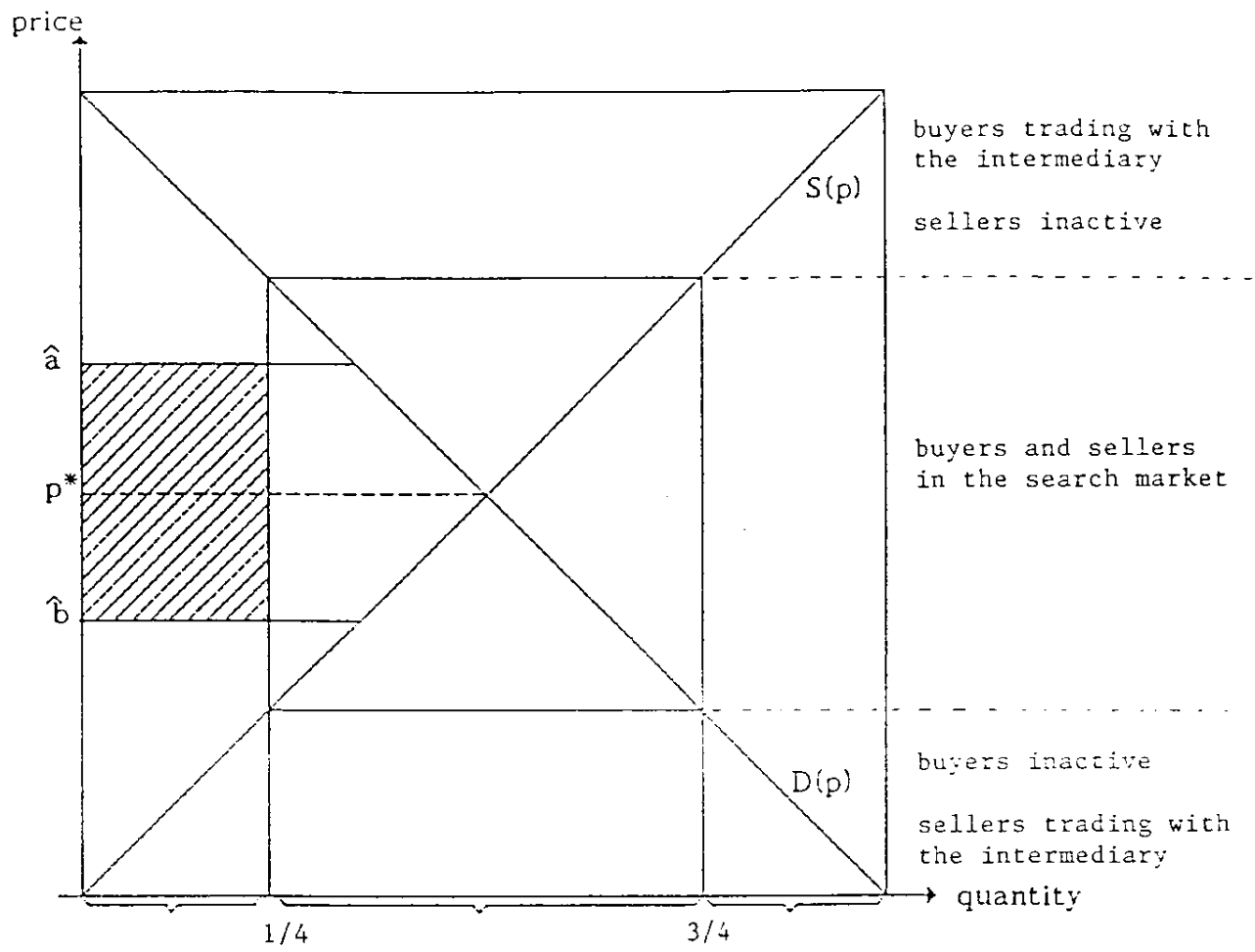


Figure 1

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