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Seller–Broker Relationship as a Double Moral Hazard Problem

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This paper studies the seller–broker relationship as a *double moral hazard* problem where the probability of selling the property is determined by the unobservable efforts of *both* the seller and the agent. The objectives of the paper are twofold. One is to examine the importance and the implications of strategic interaction between the seller's and the agent's efforts. The other is to study the efficiency and incentive effects of the percentage commission system under a general class of matching technologies, and to check whether the previous results of the literature are robust to a change in the matching technology. The analysis of the paper is also extended to the *flat-fee* and *net listing* commission systems. © 1995 Academic Press, Inc.

I. INTRODUCTION

A critical question in principal-agent models is how to design an incentive mechanism so that the agent's interests are aligned with those of the principal. This question has also attracted the attention of the literature on real estate brokerage. It is generally accepted that the percentage commission system ensures that the interests of the agent are in the same *direction* as those of the seller (principal). However, it has been argued that the percentage commission system does not generally align the *magnitude* of the interests of the agent with those of the seller. This paper reexamines these issues in a double moral hazard model.

The model studied here does not address some of the standard questions of the principal-agent models; it abstains from the issue of optimal risk-sharing by assuming that all the players are risk neutral, and avoids dealing

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with searching for an optimal compensation scheme by taking the compensation scheme as given. These issues have been examined in detail in an excellent study by Anglin and Arnott (1991). Instead, the current paper focuses on the incentive and efficiency problems associated with the *search efforts* of the agent *and* the seller under three commission systems: percentage commission, flat-fee, and net listing.

Commission systems in brokerage markets have been discussed widely in the literature. One line of literature deals with the efficiency of the amount of resources allocated to brokerage services under the percentage commission system (e.g., Yinger, 1981; Wu and Colwell, 1986; Fu, 1992). Of particular interest for the current study is another line of literature that examines the optimal risk-sharing between the seller and his[1] agent, and the efficiency and incentive compatibility of the broker's efforts under various commission structures (Anglin and Arnott, 1991; Zorn and Larsen, 1986; Arnold, 1992). Anglin and Arnott (1991) apply the standard principal-agent theory to study optimal contracting between the seller and his agent. Using a model where the agent's effort level alone determines the probability of finding a buyer, they determine the optimal risk-sharing between the seller and his agent under different combinations of risk attitudes for the seller and the agent. In Zorn and Larsen (1986), the agent is the only party who searches, and each time the agent searches she locates a buyer. However, as the agent searches further, she is more likely to locate a buyer with a higher reservation price, which translates into selling the house at a higher price. They examine the incentive compatibility of the search efforts expanded by the agent under the percentage commission and flat-fee systems. They conclude that both commission systems induce the agent to search less intensively than is optimal for the seller. Arnold (1992) studies the incentive problem from a different perspective. In Arnold's model, the agent's search effort level is *fixed*; hence there can be no conflict of interest between the seller and his agent with regard to the search efforts. The incentive problem in his model arises because the agent has superior information about the demand and supply conditions in the market, and the seller relies on the agent's information in determining his reservation price. The agent might have incentives to misrepresent the market information, and as a result, the seller's reservation price can be different than that of the agent's. Of the three commission systems he considers, percentage commission, flat-fee, and net listing, he finds that percentage commission is the only system that can perfectly

[1] For the purpose of clarifying the presentation, the seller will be portrayed as a male and the agent as a female.

align the reservation price of the agent with that of the seller. He also concludes that the incentive-compatible reservation price is the same as the socially optimal one.[2]

As in Zorn and Larsen (1986), this paper studies the efficiency and incentive-compatibility problem from the perspective of the resources allocated to search for a buyer. Unlike Zorn and Larsen (1986), however, we allow the seller as well as the agent to search. Consequently, we have a double moral hazard problem (Cooper and Ross, 1985) where the outcome is determined by the unobservable search efforts of *both* the seller and the agent. Furthermore, instead of assuming a specific functional form for the matching technology (as was done in almost every study on brokerage, including Zorn and Larsen (1986), Arnold (1992), Yinger (1981), Wu and Colwell (1986), and Yavaş (1992, 1994b)), we employ a general matching technology.

A critical implication of using a general matching technology is that it allows us to capture different types of strategic interaction between the search efforts of the seller and his agent. As pointed out in Bulow *et al.* (1985), there are three types of strategic interactions between the seller's and the agent's search efforts: their search intensities are strategic complements if an increase in one's effort level increases the optimal effort level of the other; they are strategic substitutes if an increase in one's effort level decreases the optimal effort level of the other; and they are strategically independent if a change in one's effort level has no effect on the optimal effort level of the other. It is shown that the type of strategic interaction involved in the matching technology can be critical for efficiency and incentive effects of the percentage commission system. As stated earlier, Zorn and Larsen (1986) use a specific matching technology involving strategic independence to prove that the agent's search level is neither efficient nor

[2] Also related to this issue are the papers by Miceli (1989, 1991) and Geltner *et al.* (1991, 1992). Miceli (1989) shows that the seller can induce increased effort from his agent by shortening the duration of the listing contract. This result is supported by the numerical analysis of Geltner *et al.* (1991). However, Geltner *et al.* (1991) also demonstrate that shortening the contract duration worsens the incentive problems related to information provision. Miceli (1991) looks at different commission splits between listing agents and selling agents in *MLS* sales as another source of conflict of interest between the agent and the seller. He shows that awarding the entire commission to the selling agent maximizes the joint search efforts of the agents and therefore maximizes the seller's interests. However, maximizing the joint profits of the agents requires awarding both the listing and the selling agent a positive share of the commission. Geltner *et al.* (1992) look at two alternative "incentive commission" structures. One is a time-incentive contract which pays the agent a larger commission percentage the faster the house sells. The other is a price-incentive contract which pays the agent a larger (smaller) percentage of any positive (negative) difference between the sale price and a prespecified incentive price. Their study concludes that these incentive contracts can *partially* improve the incentive problems between the seller and the agent. A more comprehensive review of these and other brokerage-related studies can be found in Yavaş (1994a).

incentive-compatible. We show that when their model is extended to include search by the seller as well as by the agent, then one can find matching technologies under which it becomes possible for either the seller's *or* the agent's (but not both) equilibrium search effort levels to be efficient and incentive-compatible. We also claim that advertising by the agent's brokerage firm to bolster the agent's search efforts and the formation of multiple listing services can help reduce/eliminate the efficiency and incentive-compatibility problems. We extend the analysis to the cases of flat-fee and net listing commission systems and argue that the results also hold under these two systems. Finally, we point to various other issues in real estate that can be analyzed by utilizing the framework presented in this paper.

Section II presents a simple search model of housing markets. Sections III and IV use this model to examine efficiency and incentive compatibility of the percentage commission system under the assumption that the price of the house is determined in the market. Section V relaxes this assumption and examines how the results change if the seller can choose the price. Section VI discusses the application of the analysis to flat-fee and net listing commission systems, and Section VII concludes.

II. THE MODEL[3]

This part of the paper presents a static bilateral search model of a housing market where a seller and a buyer search for each other. In order to focus on the incentive problems, we remove any concerns about risk-sharing (Anglin and Arnott, 1991) by assuming that both the buyer and the seller are risk neutral. The characteristics of the seller's house (location, size, etc.) coincide with the characteristics that the buyer desires in a house. The seller values the house at P_s and the buyer values it at P_b. The valuations of the two parties are private information. Each party knows his own valuation but not the valuation of the other party. However, it is common knowledge that the valuation of each party comes from a uniform distribution on the interval [0,1].[4]

Since the purpose of the paper is to examine the incentive and efficiency aspects of the percentage commission system for brokerage services, it will be assumed that the seller employs a real estate agent to help him find a buyer. The seller and his agent sign an *exclusive right to sell* type of contract

[3] The search model utilized here is very similar to those of Gould (1980) and Yavaş (1995). The current study differs from these two papers in that Gould (1980) does not involve any brokerage services, and Yavaş (1995) focuses exclusively on the search economies with multiple equilibria and examines the equilibrium selection role of brokerage in such economies.

[4] The results of the paper are robust to any distribution of valuations for the two parties. The assumption of uniform distributions helps to clarify the presentation of the paper.

whereby the agent receives $1 > k > 0$ portion of the transaction price when a willing and able buyer is contacted, regardless of whether the buyer is contacted by the agent or the seller himself. The commission rate is assumed to be determined competitively in the brokerage market.

To concentrate on the effects of percentage commission system on the search behavior of the seller and his agent, we will treat the buyer's search effort level as fixed and normalized to zero.[5] The seller and his agent, on the other hand, both choose a level of search effort to maximize their individual expected returns. The agent's search efforts include advertising the property, conducting open houses, showing the property, and providing information to prospective buyers. Similarly, the search efforts of the seller include his efforts to locate a buyer (such as telling friends and relatives about the property and promoting it through word-of-mouth advertising), taking proper care of the property to keep it presentable, being flexible about the time periods during which the agent can show the property to the buyers, leaving the property for showings and open houses, and, when necessary, agreeing to vacate the property earlier and arranging alternative accommodations in order to make it possible for the buyer to move in. Clearly, there exists some interaction between the effort levels of the broker and the seller. Effectiveness of the broker's efforts will depend upon the efforts and cooperation of the seller, and vice versa.[6] This interaction will be an important feature of the matching technology below.

Let $S \in [0, M]$ be the search effort of the seller, and let $A \in [0, M]$ be the search effort of the agent, where M is finite and bounds each player's search effort level. The cost of search is given by $\sigma(S)$ for the seller, and by $\alpha(A)$ for the agent. Both $\sigma(S)$ and $\alpha(A)$ are increasing strictly convex functions with the property that $\sigma(0) = 0$ and $\alpha(0) = 0$. The probability that the buyer is contacted by the seller or his agent is given by $0 \leq \theta(S, A) \leq 1$, where $\theta(\cdot)$ is continuously differentiable with

$$\partial\theta(S, A)/\partial S > 0,\ \partial\theta(S, A)/\partial A > 0,\ \partial^2\theta(S, A)/\partial S^2 \leq 0, \text{ and } \partial^2\theta(S, A)/\partial A^2 \leq 0. \tag{1}$$

That is, the probability of contacting the buyer increases with the search

[5] This assumption simplifies the analysis without affecting the results of the paper. It is a reasonable assumption under the Multiple Listing Service (MLS) system where the buyer can get information about the majority of houses for sale by simply contacting or being contacted by an MLS member broker.

[6] The importance of the seller effort was also verified by a local agent. As she indicated, it is not uncommon for the seller to contact potential buyers for the property. The listing agent often provides the seller with multiple copies of a data sheet for the property and encourages the seller to distribute them to his friends. As the model would indicate, the seller's effort level will depend on his search costs and the expected benefits from his search efforts.

efforts of the agent and the seller at a decreasing rate. Of critical importance is the sign of the cross partial derivatives of the function θ, $\partial^2\theta(S, A)/\partial S\partial A$. This sign determines the type of strategic interaction between the seller's and his agent's search efforts. A positive cross partial denotes strategic complementarity, a negative cross partial indicates strategic substitutability, and a zero cross partial denotes strategic independence (Bulow *et al.*, 1985). Intuitively, when S and A are strategic complements, $\partial^2\theta(S, A)/\partial S\partial A > 0$, then an increase in the effort level of one party enhances the *marginal* effectiveness of the effort by the other party. On the other hand, when S and A are strategic substitutes, $\partial^2\theta(S, A)/\partial S\partial A < 0$, *marginal* impact of more search by one party (in terms of increased probability of a match) is reduced as the effort level of the other party increases. When S and A are strategically independent, $\partial^2\theta(S, A)/\partial S\partial A = 0$, then a change in the effort level of one party has no effect on the *marginal* effectiveness of the effort by the other party. The analysis will consider all three types of interaction. The question of which brokerage markets display what type of strategic interaction is an empirical one and will not be answered in this study.

The previous models of brokerage (e.g., Zorn and Larsen, 1986; Yinger, 1981; Wu and Colwell, 1986; Arnold, 1992; Yavaş, 1992, 1994b) have assumed a specific functional form for the matching technology and/or have ignored the strategic interaction between the search efforts of the seller and his agent. As it turns out, the type of strategic interaction in the matching technology can be crucial for the analysis of the brokerage commission systems.

In order to focus on search efforts, we avoid potential incentive problems that may arise when the seller and the agent have asymmetric information (Arnold, 1992) about the market value of the property by employing a model of complete information. Thus both the seller and the buyer have the same information about the price. This price could be considered the market price that the seller and his agent take as given. Later in the paper we will allow the seller to choose the price for his house.

Let P be the price of the house. Since the buyer's reservation price is uniformly distributed on the interval [0,1], the probability that the buyer will be willing and able to purchase the house is given by $1 - P$. Given this, the seller's problem is to choose a search effort, S, to maximize his expected return,

$$V(S, A) = \theta(S, A)(P - P_s - kP)(1 - P) - \sigma(S), \tag{2}$$

where $kP > 0$ is the commission payment to the agent. The fact that the seller is trying to sell the house at P implies his surplus from selling the house, $P - P_s$, is nonnegative, and the fact that he is employing a broker implies $P - P_s$ is greater than the commission fee kP.

Similarly, the agent chooses A to maximize

$$W(S, A) = \theta(S, A)kP(1 - P) - \alpha(A). \tag{3}$$

Since the payoffs in (2) and (3) depend on the search efforts of both players, and since the search effort levels are unobservable, the players face a double moral hazard problem. The proper equilibrium concept to use in this study is that of *noncooperative Nash equilibrium* under which the seller and his agent choose their search efforts independently, based on their conjectures about the other's search effort choice. The equilibrium search efforts of the seller and his agent are given by the solution to the first-order conditions for (2) and (3), respectively,

$$\theta_S(P - P_s - kP)(1 - P) = \sigma'(S), \tag{4}$$

and

$$\theta_A kP(1 - P) = \alpha'(A), \tag{5}$$

where the subscripts denote partial derivatives and primes denote a derivative in a usual manner.

Equations (4) and (5) imply that each player chooses a search effort level to equate his/her expected marginal return from search with the marginal cost of search. Equation (4) yields the seller's search effort as a function of the agent's search effort level, $S^\circ(A)$, and Eq. (5) yields the agent's search effort as a function of the seller's search effort level, $A^\circ(S)$. The functions $S^\circ(A)$ and $A^\circ(S)$ are also known as the *reaction* (or *best response*) *functions* of the seller and his agent, respectively. If the matching technology exhibits strategic complementarity, $\partial^2\theta(S, A)/\partial S\partial A > 0$, the reaction functions of the players will be upward sloping. On the contrary, strategic substitutability, $\partial^2\theta(S, A)/\partial S\partial A < 0$, yields downward sloping reaction functions. The equilibrium search effort levels, S° and A°, can be found by solving (4) and (5) simultaneously, which gives the intersection point of the reaction functions $S^\circ(A)$ and $A^\circ(S)$.

To ensure the existence of an interior solution, we assume

$$\lim_{S\to 0} V_S(S, A) > 0\ \forall A,\ \lim_{S\to M} V_S(S, A) < 0\ \forall A \text{ and}$$
$$\lim_{A\to 0} W_A(S, A) > 0\ \forall A,\ \lim_{A\to M} W_A(S, A) < 0\ \forall A.$$

This property of the model ensures that even if one player provides no search effort at all, the best response of the other player is to provide a positive search effort. As a result, in equilibrium at least one party will provide a positive level of search effort. Therefore, given that the functions V and W are continuous, there exists an interior solution to (4) and (5).[7]

III. EFFICIENCY OF THE PERCENTAGE COMMISSION SYSTEM

Next, we consider the *efficient* (*socially optimal*, or *first-best*, or *cooperative Nash equilibrium*) search effort levels by the seller and his agent, S^* and A^*. These are the search effort levels that maximize the joint expected surplus of the seller and his agent, instead of maximizing their individual expected surpluses independently. In the context of principal-agent models, (S^*, A^*) characterizes the first-best contract between the seller and the broker when the search effort levels are observable (i.e., verifiable in a court of law).

The joint expected surplus for the seller and his agent is given by the summation of (2) and (3):

$$V(S, A) + W(S, A) = \theta(S, A)(P - P_s)(1 - P) - \sigma(S) - \alpha(A). \quad (6)$$

The solution to (6) satisfies

$$\theta_S(P - P_s)(1 - P) = \sigma'(S) \quad (7)$$

and

$$\theta_A(P - P_s)(1 - P) = \alpha'(A). \quad (8)$$

Again, (7) and (8) yield seller's and agent's search efforts as a function of each other's search effort level. Let $S^*(A)$ and $A^*(S)$ be the "efficient" reaction functions of the seller and his agent, respectively. The efficient search effort levels, S^* and A^*, can be found by solving (7) and (8) simultaneously. These are the search effort levels that the seller and the agent would contract on if their search efforts were verifiable. Unfortunately, the only thing they can observe is the outcome, i.e., whether or not a buyer is

[7] It is possible, as in Diamond (1982), that the two reaction functions cross more than once, in which case we have multiple equilibria. We confine our attention in this study to the matching technologies that yield a unique equilibrium. The role of brokerage in housing markets with multiple equilibria has been studied in Yavaş (1995). We also confine our attention to the equilibria that are *stable*. Loosely speaking, an equilibrium is stable if that equilibrium is eventually attained starting from a pair of search efforts in the neighborhood of that equilibrium. Similarly, an equilibrium is unstable if any small movement away from that equilibrium takes the economy to a different equilibrium.

contacted. Since the outcome depends on luck as well as the search efforts (given that $0 \le \theta(S, A) \le 1$, it is possible that a high search effort does not yield a match while a lower search effort results in a match), the efficient allocation cannot be implemented through a contract between the seller and his agent.

The comparison of the (noncooperative Nash) equilibrium with the efficient allocation is given by the following proposition.

PROPOSITION 1. (a) *If S and A are strategic complements, i.e.,* $\partial^2\theta(S, A)/\partial S\partial A > 0$, *then* $S^\circ < S^*$ *and* $A^\circ < A^*$;

(b) *If S and A are strategically independent, i.e.,* $\partial^2\theta(S, A)/\partial S\partial A = 0$, *then* $S^\circ < S^*$ *and* $A^\circ < A^*$; *and*

(c) *If S and A are strategic substitutes, i.e.,* $\partial^2\theta(S, A)/\partial S\partial A < 0$, *then one of the players provides less than the efficient level of search* ($S^\circ < S^*$ *or* $A^\circ < A^*$) *while the other player's search effort level might be smaller, greater, or equal to the efficient level.*

Proof. Since $kP > 0$ and $P - P_s \ge kP$, it follows from a comparison of (4) with (7) and (5) with (8) that $S^\circ(A) < S^*(A)\ \forall A$ and $A^\circ(S) < A^*(S)\ \forall S$. That is, the reaction function of each player lies below the efficient reaction function for that player. In other words, for any given search effort choice by the other player, each player provides less than the efficient level of search effort. We will refer to this as the "first-round" effect. However, when a player searches less, it affects the other player's marginal return from search, and causes the following "second-round" effect:

(a) If S and A are strategic complements, then the first-round decrease in one player's search effort leads to a decrease in the other player's expected *marginal* return. This causes a further decrease in the other player's search effort (in addition to the first-round effect for that player), which in turn decreases the expected marginal return for the first player and causes a further decrease in his/her search effort, and so on. As a result, in equilibrium both players will have less than the efficient level of search. This is shown in Fig. 1 where E° is the equilibrium allocation while E^* is the efficient allocation.

(b) If S and A are strategically independent, then we only have the first-round effect, which yields $S^\circ < S^*$ and $A^\circ < A^*$. This is illustrated in Fig. 2.

(c) If S and A are strategic substitutes, then the first-round decrease in one player's search effort leads to an increase in the other player's expected marginal return, which in turn causes an increase in the other player's search effort. This decreases the first player's expected marginal return and causes a further decrease in his/her search effort, and so on. As a result, while both the first- and second-round effects reduce the first player's search efforts, they have opposing effects on the second player's search effort choice. The net effect for the second player will depend on the magnitudes

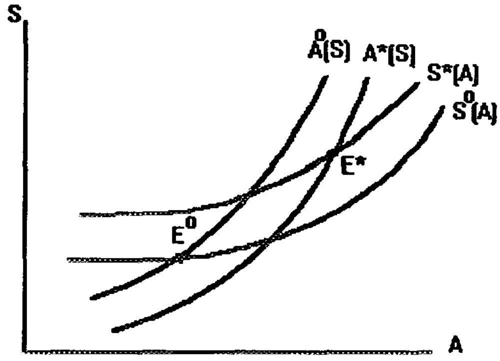

FIG. 1. Comparison of the equilibrium allocation with the efficient allocation when S and A are strategic complements.

of the two rounds. Consequently, in equilibrium the first player provides less than the efficient level of search while the second player's search effort level might be smaller, greater, or equal to the efficient level. This is illustrated in Fig. 3 where the comparison of E° with E^* depends on the magnitudes of the shifts in the two reaction functions (note that the magnitude of the shift in the seller's reaction function is determined by the size of the difference between $(P - P_s)$ and $(P - P_s - kP)$ while the magnitude of the shift in the agent's reaction function is determined by the size of the difference between $(P - P_s)$ and kP). If the equilibrium is given by E_1° in Fig. 3, we get $S^\circ < S^*$ and $A^\circ < A^*$, and if the equilibrium is given by E_2°, we obtain $S^\circ < S^*$ and $A^\circ > A^*$. ∎

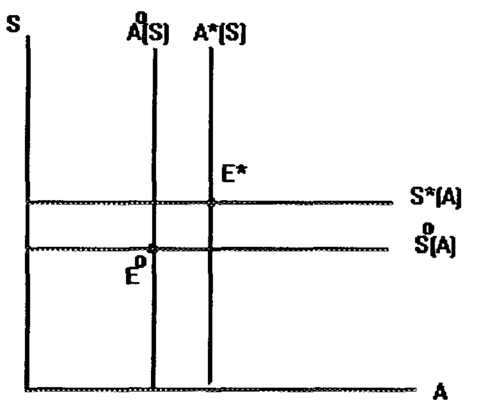

FIG. 2. Comparison of the equilibrium allocation with the efficient allocation when S and A are strategically independent.

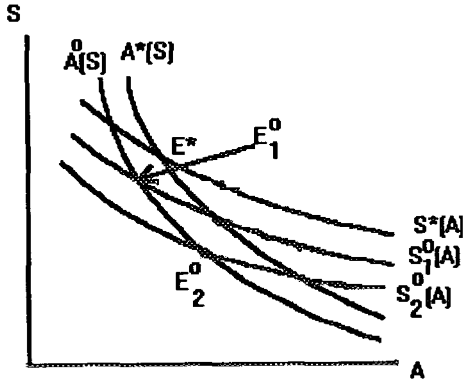

FIG. 3. Comparison of the equilibrium allocation with the efficient allocation when S and A are strategic substitutes.

Note that the result of Proposition 1 is true for any k, P, or kP. Given that the search efforts S and A are unobservable, Proposition 1 leads to the following result.

Remark. There exists no k and/or P that the seller and the agent can negotiate to induce both $A^{\circ} = A^*$ and $S^{\circ} = S^*$.

It is possible that in the case of strategic substitutes, the total search efforts of the seller and the agent, $S^{\circ} + A^{\circ}$, are equal to or greater than $S^* + A^*$. However, it is not appropriate to compare $S^{\circ} + A^{\circ}$ with $S^* + A^*$ for efficiency analysis. The seller and his agent have different search technologies; thus a unit of A affects the matching probability and the total search costs differently than a unit of S. As a result, an equilibrium allocation is efficient when both $S^{\circ} = S^*$ and $A^{\circ} = A^*$.

The reason for the shift in the reaction functions, $S^{\circ}(A) < S^*(A)\ \forall A$ and $A^{\circ}(S) < A^*(S)\ \forall S$, is that there are positive externalities involved in the search process. An increase in the search effort of one player increases the probability of a match, hence increasing the payoff of the other player. Since neither player takes into consideration the effect of his/her search on the other player's payoff, these positive externalities result in lower reaction functions than there would be in the joint interest of the two players. This is similar to the explanation by Zorn and Larsen (1986) for their result that the agent will not search as much as the seller would want her to, because the percentage commission is less than 100% (i.e., the agent receives only a portion of the total surplus, $P - P_s$). However, the matching technology in Zorn and Larsen (1986) does not involve any strategic interaction between the seller's and his agent's search efforts. Hence, their model

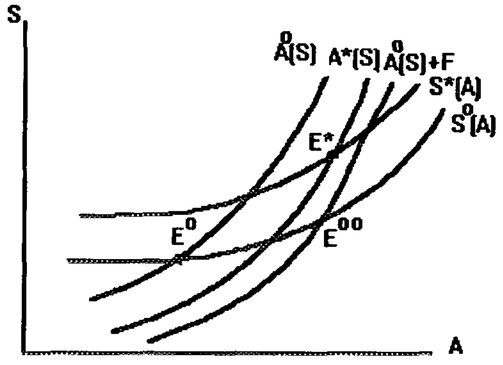

FIG. 4. The effect of advertising under strategic complementarity.

captures only part (b) of our Proposition 1 where $S^{\circ} < S^*$ and $A^{\circ} < A^*$. We have shown in part (c) of Proposition 1 that it is possible for the agent to search more than or equal to the efficient level if the search intensities are strategic substitutes.

Note from Proposition 1 that if S and A are strategic complements, then both search intensities will be less than the efficient level. Next, we will argue that the presence of strategic complementarities in an inefficient market can provide an environment where advertising by the agent's brokerage firm and the formation of multiple listing services can play a role.

In order to see this, note that an agent benefits from the advertising efforts of the firm she works for. If we treat the efforts of the firm as a subsidy to the agent's search efforts, or alternatively if we assume the efforts of the firm and the agent to be strategic complements, the efforts of the firm will shift the best response function of the agent upwards. Let F denote this shift in the agent's best response function. The new best response function for the agent becomes $A^{\circ}(S) + F\,\forall S$. Under strategic complementarity, this increase in the agent's search efforts leads to a higher effort level by the seller. This is illustrated in Fig. 4 where the firm's advertising efforts shift the agent's best response function from $A^{\circ}(S)$ to $A^{\circ}(S) + F$ and the equilibrium point from E° to $E^{\circ\circ}$. Because the firm receives a portion of the agent's commission revenue from the sale of the property, the firm benefits from the increased search efforts of both the agent *and* the seller. Thus, the resulting increase in the firm's commission revenue might more than offset the cost of advertising.[8] Note that depending upon the amount of advertising by the firm, hence the amount of shift from $A^{\circ}(S)$ to $A^{\circ}(S) + F$, we can have $A^{\circ}(S) + F$ below or above $A^*(S)\ \forall S$. Figure 4

[8] I am indebted to Paul Anglin for pointing out this implication of strategic complementarity.

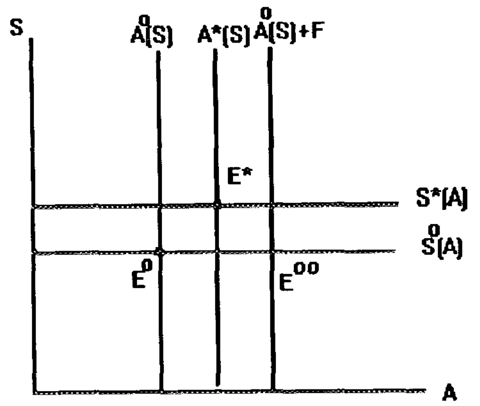

FIG. 5. The effect of advertising under strategic independence.

illustrates the case where $A°(S) + F > A^*(S)\ \forall S$. Although the firm's efforts shift the best response function of the agent in the cases of strategic substitutes and strategic independence as well, its effect will not be as significant as in the case of strategic complements. In the case of strategic independence, it will only increase the agent's search efforts without affecting the seller's search effort level (Fig. 5). In the case of strategic substitutes, the increase in the agent's search efforts will lead to a decrease in the seller's search effort level (Fig. 6). Thus, the firm does not enjoy the addi-

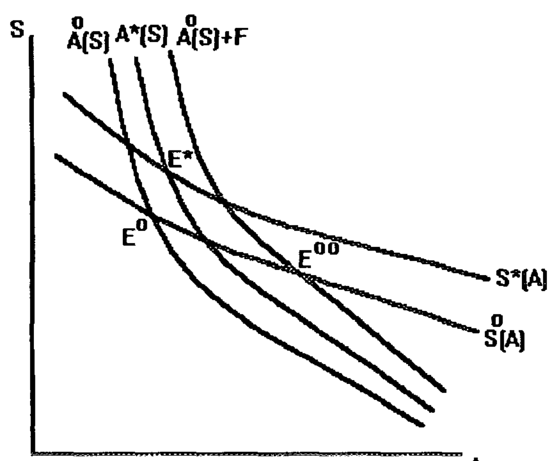

FIG. 6. The effect of advertising under strategic substitutability.

tional benefits of higher search efforts by the seller in the cases of strategic independence and strategic substitutes. However, the benefits from higher search efforts by the agent might still exceed the cost of advertising.

A similar argument can be applied to the formation of multiple listing services (MLSs). A crucial function of MLSs is that, by joining the listing pools of its members into a single pool, it improves the matching technology for the agent and the sellers. Assuming that this leads to a higher level of total search effort by the agents (by the listing and the selling agents), the above arguments can also be derived for the formation of MLSs.[9]

IV. INCENTIVE EFFECTS OF THE PERCENTAGE COMMISSION SYSTEM

Clearly, under the percentage commission system the seller and his agent have the same objectives: to sell the property for as high a price as possible and as quickly as possible. However, their objectives might differ in terms of how high the price should be and how much search effort should be expended to find a buyer. We proved in the previous section that it is possible for either the seller's or the agent's, but not both, equilibrium search effort levels to be efficient. This section of the paper examines the extent to which the percentage commission system aligns the interests of the agent with those of the seller. This question has been studied in Anglin and Arnott (1991), Zorn and Larsen (1986), and Arnold (1992) in great detail. The purpose of this section is to reexamine this question under the double moral hazard framework presented in the previous sections. We also compare the *incentive-compatible* allocation (i.e., S and A pair that perfectly aligns the agent's interests with those of the seller) with the efficient allocation.

As in the previous section, we continue to study the choice of search effort levels by the seller and his broker for a given price for the house. We will allow the seller to choose the price for his house in the next section.

The incentive-compatibility problem here is different than that of a standard principal-agent model. The seller in the current model does not choose a compensation (commission) scheme to induce the agent to expend a certain level of effort. Both components of the commission, i.e., the commission rate and the price, are determined in the market and taken as given by the players (see Anglin and Arnott, 1991, and Anglin, 1993, for the case where the seller and the agent can contract on the commission scheme).

[9] These arguments are not attempts to explain why firms advertise or why MLSs are formed. They simply point to a potential role played by firms' advertising and MLSs in double moral hazard environments.

Moreover, there are only two types of outcomes: a match or no match with a buyer. Since either outcome can arise for any search effort level choice by the agent, the outcome reveals no information about the agent's effort level. As proven in Hart and Holmström (1987), this implies that the seller should pay the agent a fixed amount, and the agent would in turn expend the minimum effort level. In housing markets, however, the agent receives the commission payment only in the event that the house is sold. Consequently, it is not necessarily true that the agent would shirk and spend the *minimum* amount of effort when the compensation is a fixed amount. More importantly, the incentive problem here is one of a double moral hazard where the search efforts depend on the conjectures of the players about each other's search efforts and by the strategic interaction between their search efforts.

Due to these differences, the usual incentive-compatibility constraints (including the first-order approach) are not applicable to the current problem. Instead, we use the following definition of incentive compatibility for the purposes of this study.

DEFINITION. Allocation (A^{**}, S^{**}) is incentive-compatible if (A^{**}, S^{**}) is the search effort pair that the seller would choose if he were equipped with the agent's search technology (defined by the function α) as well as his own search technology (defined by the function σ).

The incentive problem here is analogous to the problem of a production firm (principal) and its advertising agency (agent). The firm and the advertising agency both try to maximize their own profits. Consequently, the actions chosen by the advertising agency may not be in the best interests of the firm. To find the incentive-compatible marketing strategy, this definition suggests that we find what marketing strategy the firm would use if he owned the marketing firm.

Given the above definition, the seller's choice of A^{**} and S^{**} would maximize

$$\theta(S, A)(P - P_s)(1 - P) - \alpha(A) - \sigma(S). \tag{9}$$

Note that Eq. (9) is identical to Eq. (6). Thus,

PROPOSITION 2. *The incentive-compatible solution is identical to the efficient solution*; $A^{**} = A^*$ *and* $S^{**} = S^*$.

It is interesting to compare this result with those of Zorn and Larsen (1986) and Arnold (1992). As in the current model, Zorn and Larsen (1986) study the incentive and efficiency problem from the perspective of the search effort levels (with the exception that they allow only the agent to search) and show that the incentive-compatible outcome and the efficient outcome are not necessarily the same. Arnold (1992), on the contrary, takes the search effort levels as fixed and focuses on the informational asymmetries between the seller and the agent, and concludes that whenever the seller's reservation price is equal to that of the agent's (incentive-compatibility), it will also be equal to the socially optimal one. The above proposition indicates that when we employ a double moral hazard model, the result of Arnold (1992) will also apply to search effort levels.

Given Proposition 2, we can reiterate the result of Proposition 1 for comparing the equilibrium outcome and the incentive-compatible outcome.

PROPOSITION 3. (a) *If* $\partial^2\theta(S, A)/\partial S\partial A > 0$, *then* $S^\circ < S^{**}$ *and* $A^\circ < A^{**}$; (b) *If* $\partial^2\theta(S, A)/\partial S\partial A = 0$, *then* $S^\circ < S^{**}$ *and* $A^\circ < A^{**}$; *and*
(c) *If* $\partial^2\theta(S, A)/\partial S\partial A < 0$, *then one of the players provides less than the incentive-compatible level of search* ($S^\circ < S^{**}$ *or* $A^\circ < A^{**}$) *while the other player's search effort level might be smaller, greater, or equal to the incentive-compatible level.*

These results differ from the results of both Zorn and Larsen (1986) and Arnold (1992). Zorn and Larsen (1986) find that the agent will not search as much as the seller would want her to, because the percentage commission is less than 100% (i.e., the agent receives only a portion of the total surplus, $P - P_s$). Here, it is possible for the agent to search more than or equal to the incentive-compatible level if the search intensities are strategic substitutes. As before, the reason for the difference is that the matching technology in Zorn and Larsen (1986) captures only the case of $\partial^2\theta(S, A)/\partial S\partial A = 0$. In contrast, Arnold (1992) finds that there exists a unique commission rate at which the incentive-compatible effort level is obtained as the equilibrium outcome. In our model, this would correspond to $S^\circ = S^{**}$ <u>and</u> $A^\circ = A^{**}$. The reason this differs from our result is that Arnold (1992) looks at a different type of incentive problem. In his model, the agent's search effort level is *fixed*; hence there is no conflict of interest between the seller and his agent with regard to the search efforts.

V. PRICE AS A CHOICE VARIABLE

The above analysis assumed that the price of the house is determined in the market and is taken as given by the players. Here, we relax this assumption and examine what happens if the seller can determine the price.[10] Since the distribution of reservation prices is assumed to be common

[10] For simplicity, we ignore the bargaining stage of the game, and assume that the seller's price is his final offer. An alternative way of stating this assumption is that the seller can determine the outcome of the bargaining in advance through his choice of the listing price.

knowledge, our model does not involve any asymmetric information between the seller and the agent. Allowing for asymmetric information would create another source of incentive problem in which the two sides might have incentives to misrepresent their information to each other (Arnold, 1992).

The seller's problem is now to choose S and P to maximize

$$\theta(S, A)(P - P_s - kP)(1 - P) - \sigma(S). \tag{10}$$

The game now involves two stages. In the first stage, the seller chooses a P and informs the agent about his choise of P. In the second stage, the seller and his agent choose unobservable search effort levels. As in the case of a Stackelberg leader, the seller, in choosing P, has to take into account the impact of P on his agent's search effort level. This gives the following first-order condition for (10) with respect to P:

$$\begin{aligned}\theta(S, A)(1 - k)(1 - P) - \theta(S, A)(P - P_s - kP) \\ + \theta_A(S, A)(\partial A/\partial P)(P - P_s - kP)(1 - P) = 0.\end{aligned} \tag{11}$$

Given the P choice of the seller, the search effort reaction functions are again given by (4) and (5). Thus, the equilibrium is now defined by (4), (5), and (11), and involves three elements: S, A, and P.

The new efficient and incentive-compatible allocation requires maximization of (6) with respect to P as well as A and S. The first-order condition with respect to P yields the efficient and incentive-compatible price:

$$P^* = P^{**} = \tfrac{1}{2}(1 + P_s). \tag{12}$$

The new efficient and incentive-compatible allocation is characterized by Eq. (7), (8), and (12).

Does the fact that the seller can choose the price affect the results of Sections III and IV above? The answer is negative; Propositions 1, 2, and 3 have been proven to hold for any P. Thus, we will not have $S^\circ = S^* = S^{**}$ and $A^\circ = A^* = A^{**}$ even if $P = P^* = P^{**}$. The ability of the seller to choose the price does not provide use with flexibility, but rather adds a new requirement for the equilibrium to be efficient or incentive-compatible, $P = P^* = P^{**}$.[11]

[11] A comparison of (11) and (12) shows that $P^* \neq P^{**}$ because $k > 0$. However, comparison of P° (solution to (10)) with P^* is not trivial. Yet this comparison is not necessary because we have already shown that the equilibrium allocation is neither incentive-compatible nor efficient for *any P*.

VI. FLAT-FEE AND NET LISTING COMMISSION SYSTEMS

Under the flat-fee system, the agent's commission from the sale of a house is equal to a predetermined fixed amount (F). Under the net listing system, the agent agrees to pay the seller a predetermined fixed price ($\underline{P}$) upon the sale of the house, and the agent's commission is the residual $P_T - \underline{P}$, where P_T is the transaction price. It is clear that the above analysis can be repeated for the flat-fee and net listing systems by simply replacing kP with F and $P_T - \underline{P}$, respectively. Therefore, it can be shown that all of the results obtained for the percentage commission system in Propositions 1–3 also hold for flat-fee and net listing systems. This result is similar to that of Arnold (1992), that neither flat-fee nor net listing systems can induce the efficient and incentive-compatible allocation. The intuition behind this conclusion is simple. Efficiency requires that each player searches as if he/she receives the whole surplus, and incentive compatibility requires that both the seller and the agent join their efforts to maximize the seller's surplus. These never happen in equilibrium under any of the commission systems because in each system the seller and his agent *share* the surplus, and each player considers only his/her share in choosing his/her search effort.

The efficiency results under the three commission systems have been proven for the case of risk-neutral brokers and sellers. Suppose we allow the sellers and/or brokers to be risk averse or risk lover. This would introduce another potential source of inefficiency to the model: optimality of risk-sharing between brokers and sellers (Anglin and Arnott, 1991). Therefore, given that we have shown the impossibility of obtaining efficient effort levels for both a risk-neutral broker and a risk-neutral seller, adding risk dimension will only strengthen the results of the paper. The reason is simple: the source of inefficient effort levels is due to positive externality stemming from the fact that when a sale does occur, the broker and the seller *share* the surplus, and the presence of this positive externality is independent of the risk attitudes of the players.

VII. CONCLUDING REMARKS

The objective of this paper has been to examine the incentive and efficiency problems in seller–broker relationships in a model of double moral hazard. The model studied here does not address some of the standard questions of the principal-agent models, such as the determination of an optimal risk-sharing contract and an optimal compensation scheme. Instead, it focuses on the incentive and efficiency problems associated with the search efforts of the seller and the agent.

This paper has demonstrated that, in modeling real estate problems where the payoffs depend on the actions of more than one player, the results will crucially hinge on the assumption made about the strategic interaction between the actions of the players. The framework provided in this paper can be used to analyze various other real estate problems that involve strategic interaction between the players. Examples of such real estate problems include management of shopping centers where the payoffs of the stores and the property managers depend on the sale and promotional efforts of the stores and the managers; the listing broker's choice of the commission split between herself and the potential selling brokers in MLSs where the realization of the commission depends on the search efforts of the listing broker and the potential selling brokers; and the impact of the building codes where the probability of a structural failure depends on the quality of construction chosen by the builder and the level of care expended by the owner/tenant.

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