AREUEA Journal, Vol. 19, No. 1, 1991

Optimal Price and Selling Effort from the Perspectives of the Broker and Seller

David Geltner, Brian D. Kluger* and Norman G. Miller**

This paper uses numerical solutions of a dynamic optimization model to examine the principal-agent relationship between the seller and broker in residential real estate markets. Potential conflict of interest is quantified in two dimensions, the level of selling effort the broker puts forth, and the reservation price for the property. The dynamic optimization model reveals that the use of a finite duration listing contract will induce the broker to increase his or her effort level compared to an unlimited duration contract, and that the broker's optimal effort will increase over time, becoming greater as the listing contract expiration time draws nearer ("rational procrastination"). The numerical analysis indicates that with plausible parameter values, conflict of interest problems regarding broker effort level are minor or nonexistent near the end of the listing contract, but potentially important near the beginning of the contract. In contrast, the conflict of interest regarding reservation price is more severe near the end of the listing contract and is exacerbated by the use of finite duration contracts, the more so the shorter the contract.

BACKGROUND

Much of the recent academic literature concerning the relationship between the seller and broker in the real estate industry has focused on the principal-agent problem. Differences in the

*Department of Finance, College of Business Administration, University of Cincinnati, Cincinnati, Ohio 45221–0195.
Date Received: July 1990; Revised: November 1990.

incentives faced by the seller and his or her broker create a potential for a conflict of interest, so the broker may behave differently than if the broker and seller were somehow one and the same person. A conflict of interest problem may arise over the choice of both the price and the amount of selling effort.[1] The lower the asking price, the lower the effort required on the part of the broker to sell the property. When the cost savings to the broker from less required effort offsets the marginal benefit from the increased commission, a conflict of interest exists. In this situation, the broker may put forth less effort than would occur if the seller could more effectively monitor and control the broker. Because both the price and effort dimension are interrelated, we examine the conflict of interests over both dimensions simultaneously.

There have been two major thrusts of the literature to date, one concentrating on the pricing and effort problem in a static market, the other concentrating on the conflict of interest in a dynamic market where time to sale is explicitly considered. In a static model, Zorn and Larsen [11] note that the optimal reservation price from the seller's perspective can be defined at two levels. The "first-best" price is the price the seller would prefer if there were no principal-agent problem in the effort dimension (that is, if the broker would always put forth a selling effort equal to what she would do if the house were her own).[2] The "second-best" or conditionally optimal price is the price the seller would prefer given that he cannot directly control the broker's level of effort. However, the seller recognizes that he can indirectly influence the broker's selling effort through choice of the reservation price. Zorn and Larsen show the second best price may be lower than the first-best price, that is, the seller may find it in his interest to sacrifice a little on the price dimension to gain a closer alignment of interest on the effort dimension.

[1]A seller who engages a broker purchases a bundle of services. Conflict of interest may occur in any part of this bundle. In addition to search effort, the seller purchases advice on pricing the property. This includes advice about setting the initial asking price as well as subsequent advice once an offer is received. Because brokers most likely have better information about the market than sellers, this "price advisory" service may be quite influential and have as much effect on the ultimate outcome to the seller as does the "search effort" service.

[2]Throughout this paper, the masculine pronoun will refer to the seller, the feminine pronoun will refer to the broker. This is done solely to aid clarity, with the choice of gender dictated by the fact that surveys indicate that more than half of all licensed agents in the United States are women.

In a dynamic context, Miceli [6] has considered the role of finite listing contract duration in providing an additional incentive to increase the level of broker selling effort, thus more closely aligning seller and broker interests in the effort dimension. Miceli does not consider the effect of the listing duration on the potential conflict of interest in property pricing, nor does he consider changes in the broker's effort over the life of the listing contract.

The general conclusion of the literature to date seems to be that, with an open-ended listing contract, brokers will find it advantageous to provide too little selling effort and will prefer a property price that is too low (even from a second-best perspective). However, the use of the finite-duration listing contract increases the broker's desired level of effort, conceivably to, or even beyond, the seller's optimal level. The literature to date does not consider the extent to which the finite contract duration, while helping to align the broker's and seller's interests in the effort dimension, may exacerbate the conflict of interest in the property pricing dimension. Further, because all the results from the previous literature have been obtained from abstract analytical models without numerical or empirical analysis, there is no evidence about either the severity of the conflict of interest problem or whether the problem is worse in the effort or the pricing dimension.

The present paper seeks to build upon the existing conflict of interest literature in three ways. First, we integrate the level of selling effort, property pricing and time on the market, and listing contract duration issues. Second, we use a dynamic optimization model that reveals how the optimal broker effort changes over time. Third, we use numerical analysis to gain insight concerning both the magnitude of the problem and the relative severity in the effort and pricing dimensions.

OPTIMAL BROKER EFFORT OVER THE LIFE OF THE LISTING CONTRACT

The core of our model is the dynamic optimization of broker behavior. First suppose that a broker has a listing contract of finite length running from time $t=0$ to $t=T$. Borrowing terminology from the literature on the proportional hazards methodology of survival analysis, let h_t represent the "hazard" at time t, i.e., the conditional probability of sale of the house at t given that the house has not sold prior to t. Let x_t represent the broker's level of selling effort during period t, e.g., the number of hours the broker spends searching for potential buyers and showing the house to them. The hazard in period t is affected by the broker's effort during period t. Further, we assume that the housing market has "no memory" in the sense that effort by the broker in period t only affects the likelihood of sale in period t.[3] The hazard in period t is also affected by the price the seller is willing to accept: P.[4] Thus, we have:

$$h_t = h(x_t, P) \tag{1}$$

The assumed hazard rate can change over time, but for analytic convenience, only due to a change in the seller's effort level or the price, not as a result of time on the market, that is, $h(x_t,P,t) = h(x_t,P)$. Haurin [3] estimated the hazard function using data from the Columbus, Ohio market, and found that the function rose monotonically. This finding is consistent with our assumption because (as will be shown) the level of selling effort will increase over time and therefore the hazard will also increase. The hazard function is assumed to display declining marginal productivity. With increases in selling effort, the probability of sale increases at a decreasing rate. With increases in price, the probability of sale decreases at a decreasing rate.

Selling agents face an opportunity cost of their selling effort equal to "c" per unit of selling effort. For example, if x_t is measured in hours spent trying to sell the house, then c would be the agent's opportunity value of time per hour, which might be well approximated by the average hourly earnings of real estate agents. The agent's total costs[5] of trying to sell the house in period t is thus:

$$C_t = cx_t. \tag{2}$$

Now consider the value at time t of the listing contract to the broker: V_t. This simply equals the expected asset value of the

[3]This assumption is made for analytical convenience. Intuitively, relaxation of this assumption would likely increase the optimal effort early in the listing contract and perhaps decrease effort later on. However, there is no a priori reason to believe that this assumption distorts the *relative* differences between the optimal effort profiles from the perspectives of the broker and seller.

[4]At this point, we model the price as a given in order to solve for the optimal broker effort over the life of the listing contract. In the next sections we study the choice of the price from the viewpoint of the broker and from the seller's perspective. Note also that in our analysis the price does not change over the life of the listing contract.

[5]Fixed costs such as rent and overhead are not considered because they are not relevant to the problem here.

contract as of time t.[6] If "b" represents the broker's commission as a fraction of the selling price, and "d" represents the discount factor (that is: $d = 1/(1+r)$, where r is the required return per period of time), then:

$$V_t = h_t Pb + d(1-h_t)V_{t+1} - C_t. \tag{3}$$

If the house is sold in period t, the broker would receive the commission Pb but still pay the opportunity cost C_t. Thus, the expected proceeds are: $h_t\ Pb - C_t$. If the house does not sell in period t, then the broker still has the contract and may sell the house at some time between t and T, so the value of the contract at t conditional on the house not selling in t is $d(V_{t+1})$, the present value of the contract next period. The period t level of effort, x_t, is set by the broker at the outset of period t, before it is known whether or not the house will sell that period, so the broker will incur the C_t selling effort cost whether or not the house actually sells in period t. We assume the seller will not renew with the same agent if the house does not sell by the end of period T, which implies that $V_T = 0$.[7] Thus, the value of the contract in the period just prior to the listing contract's expiration is given by:

$$V_{T-1} = h_{T-1} Pb - C_{T-1}. \tag{3a}$$

Equations (3) and (3a) represent a closed system that can be solved recursively to value V_0.

In this setting, the broker has an incentive to sell the house quickly because an earlier sale will increase the present value of the commission receipts, reduce the accumulated selling costs (the sum of C_t each period until the house is sold), as well as reducing the probability that the listing contract will expire before the house is sold (resulting in no revenue to the broker at

---

[6]To focus on the principal-agent relationship, V_t is the incremental asset value added to the firm by listings that have already been obtained. The firm would also have fixed costs and liabilities associated with obtaining listings and operating the business. Positive value for V_t does not imply excess economic profit.

[7]This simplification is made for analytical convenience. To the extent that the seller can observe and judge the broker's performance during the first contract term, the possibility of contract renewal will serve to more closely align broker and seller interests. Therefore, by adopting the no renewal assumption, our model may tend to overstate the amount of conflict of interest. However, the difficulty the seller has in observing the broker's level of effort, and the fact that conflict of interest in the pricing dimension will not surface until a serious offer is received, suggests that the promise of listing contract renewal is a rather "blunt instrument" for the purpose of reducing the conflict of interest revealed in our model.

all). But to reduce the expected time until the sale of the house, the agent must increase the hazard, which requires an increase in the selling effort and associated costs. The concavity of the hazard function with respect to effort, combined with the linearity of the cost over effort, assures that the broker will face an optimal level of effort at each period of time, denoted by x^*_t, which implies an optimal hazard function over time: h^*_t.

To optimize x_t the broker maximizes V_t by setting the partial derivative of (3) with respect to x_t equal to zero:

$$(\partial h_t/\partial x_t)(Pb - dV_{t+1}) - \partial C_t/\partial x_t = 0 \tag{4}$$

With our linear cost assumption, $\partial C_t/\partial x_t = c$ for any level of effort, so the optimal hazard function over time is given by: $h^*_t = h(x^*_t, P)$, where $x^*_t = x_t$ such that:

$$\partial h_t/\partial x_t = c/(Pb - dV_{t+1}). \tag{4a}$$

It is easy to see from (4a) and the concavity of h_t over x_t that the optimal selling effort will be greater when b equals one rather than a small commission fraction, thus confirming Zorn and Larsen's result that the broker's profit-maximizing level of selling effort will tend to be too small from the seller's perspective.

GENERAL IMPLICATION: "RATIONAL PROCRASTINATION"

Early in the listing contract there is little consequence to the broker from not selling, but towards the end of the contract, the consequences become severe. Thus, the broker has an incentive to increase selling effort over time. In this sense it is "rational" for the broker to "procrastinate" at the start of a listing contract.

Equations (3) and (4a) provide a system of equations that can be solved recursively for V_t and x_t. As $V_t > 0$ for all t and $V_T = 0$, the denominator on the RHS of (4a) will be greatest in period $t = T - 1$, which means that, for any finite T, other things being equal, the selling agent's optimal effort (and hence the hazard function) will be higher in the last period before listing contract expiration than at any previous time. In fact, under our smoothness assumptions and the constraint that broker effort cannot be less than zero, the broker's value-maximizing effort will increase monotonically with a slight convexity as the listing expiration approaches.

Now consider the problem of a seller (a broker selling her own house). Equations (3) and (4a) still solve the optimal effort problem, however here $b=1$ and V_T is no longer equal to zero. From this perspective, $T=\infty$ in (4a), which means the listing contract never expires. In fact, $V_t = V_{t-1}$ or V at any other time because the decision problem faced by the seller is independent of time. Therefore the optimal effort and (and the hazard rate) is constant over time. Thus, while the finite duration contract does indeed increase the broker's optimal effort, it also induces a time profile of effort that is different from the seller's solution. While the broker's optimal effort increases monotonically, the seller's solution would have constant effort.

OPTIMAL CHOICE OF THE RESERVATION PRICE

The optimal reservation price with T periods remaining in the listing contract, $P^*(T)$, is the P that maximizes V_0 based on h^*_t for all t from 0 to T. Thus, the broker's optimal selling effort, hazard, and reservation price can be recursively computed at any point in time, once the broker's search production function, $h(x_t, P)$, is specified.

To find the optimal selling effort, hazard and first-best reservation price from the point of view of the *seller*, simply let T approach ∞, and redefine b in (3) and (4a) to equal one, as though the broker and seller were the same person. Zorn and Larsen's "second-best" or conditionally optimal reservation price for the seller is found by using the broker's optimal hazard function in the seller's valuation function. The second-best price is the price that a seller would pick knowing that the broker is choosing her level of selling effort. In practical terms, this second-best price is the value of P that maximizes V_0 in equation (3) with: b redefined to equal one, and h_t equal to the broker's optimal h^*_t based on b = broker's commission and T equal to the duration of a single listing contract in equation (4a). In calculating the *seller's* second-best price it is assumed that the *broker's* optimal hazard function repeats over several T-period cycles.

Unfortunately, the analytic solution for the optimal reservation price is lengthy and not particularly illuminating. Therefore, we use numerical methods to study the conflict of interest problem in the following sections.

SPECIFICATION OF THE BROKER MODEL AND BUYER PRICE DISTRIBUTION

Although abstract analysis produces some interesting insights, it does not allow the quantification necessary to ascertain the likely severity of the conflict of interest problem in the real world. To quantify the analysis we must specify both the broker's search and selling production function, $h(x_t,P)$, and her opportunity cost of search and selling time, c. The strategy is first to specify numbers and functional forms that seem realistic based on both our familiarity with the residential brokerage industry and data contained in publicly available empirical studies of the industry. Reasonable variations in the functional forms and parameters are then examined through sensitivity analysis.

To capture the key aspects of the broker's production function relevant for the property pricing and selling effort conflict of interest issues, we have expanded this production function into the product of three factors. The probability of making a sale at any time t, h_t, can be decomposed into three factors. Potential buyers must *exist*, they must be *found*, and they must be *convinced* to transact at time t. These factors are labeled as "demand potential," $(1-G)$, "broker search effectiveness," Y, and "property sellability," S. The probability of making a sale can now be expressed as the product of these three factors:

$$h_t=(1-G)Y_tS. \tag{5}$$

"Demand potential" is the proportion of the potential buyer population willing to pay at least the selling price P for the property. If we think of the buyer population as all individuals currently searching for a house similar to the subject property, then $G=G(P)$ is the probability that an individual drawn at random from this population has a maximum willingness-to-pay price equal to or below P. The distribution of the buyer population willingness-to-pay price is assumed here to be the symmetric discrete triangular distribution.[8]

The broker "Search Effectiveness Factor" in period t is a normalized measure of broker effectiveness in exposing the property to the potential buyer population. Effectiveness is defined to range from zero (at zero broker effort) to one (which represents "full" or maximum possible broker effectiveness). The Effectiveness Factor reflects the broker's productivity of

[8]The triangular distribution has the desirable property of having a finite range while being easy to work with computationally. The triangular distribution also has a plausible ratio of standard deviation to range (43% of the range is within one standard deviation of the mean, compared to 58% for the uniform distribution), and a plausible proportion of total probability within one standard deviation of the mean (65%, as compared to 58% for the uniform distribution and 68% for the normal or Gaussian distribution). The triangular is commonly used as a proxy for the truncated normal distribution.

her selling efforts and is a monotonically increasing concave function of effort in order to satisfy the law of diminishing marginal productivity. The concavity of Y_t over x_t induces concavity over x_t in the overall broker production function or hazard function, h_t.

The effectiveness or productivity of the broker's efforts is also influenced by the price of the property. It will be easier for the broker to find potential buyers for properties that are priced very low, relative to the buyer-population's willingness-to-pay distribution. Such properties will "speak for themselves," and the broker will have to put forth relatively little effort to obtain a large exposure per unit of time. Thus, we have: $Y_t = Y(x_t,P)$, which we have specified as follows:

$$Y_t = 1 - \exp(-Kx_t) \quad (6)$$

where $K = K(P)$ reflects the sensitivity of broker effectiveness to price when price is very low. The function used to specify K is:

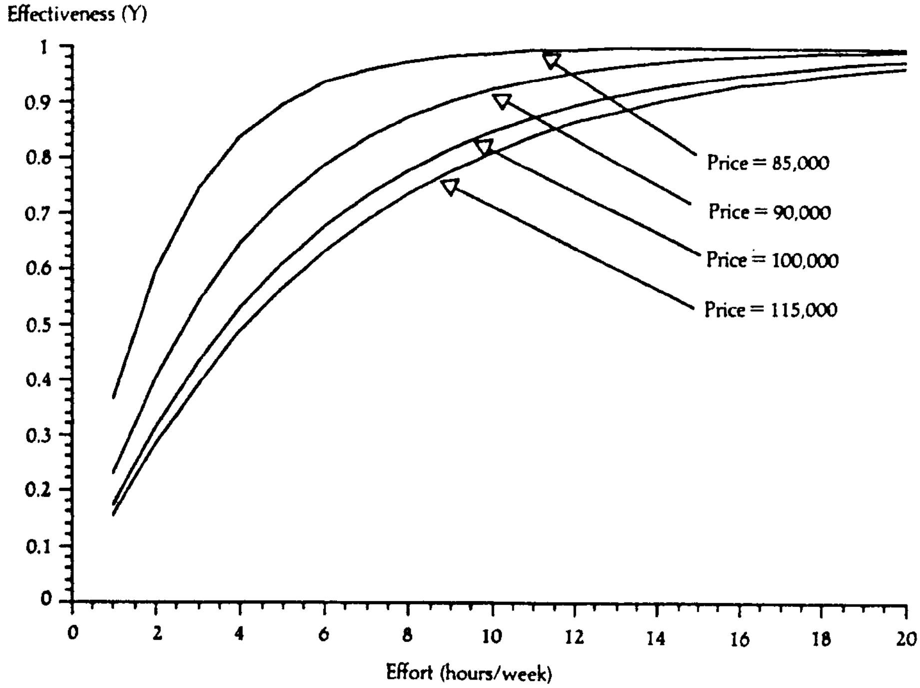
$$K = A_2(1 + [A_3(P - P_{MIN})/(P_{MAX} - P_{MIN})]^{(-A4)}) \quad (7)$$

where P_{MIN} and P_{MAX} represent the upper and lower bounds of the buyer population maximum willingness-to-pay prices. Figure 1 shows Y_t at our base case parameter values of: $A_2 = 0.15$, $A_3 = 5$, $A_4 = 1.5$, with a buyer population reservation price ranging from \$80,000 to \$120,000 with a mean of \$100,000.[9]

The third factor in the overall production or hazard function is the "Property Sellability Factor," $S = S(P)$, which reflects both the typical rate of exposure of the property at full broker effectiveness as well as buyer reactions to prices that differ markedly from the typical price for the subject type of property. Over the mid-range of prices, within one standard deviation or so of the buyer population mean maximum willingness-to-pay price, S largely reflects nothing more than the "density" of potential buyers for the subject property. Properties situated in denser markets have a faster exposure rate and shorter expected time to sale. This is reflected by the parameter S_o, which represents the inverse of the expected time on the market for a house priced at the buyer population mean and marketed with "full" broker effectiveness. (Thus S_o also is a function of the size of the time interval or "period," which we take to be weeks.)

[9]These parameters were chosen to scale the effectiveness so that a mid-range (roughly 0.5 effectiveness) maps to approximately five hours of broker effort per property. This figure is consistent with the number of hours per property, per week found in the Follain, Lutes and Meier survey [2] as well as the annual NAR profile of members survey.

Figure 1
Agent Effectiveness as a Function of Effort and Price



Houses priced significantly below the mean, especially if near the lower bound of the buyer distribution, will appear "underpriced," and will tend to be "pounced on" by knowledgeable buyers fearful that if they do not act quickly somebody else will beat them to it. At the other extreme, if the house is priced significantly above the buyer mean, even buyers who are willing to pay the price will tend to hesitate, for fear of paying more than they need to and because they know there is little danger of this house "getting away" while they continue their search for an even better deal. These behavioral tendencies of buyers are reflected in the "pounce factor," π_1, and the "hesitation factor," π_2, in the Sellability Function below.

$$S = \begin{cases} S_o + (1 - S_o)\exp[-\pi_1(P - P_{MIN})/(P_{MAX} - P_{MIN})], & P_{MIN} \leq P < E[P] \\ S_o, & P = E[P] \\ S_o - S_o\exp - \pi_2(P_{MAX} - P)/(P_{MAX} - P_{MIN})], & E[P] < P \leq P_{MAX} \end{cases} \quad (8)$$

As a factor in the hazard function, this Sellability Function must

Figure 2
The Sellability Factor

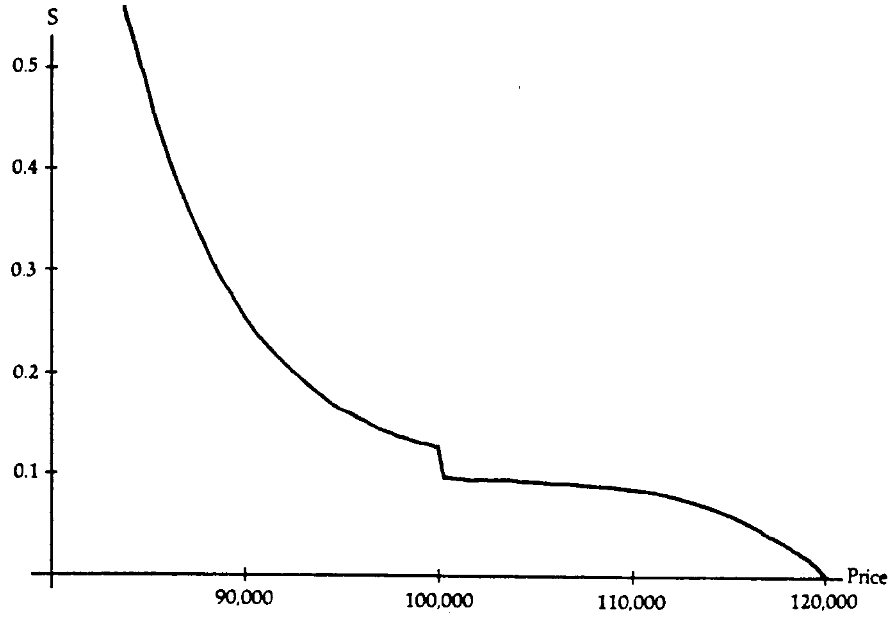
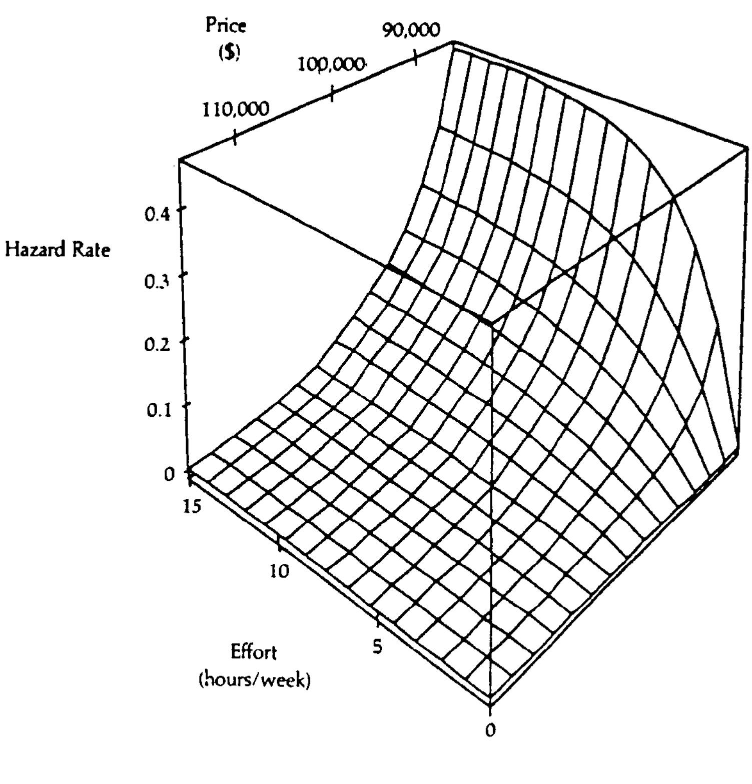


Figure 3
The Hazard Function



be bounded by zero and one, and is pictured in Figure 2 under our base case assumption of $S_0 = 0.1$ and $\pi_1 = \pi_2 = 7$.[10]

Finally, Figure 3 illustrates the entire hazard function as defined in equation 5.

RESULTS OF THE NUMERICAL ANALYSIS

For our numerical analysis we have assumed a buyer maximum willingness-to-pay price distribution ranging between \$80,000 and \$120,000 with a mean of \$100,000. We have assumed a base case value for the opportunity cost of the selling agent's time equal to \$13.00 per hour, based on the findings in Follain, Lutes and Meier [2]. Our time period is defined in weeks, with an assumed seller's horizon of 200 weeks (i.e., we treat $T = 200$ as $T = \infty$). We assume a required real return of 0.35% per week, or approximately 20% per year, and a fixed percentage selling commission to the broker of 7% of the price.[11] With these assumptions the numerical results are presented in Figures 4 through 7.

Figures 4, 5 and 6 quantify the conflict of interest in the selling effort dimension. Recall that one of the implications of the dynamic optimization model described previously is that the optimal broker effort increases over time, peaking at the last week prior to expiration of the contract. Thus, the broker's optimal selling effort will be farther below that desired by the seller in the early weeks of the contract than later on (assuming the house has not yet sold).

Figure 4, depicts the time profile of optimal effort over the life of a 15-week contract, at the seller's first-best price (the price with no principal-agent problem), which is \$99,000 in this example. The broker's optimal effort constantly and steadily increases, approaching the seller's desired level near the end of the contract (provided, of course, the house has not yet sold). At any given price, all contracts would have the same optimal effort profile over their last 15 weeks, no matter what the original duration of the listing contract was at the time of its signing. For

---

[10]These parameters imply time on the market would typically be in the range of ten to thirty weeks.

[11]All parameters are real. The required real rate of return was selected to approximate results from a recent NAR study [7]. Depending on firm size and other parameters, nominal discount rates for the valuation of a real estate brokerage firm range from 20% to 50%.

Figure 4
Time Profile of Optimal Selling Effort at the Seller's First-Best Price

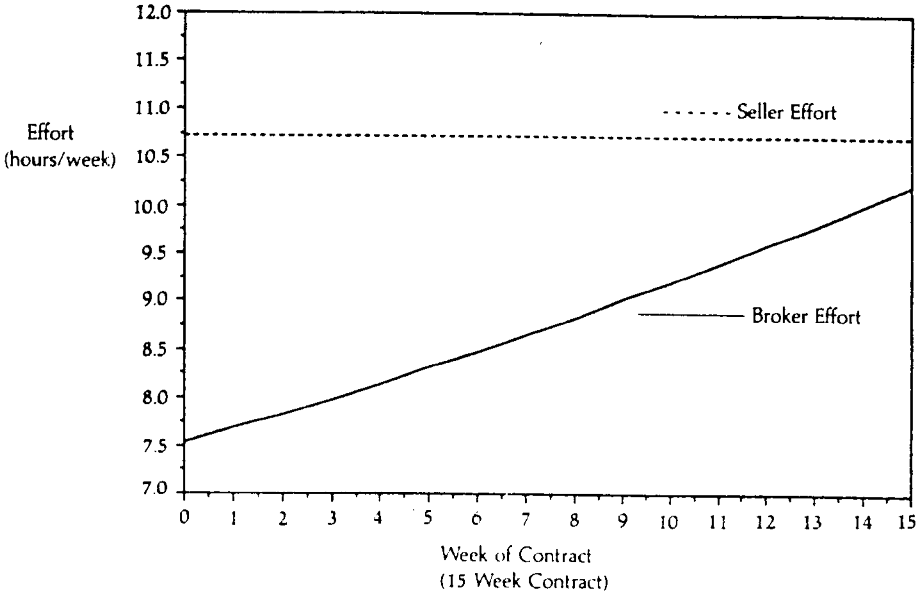


Figure 5
Optimal Initial Selling Effort

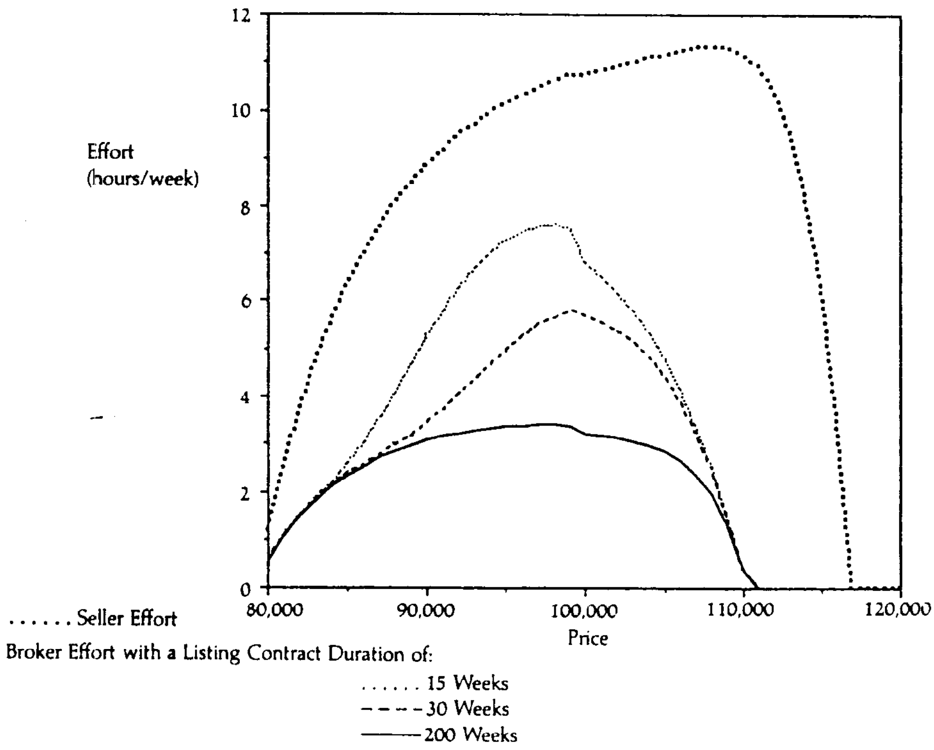
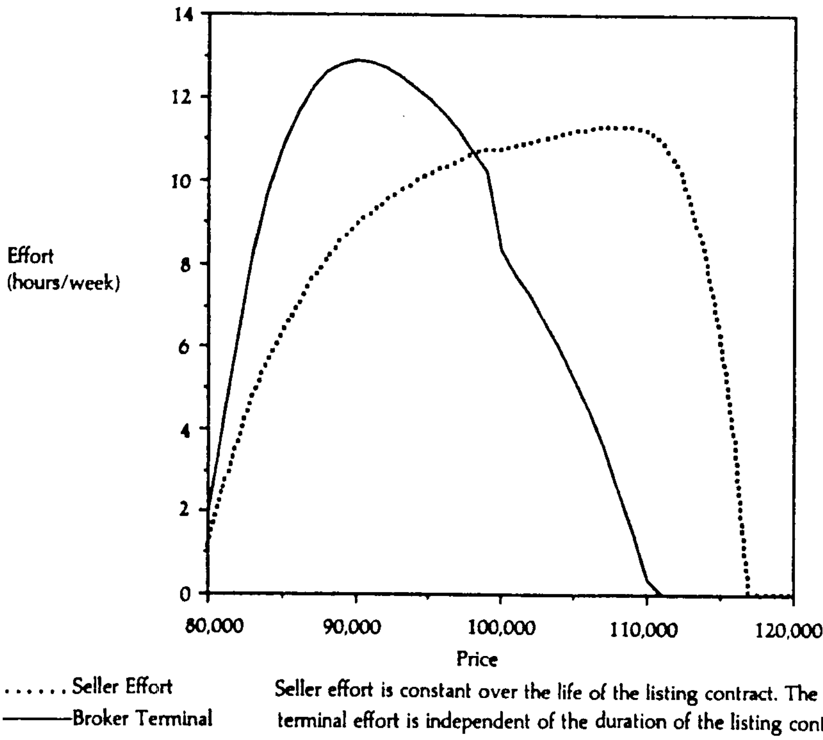


Figure 6
Optimal Terminal Selling Effort



Seller effort is constant over the life of the listing contract. The broker terminal effort is independent of the duration of the listing contract.

longer duration contracts, the optimal effort profile just extends down to the left as a monotonic convex function over the time remaining in the contract. All contracts have the same optimal effort at the end; the longer the contract, the lower the optimal effort at the beginning.

Figures 5 and 6 show the optimal level of selling effort, in hours per week, from both the broker's and seller's perspectives. Figure 5 shows the optimal effort at the start of the listing contract. The highest line in Figure 5 is the optimal effort from the seller's perspective. The three lower lines show optimal effort from the broker's perspective at the beginning of a 200-week (virtually unlimited) contract (lowest line), a 30-week contract (middle line), and a 15-week contract (top line). Clearly, the use of the finite duration listing contract increases the optimal initial effort from the broker's perspective, raising this optimal level closer to that desired by the seller, the more so, the shorter the time remaining until expiration of the contract. Figure 6 shows the effort levels in the final week of the listing contract, no matter what original length of the listing contract.

Figure 5 indicates that at the seller's first-best price of $99,000, the seller would prefer that the broker spend some 10.7 hrs/wk selling the house (this is fully considering the broker's opportunity cost of $13/hr), while the broker would prefer to spend only 3.4 hrs/wk in an unlimited duration contract, or up to 7.5 hrs/wk at the beginning of a 15-week contract.

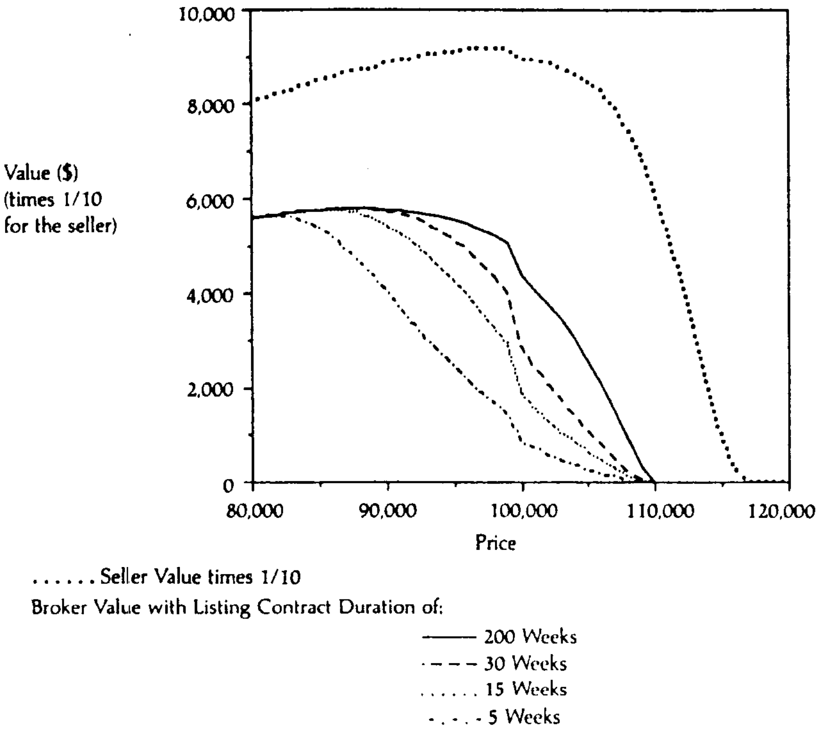
At lower prices, the optimal selling effort is lower from both the broker's and seller's perspectives because selling effort is more productive and diminished returns to scale (i.e., declining effectiveness per hour of selling effort) are reached sooner (recall the sensitivity of selling effort effectiveness to the price portrayed in Figure 1). For example, at the broker's optimal price at the beginning of a 15-week listing contract, which is $85,000, the optimal effort from the seller's perspective is only 6.35 hrs/wk, compared to 10.72 hours at $99,000. From the broker's perspective, with 15 weeks left in the contract the optimal effort is only 2.57 hrs/wk at $85,000 versus 7.53 hours at $99,000. Thus, at the initial stages of a 15-week contract, it does not appear that the conflict of interest regarding selling effort can be reduced by lowering the reservation price.

While the broker's optimal effort is clearly less than what the seller would desire at the *beginning* of the listing contract, Figure 6 reveals an interesting phenomenon near the *end* of the listing contract. No matter what the original duration of the listing contract was, the optimal effort from the broker's perspective approaches rather closely the optimal from the seller's perspective at the seller's first-best optimal price. For example, at $P=\$99{,}000$ the optimal effort from the broker's perspective in the last week prior to contract expiration is 10.2 hrs/wk, compared with the constant 10.7 hrs/wk from the seller's perspective. At lower prices, the optimal effort from the broker's perspective near the end of the contract is actually *greater* than the optimal effort from the seller's perspective.

This suggests that overall, the conflict of interest between the broker and seller in the effort dimension may be of relatively minor importance provided finite duration listing contracts are employed with relatively short durations. In that case, our model suggests that the conflict in the effort dimension becomes more a matter of timing ("rational procrastination") than overall effort, particularly if reservation prices are reduced below the optimal level for the seller.[12] This finding is consistent with the

[12]However, note that the conflict of interest in the initial stage of a listing contract is more important than at the end because there is lower probability that the house will still be on the market near the end of the contract.

Figure 7
Initial Contract Value



theoretical implications of Miceli [6] and the empirical findings of Larsen and Park [5], but contrasts with some of the earlier literature on the broker-seller principal-agent problem, e.g., Zorn and Larsen [11], which focused primary attention on the conflict of interest in the effort dimension.

As noted previously, one of the central purposes of our analysis is to examine the potential conflict of interest in the pricing dimension as well as the effort dimension. Figure 7 shows the contract-to-sell value to the broker and seller as a function of the reservation price and (in the case of the broker) also as a function of the remaining listing contract duration. This figure illustrates how the optimal price differs between the seller and his agent, and it shows the magnitude of the value penalty the agent pays if she accepts the seller's optimal price instead of her own. The top line in Figure 7 is the value to the seller (in $10 units) under the assumption of optimal selling effort from the seller's perspective. (As the seller's opportunity cost per unit of time is assumed to be constant and selling horizon is (virtually) unlimited, his optimal selling effort is constant, so the first-best value of the contract to the seller is constant, and independent of the remaining duration in the broker's listing contract.) Thus, the price where the seller's value peaks in Figure 7 is the "first-best" reservation price from the seller's perspective.

The seller's first-best optimal price depicted in Figure 7 is $99,000, just shy of the mean price of the buyer-population maximum willingness-to-pay distribution. With a $99,000 reservation price (gross of the selling commission), the net present value of the contract to the seller is $91,699, gross of the selling commission and assuming optimal selling effort from the seller's perspective. This is the first-best value that would accrue if the broker were selling her own house. The difference between the $99,000 price and the $91,699 contract-to-sell value reflects both the probability distribution of time on the market combined with the discount rate of 0.35% per week (20%/yr), as well as the cost of the expected selling effort.

The other four lines in Figure 7 show the value of the listing contract (V_t at $t=0$ in equation 3) to the broker under the assumption of optimal selling effort from the broker's perspective. Each line represents the value with a different number of weeks remaining in the listing contract. The top line is with 200 weeks remaining (effectively, an unlimited listing contract). The next line is with 30 weeks, then with 15 weeks, and the lowest line assumes 5 weeks remaining in the contract. The peaks in these broker value lines indicate that the optimal price from the broker's perspective is lower than the first-best seller's optimal price, even with the virtually unlimited listing contract, and that the gap between the broker's and seller's optimal price grows larger the shorter is the time remaining in the listing contract.

The difference between the broker's curves and the seller's curves in Figure 7 introduces the potential for agency cost, a

TABLE 1
Optimal Prices from Various Perspectives

Weeks Remaining in the Listing Contract	Optimal Price from the Perspective of: Seller's 1st-Best	Seller's 2nd-Best	Broker
200	$99,000	$96,000	$88,000
30	$99,000	$99,000	$87,000
15	$99,000	$99,000	$85,000
5	$99,000	$99,000	$82,000

TABLE 2
Contract to Sell Values at Optimal Prices from Various Perspectives

Weeks Remaining in the Listing Contract	Value to the Seller (gross*) at: Seller's 1st-Best Price	Seller's 2nd-Best Price	Broker's Optimal Price
200	$88,597	$89,131	$86,059
30	$91,256	$91,256	$85,464
15	$91,566	$91,566	$84,106
5	$91,672	$91,672	$81,714

Weeks Remaining in the Listing Contract	Value to the Broker at: Seller's 1st-Best Price	Seller's 2nd-Best Price	Broker's Optimal Price
200	$5,072	$5,465	$5,799
30	$4,005	$4,005	$5,793
15	$2,904	$2,904	$5,754
5	$1,433	$1,433	$5,641

*These values are gross of the selling commission and conditional upon the knowledge of the broker's optimal effort.

potential that clearly varies by duration of contract and level of reservation price. Table 1 shows the "optimal" price from various perspectives. With finite duration listing contracts the seller's first- and second-best optimal prices are nearly identical because, as noted earlier, the conflict of interest in the effort dimension is relatively minor with listing contracts of typical length.[13] Furthermore, the conflict in the effort dimension is not necessarily reduced by lowering the reservation price (recall Figures 5 and 6). (The main reason why the second-best price might be lower than the first-best price is to better align the interests of the broker and seller in the effort dimension.) Only in the hypothetical case of unlimited listing contracts does a noticeable difference appear. Table 1 also reveals a rather large gap between the seller's optimal price and the broker's optimal price, regardless of contract duration. The significance of this price conflict is rather small with an unlimited duration contract, particularly when viewed from the second-best perspective.

[13] Recall that the second-best price is the price that the seller would choose taking into account the brokers optimal effort profile as a function of price.

Table 2 shows the value of the contract-to-sell to the broker and the seller. With an unlimited duration listing, the contract is worth almost as much to the broker at the seller's optimal price as it is at the broker's optimal price. At the broker's optimal price of $88,000 the contract is worth $5,799 to the broker, while at the seller's second-best optimal price of $96,000 the contract is worth $5,465. Thus, the broker sacrifices roughly $334 or slightly over 5% of her potential value if she adopts the policy of advising the seller to hold out for a price of $96,000 instead of going for an offer of $88,000.

On the other hand, the potential pricing conflict of interest becomes much more problematic with finite duration listing contracts of typical length. As seen in Table 2, the pricing conflict of interest is greater, the shorter the remaining duration on the contract. By the time we get down to five weeks left in the contract (or a five-week contract at its inception), the difference in value to the broker between her optimal price versus the seller's optimal price is $4,208 (contract value to the broker of $1,433 at $P=$ $99,000 versus $5,641 at $P=$ $82,000). With five weeks left in the listing, for the broker to suggest a price that is optimal from the sellers viewpoint represents a potential sacrifice of some 75% of the broker's value.

Thus, as one would expect, the conflict of interest between the broker and seller regarding the price to charge for the house becomes considerably more severe with shorter listing contracts (or when there is less time left in the listing contract). In this respect, the use of the finite duration listing contract, while ameliorating the conflict of interest between broker and seller in the selling effort dimension, exacerbates the conflict in the pricing dimension.

SENSITIVITY ANALYSIS

The findings discussed above are based on our "base case" scenario, which represents typical residential real estate market conditions in the late 1980s. Table 3 reports the results of sensitivity analysis regarding these findings, in which several key variables are altered from their base case values. The sensitivity analysis generally confirms the previous findings over a range of plausible market conditions, and confirms some other results that are generally in keeping with intuitive expectations. We note, for example, that both the broker and seller find it

TABLE 3
Sensitivity Analysis

	Optimal Effort (b)			Optimal Price			Contract Value (c)		
	Broker				Seller	Seller		Seller	Seller
Scenario (a)	Begin	End	Seller	Broker	1st Best	2nd Best	Broker	1st Best	2nd Best
Base Case	7.54	10.23	10.73	\$85,000	\$99,000	\$99,000	\$2,904	\$91,699	\$91,566
$P = 160–240$	10.27	13.86	13.47	\$174,000	\$198,000	\$198,000	\$7149	\$185,769	\$185,667
$P = 90–110$	7.10	12.42	10.03	\$91,500	\$97,000	\$97,000	\$4,727	\$93,243	\$93,184
$S_o = 0.5$	8.48	12.82	11.76	\$97,000	\$107,000	\$107,000	\$4,121	\$101,128	\$101,049
$S_o = 0.05$	7.24	10.33	10.06	\$85,000	\$95,000	\$95,000	\$3,268	\$89,028	\$88,944
$r = 0.005$/wk	7.61	11.20	11.70	\$85,000	\$97,000	\$97,000	\$3,582	\$89,943	\$89,750
$c = \$20$/hr	6.07	8.52	9.09	\$84,000	\$98,000	\$98,000	\$2,706	\$90,661	\$90,477
$b = 3.5\%$	4.99	6.59	10.73	\$83,000	99,000	\$98,000	\$ 959	\$91,699	\$90,949

(a) All scenarios are base case except as noted. The base case has: $S_o = 0.1$, $r = 0.0035$/wk, $c = \$13$/hr and $b = 7\%$. $P = 160–240$ refers to buyer maximum willingness-to-pay distribution ranging from \$160,000 to \$240,000 with a mean of \$200,000 instead of the base case range from \$80,000 to \$120,000 with a mean of \$100,000.
(b) Hours per week. Broker values are at the beginning and end of a 15-week listing contract.
(c) Values in dollars at the beginning of a 15-week listing contract, assuming the seller's 1st best reservation price. Seller's 1st best values refer to the values when the broker is supplying effort at the optimal level from the seller's perspective (as if the broker were selling her own house). 2nd best values refer to value conditional on the broker supplying optimal effort from the broker's perspective.

wealth-maximizing to expend more selling effort when the house is more expensive (ceteris paribus, of course). This makes sense because the rewards from selling are greater measured in absolute dollar amounts. The optimal selling effort per week rises from 10.73 hours to 13.47 hours when the house value doubles from \$100,000 to \$200,000.

A tighter buyer population maximum willingness-to-pay price distribution (e.g., from \$90,000 to \$110,000, instead of from \$80,000 to \$120,000) also is good news for both the broker and seller, increasing selling contract values and reducing the conflict of interest in both the effort and price dimension. This makes sense, as a large increase in selling probability (hazard) is achieved from a small reduction in price, thus reducing the seller's optimal reservation price, while the tighter distribution enables the broker to raise her optimal reservation price and still have very high probability of sale.

The sensitivity analysis results from varying "market density" are also interesting. As we would expect, a dense market, as represented by a high value of the sellability or liquidity parameter, S_o, is good news for the seller and his broker. We tested $S_o = 0.5$ and $S_o = 0.05$, in addition to the base case $S_o = 0.1$

(implying expected time on the market of two weeks and twenty weeks instead of the base case ten weeks, at "full selling effectiveness" and at the buyer population mean price). The seller's optimal reservation price rises from $95,000 at $S_o = 0.05$ to $99,000 (just below the buyer population mean) in the base case, to $107,000 (almost a whole standard deviation above the buyer population mean) at $S_o = 0.5$. The optimal selling effort also increases with market density, implying the somewhat counter-intuitive result that, in a sense, brokers should work "harder" when selling is "easier." The combination of higher reservation price and greater probability of sale is reflected in markedly higher contract-to-sell values as market density increases.

The implications of varying the time discount factor (r) and the brokerage opportunity cost per hour (c) are not surprising. Increasing the time discount rate increases the urgency to sell, thereby increasing the optimal selling effort and reducing the optimal prices and contract-to-sell values, but in both respects, the effect is small. Increasing the brokerage opportunity cost from $13 per hour to $20 per hour naturally reduces the optimal effort as well as the prices and values.

The last scenario shown in Table 3 shows the sensitivity of the principal-agent problem to the magnitude of the percentage commission. If we reduce the commission from the base case level of 7% to 3.5%, the conflict of interest increases notably in both the effort and price dimensions. This is the only scenario in which the seller's second-best price is lower than his first-best price.

The overall impression from Table 3 seems to be rather reassuring in the effort dimension. At least at the widely prevailing standard commission rate of 7%, there is little significant conflict of interest between the broker and seller regarding the broker's selling effort. This is revealed in Table 3 by the slight difference between the contract-to-sell values to the seller under the first-best and second-best perspectives.[14] The 7% commission combined with a listing contract duration of three months or less serves rather well to blunt the potential principal-agent problem as far as the broker's selling effort is concerned. Table 3 also confirms, however, that the conflict of interest in the pricing

[14]These values are "gross," that is, they include the broker's commission. Recall that we are defining seller's values from the perspective of a broker selling her own house. This is necessary in order to focus on the principal-agent problem between the broker and the seller as opposed to the trivial conflict of interest which always exists between any buyer and seller.

dimension is pervasive under a wide range of market conditions, as evidenced by the gap between broker and seller optimal reservation prices.

SUMMARY AND CONCLUSIONS

In this paper we have used numerical methods to solve a dynamic optimization model of broker behavior and to quantify the nature of the conflict of interest between broker and seller in real estate markets. We have simultaneously considered both selling effort and property pricing, and we have incorporated the effect of the duration of finite listing contract. Several interesting findings appear in the analysis.

First, with a finite duration listing contract, the broker has an incentive to increase her effort over time as the end of the contract approaches. We call this: "rational procrastination." Second, near the end of the contract, the conflict of interest in the effort dimension is quite small (assuming a 7% selling commission). Thus, the conflict of interest regarding broker incentives to put forth effort to sell a property is severe only near the beginning of the listing and can be minimized by making use of shorter listing contracts.

The seller's second best or conditionally optimal reservation price (which reflects knowledge of the broker's selling effort) differs little if at all from the first-best reservation price, suggesting that the conflict of interest in the effort dimension is of relatively minor importance in typical situations. Furthermore, the small difference in contract value to the seller between the first-best and second-best perspectives (holding price constant) reinforces this conclusion. In practice, there are typically discrete events requiring major broker efforts at the beginning of a listing and which are relatively easy for the seller to monitor (e.g., a "broker's showing"). Thus, the conflict of interest in the effort dimension may be even less than what is implied in our model.[15] Furthermore, previous research into the economic efficiency of the brokerage industry suggests that lack of price competition combined with open entry into the brokerage

[15]The multiple listing mechanism is another real world factor omitted from our model, which serves to mitigate rational procrastination and the conflict of interest in the effort dimension, particularly near the beginning of the listing. Listing brokers are more likely to sell the house alone (without having to share the commission with another MLS broker) near the beginning of the listing, which provides an incentive for greater effort early in the listing contract.

industry may lead to excessive brokerage service provision from a social perspective (see, e.g., Yinger [10], Crockett [1], Wachter [9]). Thus, suboptimal selling effort from the private perspective may actually be closer to the socially optimal supply of selling effort. All of this suggests that the principal-agent problem between seller and broker will typically be of minor importance as far as conflict of interest regarding the broker's selling effort is concerned as long as relatively short finite duration listing contracts are employed and broker commissions are in the neighborhood of 7%.

On the other hand, our analysis reveals that there can be a serious conflict of interest regarding the reservation price. Moreover, this conflict is more severe near the *end* of the contract and is *exacerbated* by the use of short, finite duration listing contracts. While the significance of this conflict is lessened by seller self-education regarding property value, aided typically by the competition among brokers for listings prior to the seller signing a listing contract, some potential conflicts remain. Sellers may not be used to the pressure of price and deal negotiation and may be aware that their broker has superior information concerning market conditions. This would make them susceptible to influence by the broker to lower their reservation price when the first offer to buy is made. The above analysis quantifies the financial incentives for the broker to attempt to do just that.

One direction of potentially fruitful further research suggested by our analysis is to consider new and innovative compensation schemes by which brokers are paid by sellers for their services. The objective would be to find compensation terms that more closely align the interests of the broker and the seller throughout the duration of the listing contract, both in the effort and pricing dimension. The model and methodology employed in this paper could be used to pursue such research.

We would like to thank Don Haurin, Pat Hendershott and two anonymous reviewers for helpful comments.

REFERENCES

[1] J. Crockett. Competition and Efficiency in Transaction: The Case of Residential Real Estate Brokerage. *AREUEA Journal* 10: 209–27, 1982.

[2] J. Follain, T. Lutes and D. Meier. Why Do Some Real Estate Sales People Earn More Than Others. *Journal of Real Estate Research* 2(1): 73–82, Fall 1987.
[3] D. Haurin. The Duration of Marketing Time of Residential Housing. *AREUEA Journal* 16(4): 396–410, Winter 1988.
[4] P. Hendershott and D. Haurin. Adjustments in the Real Estate Market. *AREUEA Journal* 16(4): 343–53, Winter 1988.
[5] J. Larsen and W. Park. Non-Uniform Percentage Brokerage Commissions and Real Estate Market Performance. *AREUEA Journal* 17(4): 422–39, Winter 1989.
[6] T. Miceli. The Optimal Duration of Real Estate Listing Contracts. *AREUEA Journal* 17(3): 267–77, Fall 1989.
[7] National Association of REALTORS. *The Value of A Real Estate Brokerage Firm.* Real Estate Business Series, 1989 monograph.
[8] C. Read. Price Strategies for Idiosyncratic Goods. *AREUEA Journal* 16(4): 379–95, Winter 1988.
[9] S. Wachter. Residential Real Estate Brokerage: Rate Uniformity and Moral Hazard. JAI Press, *Research in Law and Economics* 10: April 1987.
[10] J. Yinger. A Search Model of Real Estate Broker Behavior. *American Economic Review* 71: 591–604, 1981.
[11] T. Zorn and J. Larsen. The Incentive Effects of Flat-Fee and Percentage Commissions for Real Estate Brokers. *AREUEA Journal* 14(1): 24–47, Spring 1986.