Brokerage Choice, Dual Agency and Housing Market Strength

Xiangou Deng*[a], Michael J. Seiler†[b], and Hua Sun‡[c]

[a]*Postdoctoral Station, Industrial and Commercial Bank of China, Beijing, 100031, China*

[b]*Department of Finance, The College of William & Mary, Williamsburg, VA, 23187, USA*

[c]*Department of Finance, Iowa State University, Ames, IA, 50011, USA*

January 3, 2019

*E-mail: xiangou.deng@icbc.com.cn

†E-mail: Michael.Seiler@mason.wm.edu

‡E-mail: hsun@iastate.edu

Abstract

This study develops a theoretical model supported by empirical evidence examining the relation between brokerage choice and market strength. Our model shows that although internal transactions (where both buyer and seller agents are either the same or work for the same firms) have the potential side benefits of higher commission rate and lower search cost, in a strong housing market, brokerage firms are more likely to engage external transactions because of the greater demand for housing. However, when the market weakens, external demand for housing decreases, and brokerage firms become more willing to conduct internal transactions. While internal transaction tends to occur at the expense of lowering the selling price, we show that it is also more likely to be chosen by brokerage firms with higher in-house searching-matching efficiency. This generates a (second order) counter-force of increasing the price. Hence our model demonstrates that the housing market has a (partial) self-correction mechanism for the principal-agent incentive misalignment problem, especially when the market strengthens. Conversely, when the market weakens, internal transactions increase and prices in the market decline, which can further weaken the market. Therefore, the equilibrium brokerage choice creates a self-reinforcing mechanism toward generating more extreme market conditions.

Keywords: incentive misalignment, real estate brokerage, dual agency, agent-intermediated search, housing market

JEL classifications:: C35, C51, L85, R31

1 Introduction

Owner-occupied housing units totaled approximately 27 trillion dollars in 2017Q1, making residential real estate one of the most important asset classes in the United States[1]. When transacting real estate, more than 80% of buyers and sellers solicit the assistance of a licensed real estate agent (Han and Hong, 2016). Miliceli, Pancak, and Sirmans (2000) explain that agents serve two primary functions. In the "searching-matching" function, they help the buyer and seller find each other. If successful, the agent then facilitates the negotiation of terms and conditions of sale through the "bargaining" stage.

Many studies have examined the role of agents in the housing market. Some focus on the distortion of agency incentives (Gruber and Owings, 1996; Garmaise and Moskowitz, 2004; Mehran and Stulz, 2007; Hendel, Nevo, and Ortalo-Magne, 2009). Others examine social inefficiencies resulting from free entry into the real estate brokerage industry (Hsieh and Moretti, 2003; Barwick and Pathak, 2015). Some use search models to explain agency behavior (Yinger, 1981; Arnold, 1999). Many focus on how brokerage firms affect the relation between selling price and time on the market (Sirmans, Turnbull and Benjamin, 1991; Yavas and Yang, 1995; Forgey, Rutherford and Springer, 1996; Huang and Palmquist, 2001; Knight, 2002; Turnbull and Dombrow, 2006 and Turnbull, Dombrow and Sirmans, 2006).

When transacting residential real estate, it can be the case that the buyer and seller are represented by agents who work at different brokerage firms (Han and Hong, 2016). Henceforth, we refer to these as external transactions. When the buyer and seller are represented by different agents who happen to work at the same firm, we refer to this relationship throughout the paper as an internal transaction. Finally, when the buyer and seller are represented by the same agent, we refer to this special

[1]See Table B.100 entitled "Balance Sheet of Households and Nonprofit Organizations" in the Federal Reserve's Flow of Funds Report, which can be found at http://www.federalreserve.gov/releases/z1/current/.

case of internal transaction as a dual agent transaction. Figure 1 displays the relationship between these transaction types. These three brokerage structures have been the source of many studies. For example, Roskelley (2008) offers explanations for transaction distortions for internal transactions based on misaligned incentives and the countervailing force of reputational capital originally investigated in Shapiro (1982, 1983) and Diamond (1989)[2]. Richard and Phillip (2005) use repeat sale methods to test for the price effect associated with internal transactions.

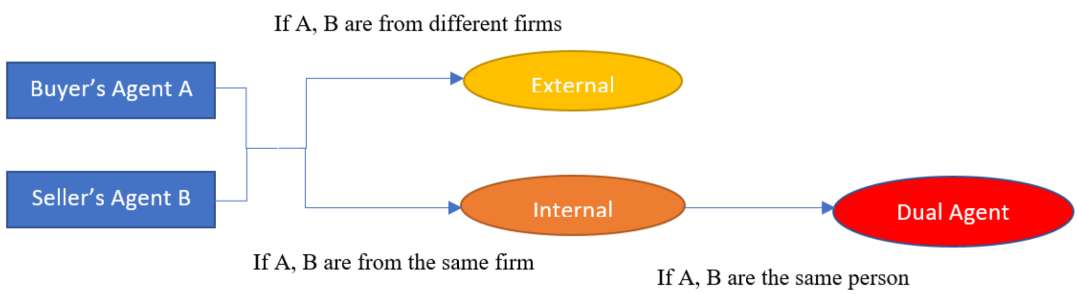

Figure 1: Three Types of Transactions Based on Brokerage Structure

Gardiner et al. (2007) examine the effect of a law change in Hawaii in 1984 requiring full disclosure of internal transactions and find that internal transactions reduced the sale price, but the effect was much smaller after the legislation (8.0 % versus 1.4 %). Moreover, they also find that internal transactions reduce time on the market by about 8.5% pre-legislation and 8.1% post-legislation. Evans and Kolbe (2005) investigate the effect of internal transactions on price appreciation for houses that are sold twice and find that internal transactions in the first sale have no impact on price appreciation. They also find very limited evidence that an internal transaction in the second sale has a negative effect on price appreciation. After controlling for

[2]Internal transactions are sometimes referred to in the literature as dual agency transactions. However, because terms have historically varied widely, confusion in the current study is avoided by only referring to the three brokerage relationships described in the Introduction.

ownership of the property, Johnson et al. (2015) conclude that internal transactions impact sales price. Moreover, these finding are differential when bifurcated by pre- and post-financial crisis periods.

Despite active literature on internal transactions and its impact on price, there are limited studies that look at the brokerage choice problem itself. While largely a qualitative discussion, Kadiyali, Prince, and Simon (2014) bring up a very important point on trade-offs when agents choose internal vs. external transactions. That is, agents face a variety of incentives and disincentives to engage in behaviors that increase the likelihood of an internal transaction. An internal transaction can be preferred because it allows for a collection of commission on both the buyer and seller side of the ledger. Moreover, an internal transaction may result in a more streamlined closing process allowing the agent to more quickly move onto the next sale. Alternatively, an external sale allows for a potentially much larger buyer pool and therefore a potentially greater selling price and shorter time on the market. In an examination of agent strategic incentives versus matching efficiency, Han and Hong (2016) conclude that agents are more inclined to engage in internal transactions when they are financially incentivized. This finding is mitigated when buyers and sellers are made more aware of agents' compensation structures.

Motivated by Kadiyali, Prince, and Simon (2014) and Han and Hong (2016), our paper examines brokerage choice from a new perspective, i.e., how will the preference for brokerage type change when market strength changes. In particular, we aim to study the following questions: (1) When do profit maximizing agents prefer to engage in external versus internal transactions? (2) Is there a linkage between brokerage choice and strength of the housing market? (3) How do internal transactions, and in particular dual agent transactions, affect sale price?

To study these questions, we first build a theoretic model which shows that, while internal transactions have the potential side benefits of higher commission and lower search costs, when the market gets stronger, firms are more likely to engage in external transactions because the pool of internal buyers and sellers becomes much smaller relative to the external market. However, when the market weakens, external demand for housing decreases, and brokerage firms become more willing to conduct internal transactions. These internal transaction tends to occur at the expense of lowering the selling price, which speaks to a principal-agent incentive misalignment problem. Nevertheless, we show that an internal transaction is more likely to be chosen by brokerage firms with higher in-house searching-matching efficiency. This generates a (second order) counter-force of increasing the price. Conversely, when the market weakens, internal transactions increase and prices in the market decline, which can further weaken the market. Hence, the equilibrium brokerage choice creates a self-reinforcing mechanism toward generating more extreme market conditions. To empirically test these relations, we use a detailed set of Multiple Listing Service (MLS) records of single-family transactions in Hampton Roads over the period 1993(Q1) to 2013(Q1), and find that our theoretical results are supported.

The key findings in our paper indicate two important results. First, a potential self-correction mechanism for the principal-agent problem may exist within the housing market, due to two underlying forces. Firstly, as the market strengthens, external buying orders become more attractive to agents, leading them to engage in more external transactions. Note that the principal-agent problem we study here mainly arises from internal transactions. This problem will be reduced by market strength because when the market strengthens, there are fewer internal transactions. Secondly, as internal transactions are more likely to be chosen by brokerage firms with higher internal operating efficiency, it helps to partially offset the lower price induced by internal transaction.

Continuing, as selling prices in internal transactions are lower on average, when the market weakens, internal transactions increase. The increase in internal transactions further reduces market price which drives sellers out and further reduces the strength of the market. In this way, the strength of the housing market can reinforce itself through agents' choosing a specific transaction type (internal or external). Hence, the equilibrium brokerage choice creates a self-reinforcing mechanism toward generating more extreme housing market conditions.

The remainder of the paper is organized as follows. A theoretic model is presented in section two, while Section three describes the data. Empirical findings are discussed in section four, and conclusions are offered in section five.

2 The Model

Our model is mainly inspired by Yinger (1981), Goetzmann and Peng (2006), Hagiu and Jullien (2011), and Han and Hong (2016). In the model, following Goetzmann and Peng (2006), we assume that the selling agents have full power in deciding whether to sell the house (i.e., with full delegation).

The search process for buying orders is assumed to follow a Poisson process at rate λ_a^i (search rate), where the search rate is decided by firm i and the order type a($a = in$ for internal orders and $a = ex$ for external orders) . This assumption is consistent with the findings of Bond et al. (2007) in which UK data are used to investigate a number of assumptions associated with the distribution of time on the market. We assume λ_a^i is determined by

$$\lambda_a^i = k_a^i N_a$$

where N_{ex} ($a = ex$ for N_a) is the total number of purchase offers that can be potentially searched by an agent externally; N_{in} ($a = in$ for N_a) is the total number of purchase offers that can be searched by an agent in internal lists. k_{in}^i, k_{ex}^i are parameters that depend on firm i. For example, more competent agents/brokerage firms can search faster for buying orders. We assume $N_{in} < N_{ex}$, which means that external transactions have larger searching pools. Note that while we distinguish the external and internal pools here, in our model the agent will find offers across the entire market. We assume the arrival of internal and external buying orders is independent, so the total process is a combined Poisson process.

$$\lambda^i = \lambda^i_{in} + \lambda^i_{ex} = k^i_{in} N_{in} + k^i_{ex} N_{ex}$$

In addition, we assume k^i_{in}, k^i_{ex} are positive for firm i, which measure a firm's searching ability in internal and external markets. Since k^i_{in}, k^i_{ex} are positive, a larger searching pool will lead to a higher corresponding search rate λ^i_a. While not explored in our model, readers can certainly imagine a case in which k^i_{in}, k^i_{ex} are increasing with firm i's size since when a firm is bigger, it can have more agents and more information for market buying orders.

Denote t_j as the waiting time between the arrival of the $(j-1)$-th and the j-th buyer, then the random arrival time of the n-th buyer satisfies

$$T^n = \sum_{j=1}^{n} t_j$$

After waiting for T^n time, the selling agent has received n bids. The selling agent can choose n to set the time he will wait in the market. Denote bid prices as $P_1, P_2, ..., P_n$. Similar to Cheng, Lin, and Liu (2008), we assume recall is allowed, thus the highest available bidder among the n offer prices is defined as

$$P^n = \max\{P_1, P_2, ..., P_n\}$$

We assume offers are uniformly distributed over the interval $\left[\underline{P}, \bar{P}\right]$. The accepted sale price is X^n, which is the price of the accepted buying order after receiving n offers. Along the search process, internal and external buying orders will arrive in the combined Poisson process as outlined above. Let b_a be the commission share for an agent who chooses order type a (recall that a can be either in for an internal transaction or ex for an external transaction), and $b_{in} > b_{ex}$. An agent's commission hence is $b_a X^n$.

Assuming the agent is risk neutral, the selling agent's utility depends on his expected payoff and can be represented as

$$U(n, X^n) \triangleq E[b_a X^n - C(n)]$$

where $C(n)$ is the cost function associated with n searches for buying orders. Since the arrival process is assumed to be a combined Poisson Process, we have

$$E(T^n) = \frac{n}{\lambda_{in}^i + \lambda_{ex}^i} \tag{1}$$

where T^n is the time spent for n searches. The expected cost associated with n searches for buying orders is

$$E(C(n)) = c_T \frac{n}{\lambda_{in}^i + \lambda_{ex}^i}$$

where c_T is the per unit time cost for n searches. So the problem becomes

$$\begin{aligned} &\underset{n,X^n}{\text{Max}} \qquad E[b_a X^n] - (c_T \frac{n}{\lambda_{in}^i + \lambda_{ex}^i}) \\ &\text{subject to} \quad X^n \leq P^n \end{aligned}$$

In this model, agents will choose the search times n. Then, during the n searches, if the commission for the external buying order of the highest price is higher than the commission for the internal buying orders of the highest price, agents will choose an external order; if the commission for the external buying order of the highest price is lower than the commission for the internal buying orders of the highest price, agents will choose an internal order; if the commission for the external buying order of the highest price is the same as the commission for the external buying order of the highest price, agents will randomize their choice. Figure 2 depicts the tradeoff of the agent between internal and external transaction choices.

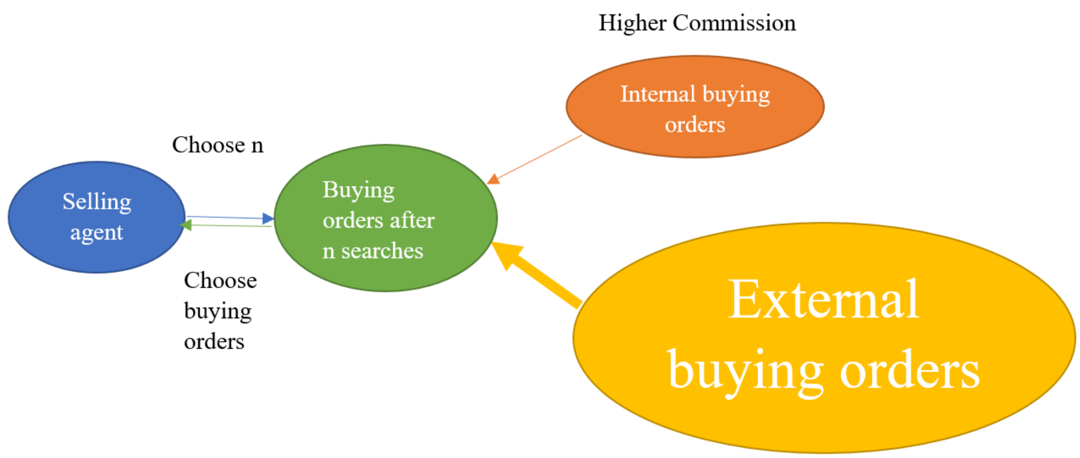

Figure 2: Tradeoff Between the Internal and External Transactions

We adopt a two-step strategy to solve the model. First, assume n has been decided and use n to find the optimal X^n. Then, substitute X^n into the original problem and find the optimal n.

In the first step, assuming n is given, the problem is

$$\underset{X^n}{\text{Max}} \qquad E[b_a X^n] - (c_T \frac{n}{\lambda_{in}^i + \lambda_{ex}^i})$$
$$\text{subject to} \quad X^n \leq P^n$$

It is easy to see that $E(C(n)) \equiv c_T \frac{n}{\lambda_{in}^i + \lambda_{ex}^i}$ is a constant given n. Let p_{in}^n be the probability of accepting an internal buying order after n searches, and let p_{ex}^n be the probability of accepting an external buying order after n searches. Thus, in this model, we have $p_{in}^n + p_{ex}^n = 1$. Denote X_{in}^n as the price of an accepted internal buying order, and denote X_{ex}^n as the price of an accepted external buying order. In addition, let n_a be the number of type a buying orders after n searches and denote P_a^n as the highest price among the searched type a orders. That is to say, after n searches, there will be n_{ex} buying orders from the external pool, and the highest price among them is P_{ex}^n; there will be n_{in} buying orders from the internal pool, and the highest price among them is P_{in}^n. By definition, we have $n_{in} + n_{ex} = n$. The problem then can be simplified as:

$$
\begin{aligned}
\underset{X_{ex}^n, X_{in}^n, p_{in}^n}{\text{Max}} \quad & p_{in}^n b_{in} X_{in}^n + (1 - p_{in}^n) b_{ex} X_{ex}^n - E(C(n)) \\
\text{subject to} \quad & X_{ex}^n \leq P_{ex}^n, X_{in}^n \leq P_{in}^n, 0 \leq p_{in}^n \leq 1
\end{aligned}
$$

Since p_{in}^n, b_{in}, and b_{ex} are all non-negative, it is easy to see that to maximize the expected utility, we have

$$X_{ex}^n = P_{ex}^n, X_{in}^n = P_{in}^n$$

So the problem can be further simplified as

$$
\begin{aligned}
\underset{p_{in}^n}{\text{Max}} \quad & b_{ex} P_{ex}^n + p_{in}^n (b_{in} P_{in}^n - b_{ex} P_{ex}^n) - E(C(n)) \\
\text{subject to} \quad & 0 \leq p_{in}^n \leq 1
\end{aligned}
$$

Then we can see that if $b_{in} P_{in}^n < b_{ex} P_{ex}^n$, the agent will accept an external buying order, the price of the accepted buying order X^n will be P_{ex}^n; if $b_{in} P_{in}^n > b_{ex} P_{ex}^n$, the agent will accept the internal buying order, and X^n will be P_{in}^n; if $b_{in} P_{in}^n = b_{ex} P_{ex}^n$, the agent will be indifferent, and X^n will be either P_{in}^n or P_{ex}^n. In addition, we assume $b_{in}/b_{ex} < \bar{P} \big/ \underline{P}$, i.e., the commission share gap between an internal and an external transaction should be in a reasonable range, otherwise agents will always choose the internal transaction, which is not consistent with reality.

With this result, the unconditional probability that agents choose internal buying orders becomes

$$
\begin{aligned}
p_{in} &= Pr(b_{ex} P_{ex}^n \leq b_{in} P_{in}^n) \\
&= \frac{\lambda_{in}^i}{\lambda_{in}^i + \frac{\frac{\bar{P} b_{ex}}{b_{in}} - \underline{P}}{\bar{P} - \underline{P}} \lambda_{ex}^i}
\end{aligned} \tag{2}
$$

And the unconditional probability that agents choose external buying orders is

$$
\begin{aligned}
p_{ex} &= Pr(b_{ex} P_{ex}^n \geq b_{in} P_{in}^n) \\
&= \frac{\frac{\frac{\bar{P} b_{ex}}{b_{in}} - \underline{P}}{\bar{P} - \underline{P}} \lambda_{ex}^i}{\lambda_{in}^i + \frac{\frac{\bar{P} b_{ex}}{b_{in}} - \underline{P}}{\bar{P} - \underline{P}} \lambda_{ex}^i}
\end{aligned} \tag{3}
$$

To simplify the notation, let

$$\beta \equiv \frac{b_{in}}{b_{ex}}$$

$$\rho \equiv \frac{\frac{\bar{P}}{\beta} - \underline{P}}{\bar{P} - \underline{P}}$$

Thus, substituting the expression of λ_a^i, we have

$$\begin{aligned} p_{in} =& Pr(b_{ex}P_{ex}^n \leq b_{in}P_{in}^n) \\ =& \frac{k_{in}^i N_{in}}{k_{in}^i N_{in} + \rho k_{ex}^i N_{ex}} \end{aligned} \tag{4}$$

$$\begin{aligned} p_{ex} =& Pr(b_{ex}P_{ex}^n \geq b_{in}P_{in}^n) \\ =& \frac{\rho k_{ex}^i N_{ex}}{k_{in}^i N_{in} + \rho k_{ex}^i N_{ex}} \end{aligned} \tag{5}$$

After solving for X_n, in the second step, we substitute it into the original problem and solve for n. In this way, the original problem becomes

$$\begin{aligned} \underset{n}{\text{Max}} \quad & p_{in} b_{in} E(P_{in}^n | b_{ex}P_{ex}^n \leq b_{in}P_{in}^n) \\ & + p_{ex} b_{ex} E(P_{ex}^n | b_{ex}P_{ex}^n \geq b_{in}P_{in}^n) - E(C(n)) \end{aligned}$$

Since we have

$$E(P_{in}^n | b_{ex}P_{ex}^n \leqslant b_{in}P_{in}^n) = \frac{n\frac{\lambda_{in}^i + \rho\lambda_{ex}^i}{\lambda_{in}^i + \lambda_{ex}^i}\bar{P} + \underline{P}}{n\frac{\lambda_{in}^i + \rho\lambda_{ex}^i}{\lambda_{in}^i + \lambda_{ex}^i} + 1} \tag{6}$$

$$E(P_{ex}^n | b_{ex}P_{ex}^n \geqslant b_{in}P_{in}^n) = \frac{n\frac{1}{\rho}\frac{\lambda_{in}^i + \rho\lambda_{ex}^i}{\lambda_{in}^i + \lambda_{ex}^i}\bar{P} + \underline{P}}{n\frac{1}{\rho}\frac{\lambda_{in}^i + \rho\lambda_{ex}^i}{\lambda_{in}^i + \lambda_{ex}^i} + 1} \tag{7}$$

to simplify the notation, denote

$$\Gamma \equiv \frac{\lambda_{in}^i + \rho\lambda_{ex}^i}{\lambda_{in}^i + \lambda_{ex}^i}$$

then we can rearrange equations (6) & (7) as

$$E(P_{in}^n | b_{ex}P_{ex}^n \leqslant b_{in}P_{in}^n) = \frac{n\Gamma\bar{P} + \underline{P}}{n\Gamma + 1}$$

and

$$E(P_{ex}^n | b_{ex} P_{ex}^n \geqslant b_{in} P_{in}^n) = \frac{n\Gamma\bar{P} + \rho\underline{P}}{n\Gamma + \rho}$$

Next substituting the above results, the maximization problem becomes

$$\begin{aligned}\operatorname*{Max}_{n} \quad & b_{in}\frac{\lambda_{in}^i}{\lambda_{in}^i + \rho\lambda_{ex}^i}\frac{n\Gamma\bar{P} + \underline{P}}{n\Gamma + 1} + b_{ex}\frac{\rho\lambda_{ex}^i}{\lambda_{in}^i + \rho\lambda_{ex}^i}\frac{n\Gamma\bar{P} + \rho\underline{P}}{n\Gamma + \rho} - \\ & (c_T\frac{n}{\lambda_{in}^i + \lambda_{ex}^i})\end{aligned}$$

Taking the derivative with respect to n, we have the First Order Condition (F.O.C) as

$$b_{in}\frac{\lambda_{in}^i}{\lambda_{in}^i + \lambda_{ex}^i}\frac{\bar{P} - \underline{P}}{(n\Gamma + 1)^2} + b_{ex}\frac{\lambda_{ex}^i}{\lambda_{in}^i + \lambda_{ex}^i}\frac{\bar{P} - \underline{P}}{(n\frac{\Gamma}{\rho} + 1)^2} = (c_T)\frac{1}{\lambda_{in}^i + \lambda_{ex}^i} \tag{8}$$

which can be further simplified as

$$(\bar{P} - \underline{P})(b_{in}\lambda_{in}^i\frac{1}{(n\Gamma + 1)^2} + b_{ex}\lambda_{ex}^i\frac{1}{(n\frac{\Gamma}{\rho} + 1)^2}) = c_T \tag{9}$$

This F.O.C equation enables us to conduct a series of comparative static analyses. From equation (9), denote $G_{foc}(\lambda_{ex}^i, n^*\Gamma)$ as follows

$$G_{foc}(\lambda_{ex}^i, n^*\Gamma) \equiv (\bar{P} - \underline{P})(b_{in}\lambda_{in}^i\frac{1}{(n^*\Gamma + 1)^2} + b_{ex}\lambda_{ex}^i\frac{1}{(n^*\frac{\Gamma}{\rho} + 1)^2}) - c_T = 0$$

where n^* is the optimal n that satisfies the F.O.C.

Taking the derivative of $G_{foc}(\lambda_{ex}^i, n^*\Gamma)$ with respect to λ_{ex}^i yields

$$\frac{\partial G_{foc}(\lambda_{ex}^i, n^*\Gamma)}{\partial\lambda_{ex}^i} + \frac{\partial G_{foc}(\lambda_{ex}^i, n^*\Gamma)}{\partial(n^*\Gamma)}\frac{\partial(n^*\Gamma)}{\partial\lambda_{ex}^i} = 0$$

Notice that

$$\frac{\partial G_{foc}(\lambda_{ex}^i, n^*\Gamma)}{\partial\lambda_{ex}^i} > 0$$

$$\frac{\partial G_{foc}(\lambda_{ex}^i, n^*\Gamma)}{\partial(n^*\Gamma)} < 0$$

Thus, we have

$$\frac{\partial(n^*\Gamma)}{\partial\lambda_{ex}^i} = -\frac{\partial G_{foc}(\lambda_{ex}^i, n^*\Gamma)}{\partial\lambda_{ex}^i}\Bigg/\frac{\partial G_{foc}(\lambda_{ex}^i, n^*\Gamma)}{\partial(n^*\Gamma)} > 0$$

Recall that

$$E(P_{in}^n | b_{ex}P_{ex}^n \leqslant b_{in}P_{in}^n) = \frac{n\Gamma\bar{P} + \underline{P}}{n\Gamma + 1}$$

then taking the derivative of $E(P_{in}^n | b_{ex}P_{ex}^n \leqslant b_{in}P_{in}^n)$ with respect to λ_{ex}^i, we have

$$\begin{aligned}
\frac{\partial E(P_{in}^n | b_{ex}P_{ex}^n \leqslant b_{in}P_{in}^n)}{\partial \lambda_{ex}^i} &= \frac{\partial (E(P_{in}^n | b_{ex}P_{ex}^n \leqslant b_{in}P_{in}^n)}{\partial (n\Gamma)} \frac{\partial (n\Gamma)}{\partial \lambda_{ex}^i} \\
&= \frac{\bar{P} - \underline{P}}{(n\Gamma + 1)^2} \frac{\partial (n\Gamma)}{\partial \lambda_{ex}^i} > 0
\end{aligned}$$

Similarly, we can show that

$$\frac{\partial E(P_{in}^n | b_{ex}P_{ex}^n \leqslant b_{in}P_{in}^n)}{\partial \lambda_{in}^i} > 0$$

Also we have

$$E(P_{ex}^n | b_{ex}P_{ex}^n \geqslant b_{in}P_{in}^n) = \frac{n\Gamma\bar{P} + \rho\underline{P}}{n\Gamma + \rho}$$

then taking the derivative of $E(P_{ex}^n | b_{ex}P_{ex}^n \geqslant b_{in}P_{in}^n)$ with respect to λ_{ex}^i yields

$$\begin{aligned}
\frac{\partial E(P_{ex}^n | b_{ex}P_{ex}^n \geqslant b_{in}P_{in}^n)}{\partial \lambda_{ex}^i} &= \frac{\partial E(P_{ex}^n | b_{ex}P_{ex}^n \geqslant b_{in}P_{in}^n)}{\partial (n\Gamma)} \frac{\partial (n\Gamma)}{\partial \lambda_{ex}^i} \\
&= \frac{\rho \left(\bar{P} - \underline{P}\right)}{(n\Gamma + \rho)^2} \frac{\partial (n\Gamma)}{\partial \lambda_{ex}^i} > 0
\end{aligned}$$

Similarly, we have

$$\frac{\partial E(P_{ex}^n | b_{ex}P_{ex}^n \geqslant b_{in}P_{in}^n)}{\partial \lambda_{in}^i} > 0$$

Therefore, as N_{ex} increases, $\lambda_{ex}^i = k_{ex}^i N_{ex}$ will increase and lead to an increase in the expected sale price for both internal and external transactions. Also, as N_{in} increases, $\lambda_{in}^i = k_{in}^i N_{in}$ will increase and lead to an increase in the expected sale price for both internal and external transactions.

Rewrite equation (9), and denote $G_{foc}^T(\lambda_{ex}^i, E(T^{n^*}))$ as

$$\begin{aligned}
G_{foc}^T(\lambda_{ex}^i, E(T_{n^*})) \equiv (\bar{P} - \underline{P}) b_{in} \lambda_{in}^i & \frac{1}{((\lambda_{in}^i + \rho\lambda_{ex}^i)E(T_{n^*}) + 1)^2} \\
+ (\bar{P} - \underline{P}) b_{ex} \lambda_{ex}^i & \frac{1}{((\lambda_{in}^i + \rho\lambda_{ex}^i)E(T_{n^*})\frac{1}{\rho} + 1)^2} - c_T = 0
\end{aligned}$$

where $E(T_{n^*}) = \frac{n^*}{\lambda_{in}^i + \lambda_{ex}^i}$ is the expected transaction time.

Taking the derivative of $G_{foc}^T(\lambda_{ex}^i, E(T^{n^*}))$ with respect to λ_{ex}^i, yields

$$\frac{\partial G_{foc}^T(\lambda_{ex}^i, E(T^{n^*}))}{\partial \lambda_{ex}^i} + \frac{\partial G_{foc}^T(\lambda_{ex}^i, E(T^{n^*}))}{\partial (E(T^{n^*}))} \frac{\partial (E(T^{n^*}))}{\partial \lambda_{ex}^i} = 0$$

Notice that

$$\frac{\partial G_{foc}^T(\lambda_{ex}^i, E(T^{n^*}))}{\partial \lambda_{ex}^i} < 0$$

$$\frac{\partial G_{foc}^T(\lambda_{ex}^i, E(T^{n^*}))}{\partial (E(T^{n^*}))} < 0$$

Thus, we have

$$\frac{\partial (E(T^{n^*}))}{\partial \lambda_{ex}^i} = -\frac{\partial G_{foc}^T(\lambda_{ex}^i, E(T^{n^*}))}{\partial \lambda_{ex}^i} \Bigg/ \frac{\partial G_{foc}^T(\lambda_{ex}^i, E(T^{n^*}))}{\partial (E(T^{n^*}))} < 0$$

Similarly, we can show that

$$\frac{\partial (E(T^{n^*}))}{\partial \lambda_{in}^i} < 0$$

Therefore, as $\partial P^*/\partial N_\alpha > 0$ and $\frac{\partial (E(T^{n^*}))}{\partial \lambda_\alpha^i} < 0$, we know that, in a stronger housing market, the expected sale prices for both internal and external transactions will be higher and the expected transaction time will be shorter.

As the housing market strengthens, there are more external and internal buying orders, i.e. both N_{ex} and N_{in} increase. Since we also expect more new entries of brokerage firms in a strong market, external buying orders should increase at a higher rate than internal buying orders, thus $\frac{N_{ex}}{N_{in}}$ also increases. The comparative static results derived above, coupled with the assumptions that $\frac{N_{ex}}{N_{in}}$ increases when the market strengthens, allow us to draw a set of clear predictions about the housing market. We summarize them in the following propositions.

Proposition 1 *When the market strengthens, i.e., as N_{ex}, N_{in}, $\frac{N_{ex}}{N_{in}}$ increase, the probability of a transaction being internal will decrease, and the probability of a transaction being external will increase.*

This relationship is depicted in Figure 3.

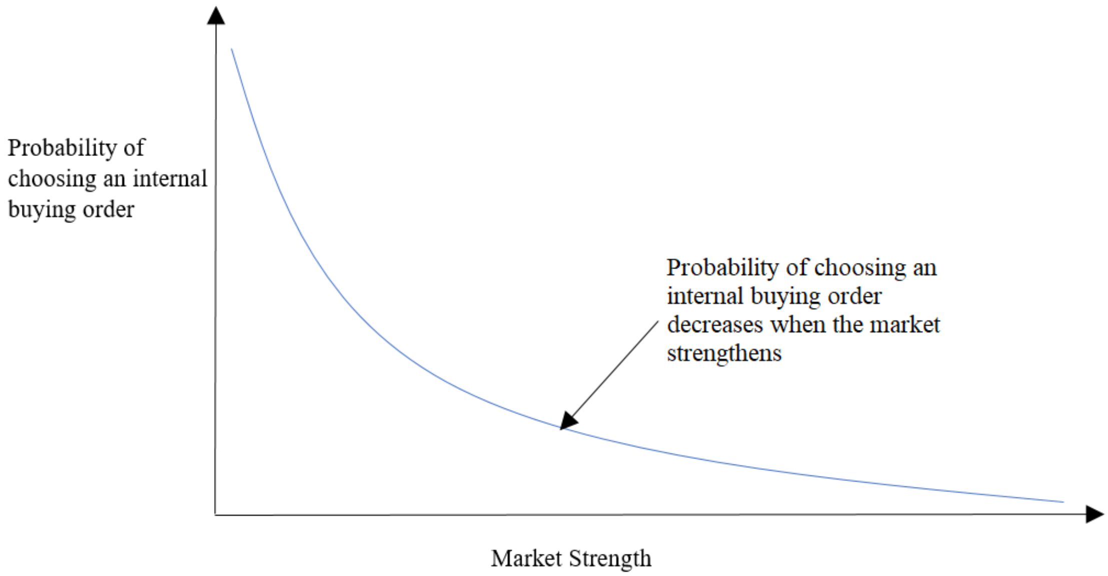

Figure 3: The Relation Between Market Strength and Transaction Type

Proof. Recall that from equations (4) & (5), we have

$$p_{in} = Pr(b_{ex}P_{ex}^n \leqslant b_{in}P_{in}^n) = \frac{k_{in}^i N_{in}}{k_{in}^i N_{in} + \rho k_{ex}^i N_{ex}} = \frac{k_{in}^i}{k_{in}^i + \rho k_{ex}^i \frac{N_{ex}}{N_{in}}}$$

and

$$p_{ex} = Pr(b_{ex}P_{ex}^n \geqslant b_{in}P_{in}^n) = \frac{\rho k_{ex}^i N_{ex}}{k_{in}^i N_{in} + \rho k_{ex}^i N_{ex}} = \frac{\rho \frac{N_{ex}}{N_{in}} k_{ex}^i}{k_{in}^i + \rho \frac{N_{ex}}{N_{in}} k_{ex}^i}$$

It is easy to see that

$$\frac{\partial p_{in}}{\partial \frac{N_{ex}}{N_{in}}} < 0$$

and

$$\frac{\partial p_{ex}}{\partial \frac{N_{ex}}{N_{in}}} > 0$$

Thus, when the market strengthens, i.e., when N_{ex}, N_{in}, $\frac{N_{ex}}{N_{in}}$ increase, the (unconditional) probability of an agent choosing internal buying orders, p_{in}, will decrease, and the (unconditional) probability of choosing external buying orders, p_{ex}, will increase. ■

Proposition 2 *When the search rate ratio between internal and external transactions becomes larger, i.e., when $\lambda^i_{in}/\lambda^i_{ex}$ increases, the probability of a transaction being internal increases.*

Proof. From equation (2), we have

$$P_{in} = \frac{\frac{\lambda^i_{in}}{\lambda^i_{ex}}}{\frac{\lambda^i_{in}}{\lambda^i_{ex}} + \frac{\frac{\bar{P}b_{ex}}{b_{in}} - \underline{P}}{\bar{P} - \underline{P}}} \tag{10}$$

It is easy to see that P_{in} is increasing in $\frac{\lambda^i_{in}}{\lambda^i_{ex}}$.

Rewrite equation (9), and denote $G^{\lambda}_{foc}(\frac{\lambda^i_{in}}{\lambda^i_{ex}}, n^*\Gamma)$ as

$$\begin{aligned} G^{\lambda}_{foc}(\frac{\lambda^i_{in}}{\lambda^i_{ex}}, n^*\Gamma) \equiv & (\bar{P} - \underline{P})b_{in}\frac{\lambda^i_{in}}{\lambda^i_{ex}}\frac{1}{(n^*\Gamma + 1)^2} \\ & + (\bar{P} - \underline{P})b_{ex}\frac{1}{(n^*\frac{\Gamma}{\rho} + 1)^2} - \frac{1}{\lambda^i_{ex}}c_T = 0 \end{aligned}$$

Then, taking the derivative of $G^{\lambda}_{foc}(\frac{\lambda^i_{in}}{\lambda^i_{ex}}, n^*\Gamma)$ with respect to $\frac{\lambda^i_{in}}{\lambda^i_{ex}}$, becomes

$$\frac{\partial G^{\lambda}_{foc}(\frac{\lambda^i_{in}}{\lambda^i_{ex}}, n^*\Gamma)}{\partial \frac{\lambda^i_{in}}{\lambda^i_{ex}}} + \frac{\partial G^{\lambda}_{foc}(\frac{\lambda^i_{in}}{\lambda^i_{ex}}, n^*\Gamma)}{\partial (n^*\Gamma)}\frac{\partial (n^*\Gamma)}{\partial \frac{\lambda^i_{in}}{\lambda^i_{ex}}} = 0$$

Notice that

$$\frac{\partial G^{\lambda}_{foc}(\frac{\lambda^i_{in}}{\lambda^i_{ex}}, n^*\Gamma)}{\partial \frac{\lambda^i_{in}}{\lambda^i_{ex}}} > 0$$

$$\frac{\partial G^{\lambda}_{foc}(\frac{\lambda^i_{in}}{\lambda^i_{ex}}, n^*\Gamma)}{\partial (n^*\Gamma)} < 0$$

Thus, we have

$$\frac{\partial (n^*\Gamma)}{\partial \frac{\lambda^i_{in}}{\lambda^i_{ex}}} = -\frac{\partial G^{\lambda}_{foc}(\frac{\lambda^i_{in}}{\lambda^i_{ex}}, n^*\Gamma)}{\partial \frac{\lambda^i_{in}}{\lambda^i_{ex}}} \Bigg/ \frac{\partial G^{\lambda}_{foc}(\frac{\lambda^i_{in}}{\lambda^i_{ex}}, n^*\Gamma)}{\partial (n^*\Gamma)} > 0$$

■

Proposition 3 *The expected sale price of an internal transaction will be less than the expected sale price of an external transaction.*

Proof. Recall that from equations (6) & (7), we have

$$E(P_{in}^n | b_{ex} P_{ex}^n \leqslant b_{in} P_{in}^n) = \frac{n\Gamma \bar{P} + \underline{P}}{n\Gamma + 1}$$

and

$$E(P_{ex}^n | b_{ex} P_{ex}^n \geqslant b_{in} P_{in}^n) = \frac{n\Gamma \bar{P} + \rho \underline{P}}{n\Gamma + \rho}$$

where

$$\Gamma \equiv \frac{\lambda_{in}^i + \rho \lambda_{ex}^i}{\lambda_{in}^i + \lambda_{ex}^i}$$

Subtracting the two equations, we have

$$\begin{aligned} E(P_{ex}^n) - E(P_{in}^n) &= \frac{n\Gamma \bar{P} + \rho \underline{P}}{n\Gamma + \rho} - \frac{n\Gamma \bar{P} + \underline{P}}{n\Gamma + 1} \\ &= n\Gamma \frac{\left(\bar{P} - \underline{P}\right)(1-\rho)}{(n\Gamma + \rho)(n\Gamma + 1)} \end{aligned}$$

Notice that

$$\rho \equiv \frac{\frac{\bar{P}}{\beta} - \underline{P}}{\bar{P} - \underline{P}}$$

where

$$\beta \equiv \frac{b_{in}}{b_{ex}} > 1$$

Thus, we have

$$\rho \equiv \frac{\frac{\bar{P}}{\beta} - \underline{P}}{\bar{P} - \underline{P}} < \frac{\bar{P} - \underline{P}}{\bar{P} - \underline{P}} = 1$$

which yields

$$E(P_{ex}^n) - E(P_{in}^n) = n\Gamma \frac{\left(\bar{P} - \underline{P}\right)(1-\rho)}{(n\Gamma + \rho)(n\Gamma + 1)} > 0$$

Therefore, the expected sale price of an internal transaction will be less than the expected sale price of an external transaction. ■

Proposition 4 *When the search rate ratio between internal and external buying orders becomes larger, i.e., when $\lambda_{in}^i / \lambda_{ex}^i$ increases, the expected sale price for both internal and external transactions will increase.*

Proof. From equations (6) & (7), we have

$$E(P_{in}^n | b_{ex} P_{ex}^n \leqslant b_{in} P_{in}^n) = \frac{n\Gamma \bar{P} + \underline{P}}{n\Gamma + 1}$$

and

$$E(P_{ex}^n | b_{ex} P_{ex}^n \geqslant b_{in} P_{in}^n) = \frac{n\Gamma \bar{P} + \rho \underline{P}}{n\Gamma + \rho}$$

From previous results, we have

$$\frac{\partial(E(P_{in}^n | b_{ex} P_{ex}^n \leq b_{in} P_{in}^n)}{\partial(n^* \Gamma)} > 0$$

$$\frac{\partial(E(P_{ex}^n | b_{ex} P_{ex}^n \geq b_{in} P_{in}^n)}{\partial(n^* \Gamma)} > 0$$

Recall that

$$\Gamma \equiv \frac{\lambda_{in}^i + \rho \lambda_{ex}^i}{\lambda_{in}^i + \lambda_{ex}^i}$$

which is increasing in $\lambda_{in}^i / \lambda_{ex}^i$

Hence, when $\lambda_{in}^i / \lambda_{ex}^i$ increases, i.e., when the firm's search rate ratio between internal and external buying orders increases, the expected sale price for both internal and external transactions will increase. ■

The Propositions 1 to 4 shed much insight on the relation between brokerage form and housing market conditions.

First, in a stronger housing market, the tendency for agents to engage in internal transactions declines (Proposition 1). In addition, as shown in Proposition 2, holding other factors constant, the brokerage firms that have superior internal searching/matching ability (i.e., a bigger $\frac{\lambda_{in}^i}{\lambda_{ex}^i}$) are more likely to engage in internal transactions. Hence, while an internal transaction tends to occur at the expense of lowering the selling price and hence is against the interest of the house seller (Proposition 3), our results imply that a potential self-correction mechanism for the principal-agent problem may exist within the housing market, due to two underlying forces. As the market improves agents become increasingly more attracted to external transactions, which dampens the principal-agent problem since the principal-agent problem is more closely associated with internal transactions. On the other hand, firms with higher internal operating efficiency are more likely to choose internal transactions, which in turn generates a counterforce to a higher price (Proposition 4). A stronger market helps to partially offset the lower price that results from a preponderance of internal transactions.

Second, Proposition 3 demonstrates that internal transactions are associated with lower prices. And when the market weakens, firms favor internal transactions. The converse is true as well. These two forces work in conjunction to further reduce home prices, and in this sense, housing market strength reinforces itself resulting in more extreme housing market conditions.

The above results are summarized in Table 1. In the Empirical Results section, we will test these predictions with empirical data.

Table 1: Summary of the Theoretical Results

Transaction type	Sign
$\partial P^*/\partial N_{ex}$, $\partial P^*/\partial N_{in}$	> 0
$\partial T^*/\partial N_{ex}$, $\partial T^*/\partial N_{in}$	< 0
$\partial p_{in}/\partial \frac{N_{ex}}{N_{in}}$,$\partial p_{ex}/\partial \frac{\lambda^i_{in}}{\lambda^i_{ex}}$	< 0
$\partial p_{ex}/\partial \frac{N_{ex}}{N_{in}}$, $\partial p_{in}/\partial \frac{\lambda^i_{in}}{\lambda^i_{ex}}$	> 0
$\partial P^*/\partial \frac{\lambda^i_{in}}{\lambda^i_{ex}}$	> 0

3 Data

Our housing transaction data are based upon the complete record of single-family transactions in Hampton Roads over the period 1993(Q1)-2013(Q1), as provided by Real Estate Information Network (REIN). Due to the strength of the data, which includes 375,800 detailed records of housing characteristics including physical structure and neighborhood information, we are able to obtain a more accurate estimate of models for internal transactions, expected market price, and time on the market. Table 2 defines the key variables examined in our model, while Table 3 introduces the housing characteristic control variables used in our regression.

One major difficulty when examining the price impact due to the impact of brokerage is unobserved housing quality (Shui 2015). To mitigate this problem, we first drop observations that have more than one sale within a year to omit potential housing flippers that might cause changes in house quality. Based on this screen, we jettisoned 73,617 data points, leaving 302,183 observations. Moreover, we take a 99% winsorization of the key variables: sales prices, original list price, price ratio, trade time and internal/external ratio. We then adopt a two-stage process similar to Genesove and Mayer (2001). In stage 1, we first run a full sample hedonic regression with all observable characteristics. We then focus only on repeat sales data and use the residual from the prior transaction of the same unit as a proxy for the unobserved housing quality, and conduct our main analysis in this stage. This treatment leaves 82,197 observations in the second stage analysis.

Table 4 provides summary statistics for our key variables based on the processed data to be used in the first stage of the hedonic regression. The Dual Agent variable describes whether the transaction is conducted by the same person who works for both sides. From the summary result, we can see that dual agent transactions accounts for 15.61% of all housing market transactions. Similarly, the Internal Transaction variable describes whether the transaction is conducted by the same firm. From the summary result, we can see that internal transactions account for 23.57% of all transactions.

Table 2: **Definition of Variables: Key Variables**

Key Variables	Description
Internal Transaction	Equals 1 if the buyer and seller agents work for the same firm; 0 otherwise.
Dual Agent	Equals 1 if the buyer and seller agent is the same person; 0 otherwise.
$MarketPrice/ListRatio_{t-1}$	Abbreviated as Price Ratio, the average ratio of sale price to original price during the month immediately preceding the transaction within the same zip code.
Trade Time	The average transaction time during the month before the transaction within the same zip code (in years).
Internal/external Ratio	Ratio of the number of internal transactions to the numbers of external transactions conducted by the brokerage firm within a year of the closed date. This variable serves as a proxy related to the ratio of arrival rates for internal transactions to the rates of external transactions.
Sale price	Selling price of the property (value is in natural log: Log(Sale Price)).
Original Price	Original list price of the property (value is in natural log form: Log(list Price)).

Table 3: Definition of Variables: House Characteristics

House Characteristic Variable	Description
#Bathrooms	Number of Bathrooms
#Bedrooms	Number of Bedrooms
#Fireplaces	Number of Fireplaces
#Rooms	Number of Rooms
Square Footage	Size of the house (000s)
#Stories	Number of Stories
Year Built	Years since the home was built (in 10 years)
Tax Amount	Taxes required per year ($ 000s)
#Floors	Number of floors in the home
POAFEE	Extra fees paid to the community to maintain the common elements
Parking	An index ranging from 1 to 4, with 4 being the most desirable parking offered
WaterviewDummy	Equals 1 if home has a water view; 0 otherwise.
CityviewDummy	Equals 1 if home has a city view; 0 otherwise.
WoodsviewDummy	Equals 1 if home has a woods view; 0 otherwise.
WaterDummy	Equals 1 if home is connected to the city water system; 0 otherwise.
AtticDummy	Equals 1 if the home has an attic; 0 otherwise.
FeeSimpleDummy	Equals 1 if the home is owned as fee simple; 0 otherwise.
GasDummy	Equals 1 if water heater is gas; 0 otherwise.
DetachedDummy	Equals 1 if home is detached; 0 otherwise.
NewConstructionDummy	Equals 1 if home is new construction; 0 otherwise.

Table 4: Summary of the Key Variables

	(1)				
	count	mean	sd	min	max
Dual Agent	302,183	0.1561	0.3629	0	1
Internal Transaction	302,183	0.2357	0.4244	0	1
Sales Price ($ 000s)	302,183	189,894	122.4014	33	699
Original Price ($ 000s) [a]	302,183	196,646	129.4712	39.9	750
Price Ratio [b]	302,183	0.9670	0.0713	0.6360	1.1278
Trade Time (year)[c]	302,183	0.1624	0.2010	0.0027	1.0657
Internal/external Ratio[d]	302,183	0.3492	0.2253	0.0418	1.375

a, *b*, *c*, *d*: To facilitate cross variable comparison, we standardize these variables when we conduct our empirical analysis.

The average sale price is 189,894, a little lower than the original list price (196,646). $MarketPrice/ListRatio_{t-1}$ describes the lagged market-wide ratio of the sale price to the original list price. In addition to the level of price index, we use this variable as a proxy for market strength, where a higher ratio suggests a stronger market. The mean price ratio in the sample is 0.9670. Trade Time describes transaction time of a house from listing to selling. The mean trade time in the sample is 0.1624 years (about 2 months). This variable serves as another proxy for market strength in our model, where a shorter trade time suggests a stronger market.

In our model, $\lambda_a^i = k_a^i N_a$ is the arrival rate for an identified type α buyer for brokerage firm i. Upon arrival, there will be a random draw of bidding offer from a given distribution. In this sense, a firm (agent) who is more capable of generating a higher arrival rate internally relative to externally will exhibit a higher ratio $\frac{k_{in}^i N_{in}}{k_{ex}^i N_{ex}}$. And given any fixed time interval, it will yield a higher expected trade price internally because of more draws taken. Therefore, $\frac{k_{in}^i N_{in}}{k_{ex}^i N_{ex}}$ is nothing but a theoretical measure of a brokerage firm's relative searching-matching efficiency when conducting internal transactions. Empirically, we use internal/external transaction ratio, defined as the ratio of the number of internal transactions to the numbers of external transactions conducted by the brokerage firm within a year prior to the closing date for transaction h, as a proxy for $\frac{k^i_{in} N_{in}}{k^i_{ex} N_{ex}}$. Hence, a firm (agent) with a higher internal/external transaction ratio aims to capture the ones that are better at generating a quality match internally. [3]

4 Empirical Results

4.1 Brokerage Choice and Market Strength

Recall that **Proposition 1** predicts a lower probability of engaging internal transactions when the housing market gets stronger. As a preliminary visual check, in Figure 4 we plot the association between the proportion of internal transactions in a given period vs price index, a measure of market strength. The index is estimated from our first stage of the hedonic regression, which is reported in the appendix.

[3] This proxy is closely related to the realized version of arrival ratio, $\frac{k^i_{in} N_{in}}{k^i_{ex} N_{ex}}$. Hence, a fair concern is whether a bigger realized ratio truly reflects the superior matching efficiency internally which should, according to our theory, exhibit a positive price impact for internal transactions. Or does it simply relate to some other unobserved brokerage characteristics that are unrelated to its internal searching-matching ability? As will be shown in the next section, we find significant evidence that brokerage firms (agents) that have higher internal/external ratio tend to deliver higher prices, especially when it engages in internal transactions.

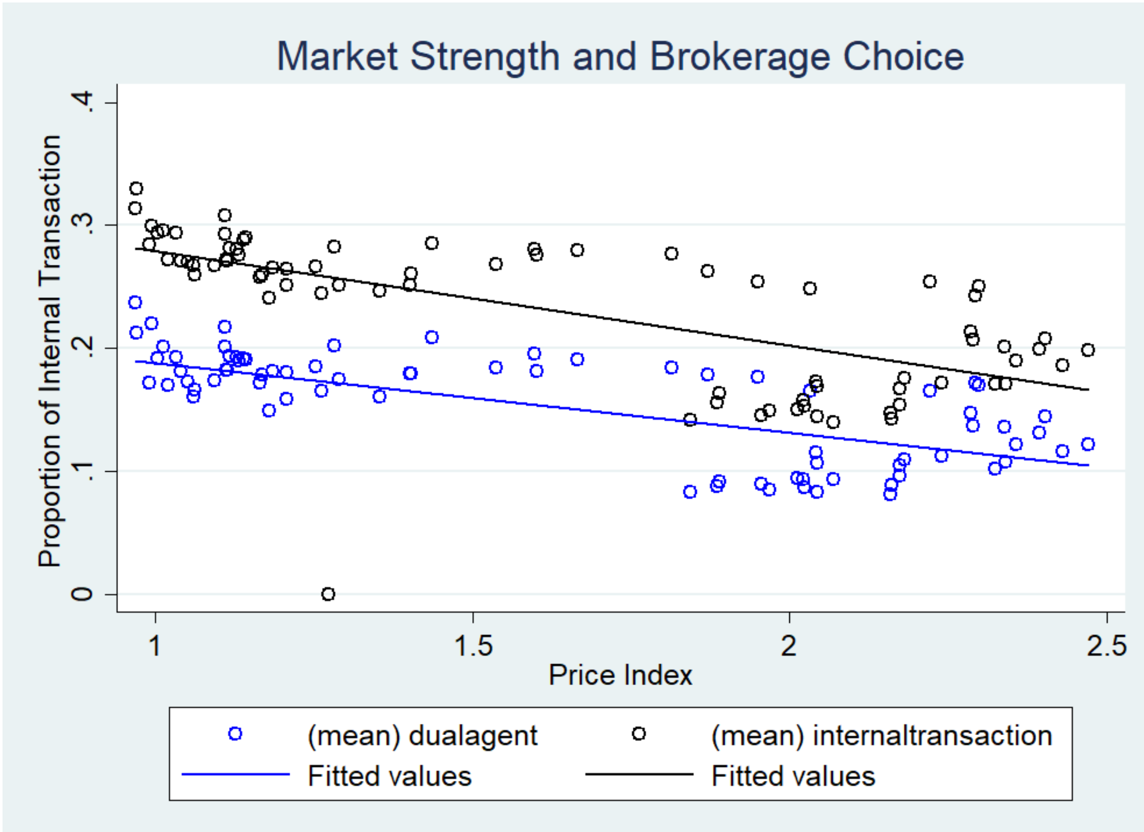

Figure 4: The Relation Between Market Strength and Transaction Type

Consistent with **Proposition 1**, when the market gets stronger, as reflected by a higher price index level, we observe a lower percentage of internal transactions. While we believe price index is a sensible measure of market strength, there is no doubt that this measure alone has its limitation. For example, people can argue that market strength can be different when it reaches a price level from below (hence going upward) vs. from above (hence going downward). Nevertheless, the pattern revealed by Figure 4 is encouraging enough to warrant a closer look at the impact of market strength on brokerage choice.

To test this impact more rigorously, following Han and Hong (2016), we use the following Logistic model:

$$P(d_{hit} = 1 | Z_{ht}, X_{ht}, W_{it}) = \frac{\exp(Z_{ht}\gamma_e + X_{ht}\gamma_h + W_{it}\delta + \eta_{hit})}{\exp(Z_{ht}\gamma_e + X_{ht}\gamma_h + W_{it}\delta + \eta_{hit}) + 1}$$

where d_{hit} is an indicator variable for whether transaction h in period t is an internal transaction carried out by brokerage i, and Z_{ht} is a vector of variables measuring market strength around transaction h . In addition to price index, we construct two additional measures of market strength as part of Z_{ht} . The first measure, $PriceRatio$ is the average ratio of sale price to original list price during the month preceding transaction h within the same zipcode. The second measure, $TradeTime\ t$, is the average market transaction time during the month before transaction h within the same county. X_{ht} refers to a vector of home characteristic control variables including lot size, number of bedrooms, number of bathrooms, a basement dummy, etc. W_{it} refers to brokerage level variables. Finally, η_{hit} contains various fixed effects for the year and month of the transaction, brokerage firm, region, and home characteristics.

The estimation of this model is displayed in Tables 5 and 6. In Table 5, internal transactions are reported, whereas in Table 6, the more narrowly defined dual agent transaction results are shown.

Table 5 reports the estimation results for the likelihood of being engaged in an internal transaction. Four different models are estimated. Column 1 is the baseline estimation where market strength is measured using both the ratio of sale price to original list price (i.e., the price premium effect) and market transaction time (i.e., the liquidity premium effect). The related coefficient for price ratio estimated in column 1 is statistically significant, and the sign is consistent with expectations. The ratio of sale price to original list price has a negative impact on the probability of a realized internal transaction. We can also see that market transaction time has a positive impact on the probability of an internal transaction, although the coefficient is not significant. When the market gets stronger, the ratio of sale price to original list price increases, market transaction time decreases, and the probability of observing an internal transaction decreases. This is consistent with **Proposition 1** which claims the probability of a transaction being internal will decrease with market strength. From the estimation of the Logistic model, we can observe the average marginal effect

Table 5: Impact of Market Strength on Brokerage Choice

	(1)	(2)	(3)	(4)
	Internal	Internal	Internal	Internal
Internal Transaction				
Price Ratio	-0.0556***	-0.0564***	-0.0564***	-0.0427***
	(0.0136)	(0.0140)	(0.0144)	(0.0152)
Trade Time	0.0069	0.0091	0.0091	-0.0116
	(0.0192)	(0.0189)	(0.0180)	(0.0189)
Internal/external Ratio	0.3252***	0.3043***	0.3043***	0.3073***
	(0.0187)	(0.0171)	(0.0175)	(0.0160)
Stage 1 Residual	-0.2582**	-0.2585**	-0.2585***	-0.2698***
	(0.1137)	(0.1143)	(0.0962)	(0.0961)
Constant	-0.2635	-0.2583	-0.2583	-0.9678
	(0.2452)	(0.2389)	(0.2519)	(0.6344)
FEregion	Yes	Yes	Yes	Yes
FEyear	Yes	Yes	Yes	Yes
FEhousecharacteristic	Yes	Yes	Yes	Yes
Original price	Yes	Yes	Yes	Yes
FEoffice	No	Yes	Yes	Yes
FEzipcode*month	No	No	No	Yes
Number of Observation	82222	82222	82222	82222

Note:Robust standard errors clustered at zip code level in parentheses for (1), (2). Robust standard errors clustered at zip code level and brokerage office level in parentheses for (3), (4).

* Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level

of the variables. For example, when other variables are evaluated at their average value, a 1 standard deviation increase in the ratio of sale price to original list price will lead a 0.77% decrease in the probability of an internal transaction being realized. When other variables are evaluated at their average value, a 1 standard deviation increase in market time will increase the probability of a realized internal transaction by 0.1%. Compared with the overall proportion for an internal transaction (23.57%), this effect amounts to over 7 % variation and hence is non-trivial. Furthermore, note that the empirical estimation is for the realized probability that the transaction is internal. Since the market shares for the new buying orders are different among firms, the willingness to choose external transactions may not be fully realized in reality when the market strengthens. So market strength can have a greater impact on the preference for internal transactions than the estimated result. Recall that, from the theoretical section, we have

$$\frac{\partial p_{in}}{\partial \frac{N_{ex}}{N_{in}}} = = -\frac{k_{in}^i}{(k_{in}^i + \rho k_{ex}^i \frac{N_{ex}}{N_{in}})^2} \rho k_{ex}^i = -\frac{p_{in}^2}{k_{in}^i} \rho k_{ex}^i$$

which means the impact of market strength on preference for an internal transaction will be greater for firms with a higher probability of choosing internal transactions. Note that the estimated result is for the average effect, so agents who previously had a higher probability of choosing an internal transaction will be more impacted by market strength. This implies that the estimated effect is stronger for firms who are mainly engaged in internal transactions. If a firm is primarily engaging in internal transactions, our results indicate that market strength may have a larger impact on its preference for choosing the type of transaction.

Concerning the coefficient associated with the internal/external transaction ratio, it is positive and highly significant, which is also consistent with **Proposition 2** which claims the probability of a transaction being internal will increase with the search rate ratio between internal and external transactions. Intuitively, when the internal/external transaction ratio is larger, a firm's search efficiency for internal buying orders is higher. Thus, the incentive for internal transactions increases, which leads to more internal transactions. This finding hence presents a two-sided story when it comes to the brokerage choice of internal transactions. That is, while internal transaction tends to occur at the expense of lowering the selling price (as we show later), it is also more likely to be chosen by brokerage firms with higher in-house searching-matching efficiency. Although studies talking about the bigger incentive-misalignment problem associated with internal transaction are often seen, to our knowledge, this flip-side about the revealed signaling of better in-house searching-matching efficiency has not been discussed much in the literature.

In the baseline estimation, we control for a wide range of attributes including home characteristics, region, time, and so forth. To control for the potential effect of unobserved brokerage office characteristics, we include brokerage office fixed effects in the baseline model. The result in column 2 reveals that the key coefficient estimates on ratio of sale price to original list price and internal/external transaction ratio continue to be significant and have the expected sign. We can also see that the coefficient on market transaction time remains positive, although the coefficient is not significant. This suggests that the unobserved brokerage office effect is unlikely to change the interpretation of our findings.

To allow for intragroup autocorrelation within the area and the brokerage office, we estimate a model with two-way clustering at both the zip code level and brokerage office level. We can see in column 3 that the signs and significance levels of the price ratio and internal/external transaction ratio remain the same, which indicates that our results are robust to this change. In addition, the coefficient on market transaction time becomes significant. The results presented here demonstrate a strong relation between market strength and the probability of engaging in internal transactions.

To control for interacting effects of region and time, in column 4, we include the interaction term of zip code and the month of closing date. We can see that the key coefficient estimates on ratio of sale price to original list price and internal/external transaction ratio continue to be significant and have the expected sign. This finding lends further support to the robustness of our result.

We next examine the relation between market strength and the probability of engaging in dual agent transactions, a subset of internal transactions where the buyer and seller are represented by the same agent. In Table 6, we see that the sign and significance level of the coefficient estimates on ratio of sale price to original list price and market transaction time remain qualitatively similar.

4.2 Causal Impact of Internal Transactions on Sale Price

In this section we aim to estimate the causal impact of an internal transaction on sale price. We adopt the log-linear outcome model:

$$\ln P_{hit} = d_{hit}\theta + Z_{ht}\alpha + X_{ht}\beta + W_{it}\delta + \eta_{hit} + \epsilon$$

where the vectors of control variables are defined the same way as before. Our key parameter of interest is θ, which aims to measure the average treatment effect (ATE) of internal transaction on selling price.

4.2.1 Identification Strategy

The biggest challenge on our causal inference is to control for confounding factors that affect both the outcome (price) and treatment decision (brokerage choice). As shown in our model and in section 4.1, agents' brokerage choice depends on market strength as well as agent's ability on dealing with internal transaction. Simply put, when market is weaker, or when agent is more capable of sharing information internally, internal transaction is more often chosen by an agent. However, market strength and internal dealing capability likely will also affect the realized transaction price.

While we could control the confounding factors directly from a regression model of the outcome, the ATE estimator is only consistent and hence asymptomatically unbiased assuming we have correctly specify the outcome model. Alternatively, given the predicted imbalance on regressors between the treated group (i.e., those from internal

Table 6: Impact of Market Strength on Dual Agent Preference

	(1)	(2)	(3)	(4)
	Dual Agent	Dual Agent	Dual Agent	Dual Agent
Dual Agent				
Price Ratio	-0.0759***	-0.0781***	-0.0781***	-0.0500***
	(0.0208)	(0.0206)	(0.0175)	(0.0189)
Trade Time	0.0165	0.0129	0.0129	-0.0085
	(0.0221)	(0.0221)	(0.0216)	(0.0230)
Internal/external Ratio	0.2715***	0.2768***	0.2768***	0.2833***
	(0.0203)	(0.0192)	(0.0181)	(0.0184)
Stage 1 Residual	-0.4073***	-0.3981***	-0.3981***	-0.4177***
	(0.1391)	(0.1354)	(0.1203)	(0.1190)
Constant	-0.8705***	-0.7400**	-0.7400**	-0.5446
	(0.2889)	(0.2900)	(0.3130)	(0.6524)
FEregion	Yes	Yes	Yes	Yes
FEyear	Yes	Yes	Yes	Yes
FEhousecharacteristic	Yes	Yes	Yes	Yes
Original price	Yes	Yes	Yes	Yes
FEoffice	No	Yes	Yes	Yes
FEzipcode*month	No	No	No	Yes
Number of Observation	82222	82222	82222	82222

Note:Robust standard errors clustered at zip code level in parentheses for (1), (2). Robust standard errors clustered at zip code level and brokerage office level in parentheses for (3), (4).

* Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level

transactions) and control group (i.e., those from external transactions), one could do a propensity score matching on market strength, brokerage and housing characteristics. One way on applying propensity score matching is to use the inverse of the propensity score as a weighting mechanism to achieve the balance of confounders between the control and treated groups (Rosenbaum and Rubin, 1983; Greenland, Pearl and Robins, 1999; Robins and Hernn, 2009, etc). The ATE can then be consistently estimated assuming the treatment model has been correctly specified.

In this study, we adopt a doubly robust (DR) estimator that combines both prospectives. In particular, we specificity jointly the treatment model on brokerage choice and the outcome model on its impact to house price. We model the relations between confounders and sale price within each exposure group. Then for each house transaction h in our data, we use the resulted parameters to estimate the predicted price under each treatment exposure. We then define the expected response from each transaction h as:

$$DR_{h,internal} = \frac{\ln P_h \times I_{h,internal}}{PScore_{h,internal}} - \frac{\widehat{\ln P_{h1}} \times (I_{h,internal} - PScore_{h,internal})}{PScore_{h,internal}}$$

$$DR_{h,external} = \frac{\ln P_h \times (1 - I_{h,internal})}{(1 - PScore_{h,internal})} + \frac{\widehat{\ln P_{h0}} \times (I_{h,internal} - PScore_{h,internal})}{1 - PScore_{h,internal}}$$

where $\ln P_h$ is the logarithm of the observed price for transaction h, and $\widehat{\ln P_{h0}}$ and $\widehat{\ln P_{h1}}$ are predicted prices from the outcome mode, had treatment been external and internal respectively. $I_{h,internal}$ is an indicator function on whether transaction h is conducted internally, and $PScore_{h,internal}$ is the estimated propensity score on internal transaction obtained from the treatment model. The average treatment effect can be estimated by:

$$\widehat{ATE_{internal}} = \sum_{h=1}^{h=n} (DR_{h,internal} - DR_{h,external})$$

Similarly, we can define a doubly robust estimator on dual agency. An appealing feature of this doubly robust estimator is that the ATE as defined above is unbiased as long as either treatment model or outcome model is correctly specified. In another word, it provides a second protection as we can now afford to have one misspecification on underlying models without losing the desired property of an unbiased estimator on ATE. For the original discussion on doubly robust estimator, see Robins et al (2001). An intuitive description of this estimator can also be found at Funk et al, (2011) and Morgan and Winship (2015, section 7.3).

Another empirical issue is on statistical inference. As discussed earlier, we use the hedonic residual from stage 1 regression as a control for the unobserved housing quality. It causes a generated regressor problem in our stage 2 regressions in both the treatment and outcome model.To correct the standard error bias caused by the it, we use a two-stage bootstrap method for the estimations.

In the next two subsections, we separately present the naive estimator on outcome model only and a doubly robust estimator.

4.2.2 Naive Regression Estimator from Outcome Model

We first present the results from a naive outcome regression model only. The estimation results are displayed in Tables 7 and 8. Table 7 reflects internal transactions, whereas Table 8 reports results for dual agent transactions.

Table 7 displays estimation results for sale price using four nested specifications. To control for unobserved home quality which impacts sale price, we include the original list price in all of the three estimations. In column 1, the baseline model, we see that an internal transaction has a negative impact on sale price after controlling for market strength, among other variables. The underlying coefficient suggests that, holding other factors constant, an internal transaction is associated with a 0.9% reduction in sale price. This is consistent with **Proposition 3** which predicts that the expected sale price of the internal transactions will be less than the expected sale

Table 7: Impact of Internal Transactions on Sale Price

	(1)	(2)	(3)	(4)
	Log(Sale price)	Log(Sale price)	Log(Sale price)	Log(Sale price)
Internal Transaction	-0.0090***	-0.0092***	-0.0081***	-0.0083***
	(0.0012)	(0.0012)	(0.0011)	(0.0011)
Price Ratio	0.0128***	0.0127***	0.0128***	0.0127***
	(0.0011)	(0.0011)	(0.0011)	(0.0011)
Trade Time	0.0012	0.0012	0.0012	0.0012
	(0.0010)	(0.0010)	(0.0010)	(0.0010)
Internal/external Ratio	0.0090***	0.0078***	0.0072***	0.0060***
	(0.0009)	(0.0009)	(0.0009)	(0.0009)
Stage 1 Residual	0.0763***	0.0752***	0.0764***	0.0753***
	(0.0102)	(0.0102)	(0.0102)	(0.0102)
Internal*Lambdaratio			0.0066***	0.0067***
			(0.0013)	(0.0013)
Constant	11.7487***	11.7281***	11.7340***	11.7266***
	(0.0208)	(0.0203)	(0.0201)	(0.0204)
FEregion	Yes	Yes	Yes	Yes
FEyear	Yes	Yes	Yes	Yes
FEhousecharacteristic	Yes	Yes	Yes	Yes
Original price	Yes	Yes	Yes	Yes
FEoffice	No	Yes	No	Yes
FEzipcode*month	Yes	Yes	Yes	Yes
R-Square	0.9597	0.9599	0.9597	0.9599
Number of Observation	82222	82222	82222	82222

Note:Robust standard errors clustered at zip code level and brokerage office level.

* Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level

price of the external transactions. As for the effect of market strength, we can see that the coefficient on the sale to list price ratio is positive and significant at 1 %, which supports the expectation that a stronger housing market implies a higher price. The coefficient on market transaction time is positive but insignificant, suggesting a qualitatively consistent but weak impact from market liquidity.

With regard to a brokerage firm's internal efficiency, in column 1, the coefficient on internal/external transaction ratio is positive and significant at 1%. The magnitude of the coefficient suggests that for a 1 standard deviation increase in the firm's internal searching efficiency, the realized price is increased by 9%. However, at this point, it is unclear whether the price premium is due to the fact that these firms are more efficient in internal matching, which would be consistent with our model, or simply because they are more competent when matching in general. To control for the potential effect of unobserved brokerage office characteristics that are not transaction type dependent, we include brokerage office fixed effects in column 2. There is indeed some evidence that the observed premium could be partially attributed to these unobserved common brokerage characteristics, as the coefficient is now increase from 0.009 to 0.0092, although it is still significant at 1%. To fully isolate the transaction type effect, in columns 3 and 4 we further add the interaction term between internal transaction and internal/external ratio, where we only add brokerage fixed effects in column 4. It is clear from columns 3 and 4 that there is significant evidence that firms with high internal/external ratios deliver a bigger price premium for the realized internal transactions than for external transactions. Interestingly, when we add the brokerage fixed effect in column 4, the main term on internal/external ratio becomes smaller (down from 0.0072 in column 3 to 0.006), while the interaction term of 0.0067 (significant at 1%) suggesting that its impact on internal transaction is more than doubled. Hence we find strong evidence that the price premium generated by firms with a high internal/external ratio is largely due to the internal transactions they conduct. Hence it supports our expectation that the internal/external ratio serves as a good proxy for firm's internal matching efficiency. Finally, as the internal/external ratio has been standardized and hence has mean zero, column 4 makes it clear that the first order price effect on internal transaction is still negative, although firms with higher in-house efficiency help to mitigate the price reduction, hence providing a second order counter force to partially offset the price loss to home sellers. This finding is consistent with **Proposition 3** which states that on average, the price from an internal transaction is lower than from an external transaction. Finally, the key results on market strength also remain similar across columns.

As before, we next examine the relation between sale price and dual agent transactions. As reported in Table 8, the sign and significance level of the coefficient estimates remain similar. The only difference is that the coefficient on dual agent becomes more negative, implying a large price reduction for dual agent transactions.

From Tables 7 and 8, we see that for internal transactions, sale prices will be lower. This result shows the principal-agent incentive misalignment problem in the housing market. Sellers want to sell the house at the highest price, while agents want to earn the highest commissions at a given searching cost. Thus, for internal transactions, agents are willing to accept lower prices offered by internal buying orders to receive higher commission, which is not in the seller's best interest. Nevertheless, from Tables 5 and 6, we see that as the market strengthens, agents are more likely to engage in external buying orders, which helps reduce the principal-agent incentive misalignment problem. These results jointly indicate that the housing market has a self-correction mechanism for the principal-agent problem. As the market strengthens, external buying orders become more attractive causing agents to engage in more external transactions. Since the principal-agent incentive misalignment problem we study here mainly comes from internal transactions, it is mitigated when the market strengthens. From the above results, we have another important implication. Since selling prices in internal transactions are lower, when the market weakens, internal transactions

Table 8: Impact of Dual Agent on Sale Price

	(1)	(2)	(3)	(4)
	Log(Sale price)	Log(Sale price)	Log(Sale price)	Log(Sale price)
Dual Agent	-0.0113***	-0.0110***	-0.0105***	-0.0102***
	(0.0016)	(0.0016)	(0.0015)	(0.0015)
Price Ratio	0.0127***	0.0127***	0.0128***	0.0127***
	(0.0011)	(0.0011)	(0.0011)	(0.0011)
Trade Time	0.0012	0.0012	0.0012	0.0012
	(0.0010)	(0.0010)	(0.0010)	(0.0010)
Internal/external Ratio	0.0089***	0.0077***	0.0070***	0.0058***
	(0.0009)	(0.0009)	(0.0009)	(0.0009)
Stage 1 Residual	0.0762***	0.0751***	0.0762***	0.0752***
	(0.0102)	(0.0102)	(0.0102)	(0.0102)
Dualagent*Lambdaratio			0.0070***	0.0071***
			(0.0013)	(0.0013)
Constant	11.7362***	11.7287***	11.7345***	11.7271***
	(0.0200)	(0.0202)	(0.0201)	(0.0204)
FEregion	Yes	Yes	Yes	Yes
FEyear	Yes	Yes	Yes	Yes
FEhousecharacteristic	Yes	Yes	Yes	Yes
Original price	Yes	Yes	Yes	Yes
FEoffice	No	Yes	No	Yes
FEzipcode*month	Yes	Yes	Yes	Yes
R-Square	0.9597	0.9599	0.9597	0.9599
Number of Observation	82222	82222	82222	82222

Note: Robust standard errors clustered at zip code level and brokerage office level.

* Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level

increase and selling prices tend to be further reduced. A low price in the housing market can drive sellers out of the market, further weakening it. When the market strengthens, the opposite situation tends to occur. In this sense, the strength of the housing market can reinforce itself toward the more extreme conditions through switching brokerage preference.

4.2.3 Doubly Robust Estimator

The results from our doubly robust estimation procedure are reported in Table 9. Column 1 corresponds internal transaction as treatment, while column 2 defines dual agency as treatment.

The coefficient on average treatment effect is negative and significant at 1 % at both models. The coefficient of -0.0131 in column 1 reveals that, compared with external transactions, the price of internal transactions on average is 1.31 % lower, which is again consistent with our model predictions. Notably, the magnitude of ATE estimated from our doubly robust estimation is larger than from naive outcome model (which is around 0.8%), suggesting evidence of potential bias correction.

Another interesting finding is on Lambda Ratio. Recall from our selection model that it is significantly positive, suggesting that firms that are better handling internal transactions are more likely to choose this brokerage format. Here, for treatment group, its coefficient (e.g., 0.0099 in column 1) is more than half of the ATE in opposite direction, suggesting that for a one standard deviation increase on brokerage firm's internal ability, it can offset the price drop of internal transactions by about 0.99%, consistent with the prediction of a second-order mitigation effect from our theoretical model. Further, a higher Lambda Ratio tends to increase the price for both control and treatment group, suggesting that a brokerage firm that is more competent on handing internal transaction is likely to be more competent in general. However, a larger coefficient in the treatment group (e.g., 0.0099 vs 0.0081 in column 1) implies that brokerage firms that are better handling internal transactions also

Table 9: Impact of Internal Transaction(Dual Agency) on Price: DR Estimation

	(1)	(2)
	Internal Transaction	Dual Agency
Log(Sale price)		
ATE: Internal Transaction	-0.0131***	-0.0189***
	(0.0017)	(0.0025)
Outcome Model: Treated Group		
Internal/external Ratio	0.0099***	0.0094***
	(0.0018)	(0.0021)
Price Ratio	0.0104***	0.0113***
	(0.0025)	(0.0033)
Trade Time	-0.0014	-0.0000
	(0.0025)	(0.0036)
Outcome Model: Control Group		
Internal/external Ratio	0.0081***	0.0087***
	(0.0010)	(0.0009)
Price Ratio	0.0152***	0.0148***
	(0.0012)	(0.0012)
Trade Time	0.0005	0.0002
	(0.0011)	(0.0011)
Treatment Model	Y	Y
Other Controls		
FEregion	Y	Y
FEyear	Y	Y
FEoffice	Y	Y
House Characteristics	Y	Y
Original Price	Y	Y
Stage 1 Residual	Y	Y
Number of Observation	60,646	60,646

Note:Standard errors are constructed through a two-step housing unit stratified bootstrap procedure.

* Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level

generates a higher price than from less competent firms when internal transaction is indeed adopted. In column 2, qualitatively similar findings can be seen when we use a narrower set of dual agent transactions only as treatment group.

5 Conclusion

Many studies have been conducted to understand the impact that brokerage representation has on the home transaction process. We investigate brokerage choice not only between external (where agents from different firms represent the buyer and the seller) versus internal (where different agents from the same firm represent the buyer and the seller) transactions, but also for a subset of internal transactions known as dual agent transactions, where a single agent represents both the buyer and the seller in the same transaction.

We begin by building a theoretical model to establish a framework on which an empirical model is based. Consistent with our theory, we find that as the housing market strengthens, brokerage choice tends to shift to external transactions because the relative demand pool becomes much greater potentially resulting in a higher selling price and shorter time on the market. Moreover, after controlling for market strength, we find that internal transactions result in a lower sale price. The intuition behind this result is that since agents in internal transactions capture higher commissions from both parties, they have a stronger incentive to expedite the transaction at the expense of lowering the sale price. This speaks to the principal-agent problem in residential brokerage. Interesting, our model reveals another side associated with internal (dual-agent) transactions. That is, the firms who engage in internal transactions are also more likely to be the ones that have superior in-house searching/matching efficiency, which yields a (second order) positive impact on trade price, which helps mitigate the price discount realized from internal transactions. To our knowledge, this self-revealed signaling effect on brokerage firm's underlying in-house productivity has not been documented in the literature. We strengthen our model identification strategy by adopting a doubly robust estimator, which combines the traditional regression based model and propensity score matching on outcome. This estimator allows us to obtain an unbiased estimator on average treatment effect of internal transaction on price, provided we don't misspecify the treatment and outcome models simultaneously. We find some notable difference on results from our DR estimator and naive outcome regression estimator, suggesting some power on bias correction from this procedure.

In sum, different from Johnson et al. (2015), which finds that dual agent brokerage has no effect on sale price, our result suggests that internal transactions tend to lower sale price (which harms the seller). But, when the market gets stronger, there are fewer internal transactions, and this agency problem is mitigated. As such, the housing market has a self-correction mechanism for the principal-agent incentive misalignment problem. In comparison with Han and Hong (2016), which finds that agents are more likely to promote internal listings when they are financially rewarded and that this effect becomes weaker when consumers are more aware of agents' incentives, our study provides another kind of incentive misalignment between real estate agents and their clients, and the potential self-correction mechanism in the market. This result is useful to real estate industry participants in that sellers suffer from a suboptimal selling price. The good news is that as the market strengthens, the principal-agent problem will be mitigated. However, the strength of the housing market can be self-reinforcing. We find that internal transactions are associated with lower transaction prices. So, when the market weakens, the ratio of internal transactions in the market increases and prices decline, which can cause the market to further weaken. Hence, the equilibrium brokerage choice creates a self-reinforcing mechanism toward generating more extreme market conditions.

References

[1] Anglin, P. M., Rutherford, R., and Springer, T. M. (2003). The trade-off between the selling price of residential properties and time-on-the-market: The impact of price setting. *Journal of Real Estate Finance and Economics*, *26*(1), 95–111.

[2] Arnold, M. A. (1999). Search, bargaining and optimal asking prices. *Real Estate Economics*, *27*(3), 453–481.

[3] Bond, S. A., Hwang, S., Lin, Z., and Vandell, K. D. (2007). Marketing period risk in a portfolio context: Theory and empirical estimates from the UK commercial real estate market. *Journal of Real Estate Finance and Economics*, *34*(4), 447–461.

[4] Carrillo, P. E. (2013). To sell or not to sell: Measuring the heat of the housing market. *Real Estate Economics*, *41*(2), 310–346.

[5] Cheng, P., Lin, Z., and Liu, Y. (2008). A Model of Time on Market and Real Estate Price Under Sequential Search with Recall. *Real Estate Economics*, *36*(4), 813–843.

[6] Forgey, F. A., Rutherford, R. C., and Springer, T. M. (1996). Search and liquidity in single family housing. *Real Estate Economics*, *24*(3), 273–292.

[7] Garmaise, M. J., and Moskowitz, T. J. (2003). Confronting information asymmetries: Evidence from real estate markets. *Review of Financial Studies*, *17*(2), 405–437.

[8] Genesove, D., and Mayer, C. (2001). Loss aversion and seller behavior: Evidence from the housing market. *Quarterly Journal of Economics*, *116*(4), 1233–1260.

[9] Goetzmann, W., and Peng, L. (2006). Estimating house price indexes in the presence of seller reservation prices. *Review of Economics and statistics*, *88*(1), 100–112.

[10] Gruber, J., and Owings, M. (1994). Physician financial incentives and cesarean section delivery (No. w4933). *National Bureau of Economic Research*,

[11] Hagiu, A., and Jullien, B. (2011). Why do intermediaries divert search?. *RAND Journal of Economics*, *42*(2), 337–362.

[12] Han, L., and Hong, S. H. (2016). Understanding in-house transactions in the real estate brokerage industry. *RAND Journal of Economics*, *47*(4), 1057–1086.

[13] Heisler, J., Kallberg, J. G., and Liu, C. H. (2007). The impact of dual agency. *Journal of Real Estate Finance and Economics*, *35*(1), 39–55.

[14] Hendel, I., Nevo, A., and Ortalo-Magné, F. (2009). The relative performance of real estate marketing platforms: MLS versus FSBOMadison. com. *American Economic Review*, *99*(5), 1878–98.

[15] Hsieh, C. T., and Moretti, E. (2003). Can free entry be inefficient? Fixed commissions and social waste in the real estate industry. *Journal of Political Economy*, *111*(5), 1076–1122.

[16] Huang, J. C., and Palmquist, R. B. (2001). Environmental conditions, reservation prices, and time on the market for housing. *Journal of Real Estate Finance and Economics*, *22*(2-3), 203–219.

[17] Inaltekin, H., Jarrow, R. A., Sağlam, M., and Yıldırım, Y. (2011). Housing prices and the optimal time-on-the-market decision. *Finance Research Letters*, *8*(4), 171–179.

[18] Johnson, K., Zumpano, L., and Anderson, R. (2008). Intra-firm real estate brokerage compensation choices and agent performance. *Journal of Real Estate Research*, *30*(4), 423–440.

[19] Johnson, K. H., Lin, Z., and Xie, J. (2015). Dual agent distortions in real estate transactions. *Real Estate Economics*, *43*(2), 507–536.

[20] Kadiyali, V., Prince, J., and Simon, D. H. (2014). Is dual agency in real estate a cause for concern? *Journal of Real Estate Finance and Economics*, *48*(1), 164–195.

[21] Knight, J. R. (2002). Listing price, time on market, and ultimate selling price: Causes and effects of listing price changes. *Real Estate Economics*, *30*(2), 213–237.

[22] Lin, Z., and Vandell, K. D. (2007). Illiquidity and pricing biases in the real estate market. *Real Estate Economics*, *35*(3), 291–330.

[23] Mehran, H., and Stulz, R. M. (2007). The economics of conflicts of interest in financial institutions. *Journal of Financial Economics*, *85*(2), 267–296.

[24] Micelli, T., Pancak, K., and Sirmans, C. (2000). Restructuring agency relationships in the real estate brokerage industry: An economic analysis. *Journal of Real Estate Research*, *20*(1-2), 31–47.

[25] Patron, H. E., and Roskelley, K. D. (2008). The effect of reputation and competition on the advice of real estate agents. *Journal of Real Estate Finance and Economics*, *37*(4), 387–399.

[26] Richard, E., and Phillip, K. (2005). Homeowners' Repeat-Sale Gains, Dual Agency and Repeated Use of the Same Agent. *Journal of Real Estate Research*, *27*(3), 267–292.

[27] Shapiro, C. (1982). Consumer information, product quality, and seller reputation. *Bell Journal of Economics*, *2*0–35.

[28] Shapiro, C. (1983). Premiums for high quality products as returns to reputations. *Quarterly Journal of Economics*, *98*(4), 659–679.

[29] Shui, X. (2015). Does experience matter? The impact of agent experience on real estate. *Federal Housing Finance Agency*,

[30] Sirmans, C. F., Turnbull, G. K., and Benjamin, J. D. (1991). The markets for housing and real estate broker services. *Journal of Housing Economics*, *1*(3), 207–17.

[31] Turnbull, G. K., Dombrow, J., and Sirmans, C. F. (2006). Big house, little house: relative size and value. *Real Estate Economics*, *34*(3), 439–456.

[32] Turnbull, G. K., and Dombrow, J. (2006). Spatial competition and shopping externalities: Evidence from the housing market. *Journal of Real Estate Finance and Economics*, *32*(4), 391–408.

[33] Yavas, A., and Yang, S. (1995). The strategic role of listing price in marketing real estate: theory and evidence. *Real Estate Economics*, *23*(3), 347–368.

[34] Yinger, J. (1981). A search model of real estate broker behavior. *American Economic Review*, *71*(4), 591–605.

Appendix

Here we present the results from the first stage hedonic regression using the full sample of observations in Table A.1.

Table A.1: Hedonic Regression

	(1) Log(Sale price)
Baths_Full_	0.128***
	(0.00931)
Baths_Half_	0.0509***
	(0.00841)
Bedrooms_	0.0488***
	(0.00556)
Fireplaces_Number_	0.0580***
	(0.00632)
Rooms_Number_	0.0198***
	(0.00214)
Square_Feet_Approx_	0.0627***
	(0.00632)
Stories_Number_	0.000287
	(0.000389)
Year_Built_Approx_	0.00307***
	(0.000514)
Tax_Amount_Approx_	0.145***
	(0.0145)
Floorscale	0.0817***
	(0.00571)
POAFEE	-0.0139
	(0.0149)
Parkingscale	0.0801***
	(0.00759)
Waterdummy	0.0903***
	(0.00856)
Atticdummy	0.0454***
	(0.00653)
waterscale	0.0546***
	(0.00431)
cityscale	0.131***
	(0.0202)
woodsscale	0.137***
	(0.0151)
dummy of owner type	-0.0786***
	(0.0202)
dummy of waterheat type	0.0543***
	(0.00745)
dummy of residential type	0.218***
	(0.0166)
dummy of Construction type	0.126***
	(0.0124)
Constant	10.22***
	(0.0958)
FEregion	Yes
FEyear	Yes
R-Square	0.798
Number of Observation	302183

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Robust standard errors clustered at zip code level in parentheses.

* Significant at 10% level, ** Significant at 5% level, *** Significant at 1% level.