UCF College of Business Administration

Dr. P. Phillips School of Real Estate

Real Estate Agents, House Prices, and Liquidity*

Henry J. Munneke†
Department of Ins/LS/RE
University of Georgia
hmunneke@terry.uga.edu

Joseph T.L. Ooi
Department of Real Estate
National University of Singapore
rstooitl@nus.edu.sg

C.F. Sirmans
Department of Risk Mgt/Insurance, Real Estate, and Bus. Law
Florida State University
sirmanscf@gmail.com

Geoffrey K. Turnbull
Dr. P. Phillips School of Real Estate
University of Central Florida
gturnbull@bus.ucf.edu

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Geoffrey K. Turnbull
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gturnbull@bus.ucf.edu

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Abstract. Comparing agent-owner with agent-represented home sales illustrates that commission contracts lead to external agent moral hazard. Real estate developers are sophisticated sellers who can either use external agents or hire internal agents. The theory shows that neither scheme eliminates agent moral hazard. The empirical study of how the seller-agent relationship affects both price and liquidity in a simultaneous system concludes that external agents enjoy superior selling ability that offset moral hazard effects.

† communicating author

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Real Estate Agents, House Prices, and Liquidity

1. Introduction

The principal-agent problem inherent in the seller-agent relationship remains a fundamental issue in real estate brokerage and property markets. While the theoretical literature dealing with principal-agent issues is quite extensive, limited data and the general complexity of the problem have hindered empirical analysis in the real estate context. As a result, there is little empirical knowledge about how agency relationships affect real estate asset pricing and market performance. Studies of external property management compare external and internally managed properties to identify productivity and moral hazard effects on rents and values (Glascock, et al., 1993; Sirmans, et al., 1999). Real estate brokerage studies follow three broad approaches: comparing agent compensation effects in terms of market performance (Hendel, et al., 2009; Munneke and Yavas, 2001; Sirmans and Turnbull, 1997; Sirmans, et al., 1991); comparing professional agent-represented sales versus unassisted sales by owners (Jud and Frew, 1986; Kamath and Yantek, 1982); or focusing directly on real estate broker moral hazard by comparing agent-owner versus agent-represented home sales (Levitt and Syverson, 2008; Rutherford, et al., 2005).

Taking these studies as a point of departure, this paper addresses unsettled important questions regarding principal-agent problems relevant to real estate brokerage. The existing evidence, as scant as it is, only pertains to agents representing unsophisticated sellers. In some settings, though, sellers are developers, investors, or other sophisticated market participants. This opens the question, is the agent moral hazard problem as extensive when the seller is sophisticated? And, if so, to what extent can different feasible incentives schemes reinforce or ameliorate principal-agent effects in these environments?

To answer these questions the empirical model must capture the effects of the seller-agent relationship on both dimensions of a transaction, price and liquidity. This raises an econometric issue. Selling price and liquidity are jointly determined in search market equilibrium (Krainer, 2001), which means that realized prices and selling time are both functions of the same set of asset characteristics. To deal with this, we adapt the identification approach suggested by Zahirovic-Herbert and Turnbull (2008) to our data environment and estimate the price and liquidity equations as a simultaneous system. This approach exploits the spatial nature of the competition between neighboring units that are on the market at the same time to identify the separate price and liquidity equations. In our application, this strategy provides direct estimates of different agency effects on selling price and selling time in a simultaneous systems context. The results yield new insight into the extent to which the principal-agent moral hazard problem reflects the commission structure, irresolvable information asymmetries between principal and agent, and sales productivity differences between sellers and agents.

The sale of new condominiums provides an appropriate setting for addressing these questions. We examine a market in which condominium developers either rely on external real estate agents with traditional commission contracts or hire internal agents as employees and compensate them with bonuses based on performance standards or quotas. In each case the seller is arguably a sophisticated market participant—in contrast to previous broker studies. We measure seller market knowledge by prior experience. The data therefore allow us to measure differential price and liquidity effects attributable to differences in the agent reward scheme (external commission versus employee performance based compensation) as well as differences in seller sophistication (little versus extensive previous experience as a developer in the local market).

The theory shows that neither scheme eliminates agent moral hazard. The empirical results are consistent with the notion that external agents enjoy superior selling ability that offset moral hazard effects. Relying on internal agents leads to lower selling prices in all of the models and while there is some evidence that internal agents generate faster sales than external agents, the significance of this effect varies across specifications. Finally, external agents are more attractive to the most active publicly listed developers in general and to all developers when overall market conditions are poor. Overall, the theory and empirical results show that internal agents do not fully resolve the principal-agent problem. The results reflect the inability of the employee-internal agent structure to overcome persistent information asymmetries confronting even sophisticated property sellers.

The discussion is organized as follows. Section 2 discusses the principal-agent problem relevant to the market for new construction, comparing outcomes under internal and external agent scenarios in different information environments. Section 3 describes the empirical models used in the study. Section 4 discusses the data and section 5 the empirical results. Section 6 concludes.

2. Internal versus External Agents

The fundamental principal-agent problem in real estate brokerage concerns how to align the agent's interest with the seller's interest. Different incentives mechanisms exist, but not all can be applied in all types of real estate principal-agent relationships. Further, when agent interests cannot be reasonably aligned with the principal's interests, which the incentives theory literature suggests is often the case, the question remains whether agent performance differences across schemes are even economically important.

Consider a developer with an inventory of new (or forthcoming) housing units to offer to the market. We observe developers in the market choosing either to employ an internal agent whose performance and rewards are governed by an employment relationship or relying upon external independent agents rewarded with traditional selling commissions. Principal-agent relationships exist in both arrangements, but they differ. Our concern is whether they lead to different performance outcomes and whether observed differences in selling prices and liquidity are significant.

The principal-agent environment assumes asymmetric information between the principle and external agents and stochastic productivity that ensures that external agent effort cannot be inferred from observed outcomes (prices and liquidity). Whether or not internal agent selling effort can be inferred by the developer depends upon the various information environments considered separately below. In all asymmetric information cases, though, agent selling effort, e, is not directly observed by the developer.

Consider a developer with a given inventory of new housing units to sell. The total number does not matter for this discussion, so we shall leave it unspecified. The developer is generally concerned with the selling price of units, P, and how fast they sell, or their liquidity, L (e.g., number of units sold per unit of time). Both are functions of agent effort and marketing inputs supplied by the developer. Without loss of generality, assume the developer prefers more sales revenue per period over less. Assuming that both P and L are stochastic functions of e, realized revenue per period can be specified more simply as the function

$$PL = wf(e) + v$$

where $w > 0$ is the stochastic market determined sales productivity parameter mediating how sales and marketing input e generates sales outcomes (e.g., reflecting buyers' willingness-to-pay) and v is a stochastic term reflecting sales outcome effects that are unrelated to inputs (including luck). The stochastic terms w and v have well-behaved continuous distributions (i.e., finite means and variances) denoted W and V, respectively. Note for what follows that $E[v] = 0$. The underlying production function f is nonstochastic and increasing concave in effort ($f_e > 0$, $f_{ee} < 0$).

All parties are assumed to be risk neutral. The developer pursues strategies to maximize expected profit while the agent, whether internal employee or external, pursues strategies to maximize expected utility. The decision sequence and information environment is as follows. At the contracting stage, the developer and agent agree to the incentive structure knowing the distribution functions W and V but before observing the realized stochastic terms w and v. In the selling stage, we consider two separate cases; one in which the developer can and one in which it cannot observe w ex post for internal employee agents. In all cases, the developer cannot directly observe w ex post for external agents (the presence of the additive stochastic v term in the realized revenue function ensures that observing PL is not sufficient to infer agent effort even if w were observed).

Regardless of the developer's information, in the selling stage the agent (employee or outside third party) observes the realized productivity parameter w and chooses effort e to maximize expected utility for the realized state w,

$$U(w) = E_v[I] - e \tag{1}$$

where the function describing the agent's realized income I is determined by the incentive structure set in the agreement, specified for each case below.

Efficient Benchmark. We first derive the first-best or efficient effort plan as an analytical benchmark for comparing the various outcomes. The net social surplus to both developer and agent is total expected sales revenue (per time period) less the agent's input cost, or

$$S = \int_w \int_v [wf(e) + v - e] dWdV \tag{2}$$

Using subscripts to denote derivatives, the efficient effort rule $e^*(w)$ maximizing S satisfies the marginal conditions[1]

$$wf_e(e) - 1 = 0 \tag{3}$$

[1] This is a degenerate calculus of variations problem for which the applicable Euler equation reduces to the given marginal condition with distribution function W yielding the appropriate end point conditions for solution. The concavity of f ensures that the efficient solution functional or trajectory $e^*(w)$ is unique.

for all w on the support of W. These conditions have standard interpretations: e is set to equate marginal ex post productivity and marginal effort cost in each realized productivity state w. Implicit solution yields the efficient effort rule $e^*(w)$ such that

$$de^*/dw = -f_e/wf_{ee} > 0 \tag{4}$$

so that the efficient effort is increasing in productivity, as depicted by the benchmark labeled e^* in figure 1.

External Agent. Now consider the case in which the developer relies on an external independent agent to sell the inventory of units. At the outset, the developer and agent agree to the commission rate c. The analysis is not affected by the extent to which the commission rate is the outcome of negotiation or reflects a market-determined value, so we can take this value as given in what follows. (The underlying participation constraint that the agent at least meets his opportunity cost is implicitly assumed satisfied throughout the analysis.)

Given the agent observes w before making decisions, the agent chooses effort to maximize expected utility (1), which reduces to

$$U(w) = cwf(e) - e \tag{5}$$

The external agent's optimal effort satisfies the marginal condition

$$cwf_e(e) - 1 = 0 \tag{6}$$

The outside agent's equilibrium effort supply $e^o(w)$ is the implicit solution to (6) for which

$$de^o/dw = -f_e/wf_{ee} > 0 \tag{7}$$

using the concavity of f. Comparing the equilibrium condition (6) with the efficiency condition (3) yields the long recognized result that *the external agent compensated with commissions does not generate an efficient outcome. Specifically, the outside agent exerts inefficiently low selling effort in each realized state ($e^o(w) < e^*(w)$).* By (7) outside agent effort is increasing in productivity as illustrated by the upward sloped curve e^o that lies everywhere below the efficient benchmark in figure 1.

Inside agent employee: developer observes realized productivity w. When owner-occupier sellers of existing houses sell their properties themselves, they are effectively both principal and agent, and in the latter role, directly observe w before making decisions regarding selling effort. The seller's expected utility is the social surplus S and the seller's choice of selling effort or work rule replicates the efficient rule $e^*(w)$. This is the principal-agent problem envisioned in the resale housing literature (Levitt and Syverson, 2008; Rutherford, et al., 2005); external agent moral hazard leads to less sales effort than the efficient amount exerted by the internal (owner) agent.

When developers are selling new units using internal marketing staff, however, they do not sell the units themselves; they hire agents as employees. Retaining for now the assumption that developers observe w before sales decisions are made by their employees, the developer's problem is now recast as one of setting the state-dependent work rule $r(w)$ for the employee. This is Simon's employment relationship: at the contracting stage the employee accepts fixed wage or income I_r in return for agreeing to expend effort $r(w)$ when productivity is w (Simon, 1951; Turnbull, 1993). The agent's expected utility under this employment relationship is

$$EU(w) = \int_w [I_r - r(w)]dW \tag{8}$$

which must at least meet the agent's opportunity cost ex ante in order to fulfill the participation and incentive compatibility constraints (Turnbull, 1993). Setting expected utility equal to opportunity cost U' and solving for employee income yields the cost to the developer of implementing the set of work rules $r(w)$:

$$I_r = U' + \int_w r(w)dW \tag{9}$$

The developer's optimal work rule $r(w)$ maximizes expected profit, which is expected sales revenue less worker wage

$$\Pi = \int_w \int_v [wf(r(w)) + v - U' - r(w)]dVdW \tag{10}$$

Comparing (10) with social surplus (2) reveals that the work rule that maximizes (10) replicates the efficient sales effort supply. In terms of figure 1, $r = e^*$. This further implies that the equilibrium expected selling revenue per period of time from an external agent, P^oL^o, is less than the efficient level P^*L^*, which just happens to be what the seller using an internal agent generates when there is no seller-internal agent information asymmetry. What we cannot ascertain from the theory at this point is precisely how the expected selling prices and expected liquidities compare in the two situations, whether higher price, lower liquidity, or a combination of both.

There is one important element not considered thus far. External agents may have greater selling ability or skills which leads them to greater selling productivity than developers (who set internal agent work rules). The effects of greater outside agent productivity are easily derived in this simple framework. Introduce the ability parameter $a > 1$ for outside agents so that sales revenue per period are now $PL = waf(e)+v$. The efficient solution calls for using the more productive agent, the outside agent. Substituting a into the social surplus (2) and solving for the new efficiency conditions yields

$$waf_e(e) - 1 = 0 \qquad (11)$$

from which $de^*(w)/da = -f_e / af_{ee} > 0$ so that greater outside agent productivity shifts the efficient sales effort upward at each w in figure 1. Nonetheless, the internal agent/employee outcomes are unaffected by this external agent productivity advantage so that the modified efficient effort supply e^{**} for $a > 1$ exceeds internal agent effort supply r in figure 1 at all w even under symmetric information. Simply put, the internal agent is no longer efficient.

Introducing the ability parameter into the external agent model, the relevant external agent marginal condition becomes

$$cwaf_e(e) - 1 = 0 \qquad (12)$$

Comparing (11) and (12), $c < 1$ ensures that the outside agent is still not efficient: $e^o < e^{**}$. But implicitly differentiating (12) reveals $de^o(w)/da = -f_e / af_{ee} > 0$ so that greater outside agent ability shifts the outside agent effort curve upward from e^o to say e' or even e'' in figure 1, depending on the level of ability. This means that greater external agent ability may or may not lead to greater effective selling effort than would be forthcoming from the internal agent relationship: $e' < r$ and $e'' > r$ are both possible.

Pulling these results together, *the outside agent moral hazard leads to lower sales effort, hence lower expected sales revenue, than the internal agent (with no information asymmetry).* Greater outside agent productivity or ability, however, leads to greater outside agent sales effort. Clearly, then, *observing higher expected sales revenue implies that external agent productivity or ability is sufficiently great to completely offset the moral hazard effects relative to the internal case.* The additional implication is that the outside agent arrangement, although never efficient, can be more efficient than the internal agent in this case.

Inside agent employee: developer does not observe realized productivity w. Now consider the more interesting situation in which agent employees engaged in the selling process observe the difficulty of making sales, but developers do not. Recall that the presence of the additive stochastic term v in this environment precludes developers from using observed sales outcomes to correctly infer employee agent effort, making a work rule like $r(w)$ derived above infeasible. It is not surprising that developers in our sample instead use an employment relationship for internal agents that can be described as a performance standard with bonus scheme.

In the bonus scheme for this context, the developer sets a performance standard or quota q such that the internal agent receives a base income I_b when sales performance falls short of the quota and base income plus premium or bonus B when performance meets or exceeds the quota. The probability of the agent meeting or exceeding the performance quota is

$$p(wf+v \geq q) = \int_{v \geq q-wf} dV \qquad (13)$$

so that the internal agent's expected utility in productivity state w is

$$U(w) = I_b + p(wf+v \geq q)B - e \qquad (14)$$

Choosing effort to maximize expected utility, the inside agent's effort $e^i(w,B,q)$ satisfies the marginal condition

$$BV_v(q-wf)wf_e(e) - 1 = 0 \qquad (15)$$

where $V_v(q\text{-}wf)$ is the marginal density evaluated at the lower bound of the integral in (13). Condition (15) requires that the agent exert effort to the point where the effect on the expected bonus or prize from the greater probability of meeting the performance benchmark equals the marginal cost of effort. Once again, we assume the participation constraint is fulfilled (expected utility at least meets the opportunity cost for the employee). In addition, though, (15) requires that the bonus be set high enough to ensure that some effort is forthcoming in all realized states.[2] And since varying base income I_b does not affect agent effort, this variable can be arbitrarily increased or decreased by the developer to the level that ensures the inside agent's participation constraint is fulfilled. This is, of course, part of the incentive structure that is agreed to in the initial contract stage.

Equilibrium condition (15) for agent effort needs more careful consideration. In a special case, if the distribution function V is uniform then the term BV_v is constant. In this case, B can be set to ensure that the efficient agent effort condition (3) is fulfilled in all productivity states: $e^i = e^*$ for all w. More generally, though, suppose V is single peaked symmetric, a common characterization in incentives theory. In this situation, the appendix shows that BV_v is decreasing in w for low levels of realized productivity (where $q - wf > 0$) and increasing in w for high levels of productivity (where $q - wf < 0$). As the appendix shows, this implies that B and q can be set such that there are at most two productivity states w in which internal agent effort is efficient. Thus, *the internal agent scheme is inefficient almost everywhere.* Put differently, developer-agent information asymmetry ensures that using an internal agent cannot fully resolve the principal-agent problem previously thought to pertain solely to the commissioned external agent case in the real estate agent literature.

Neither the internal nor external agent schemes is efficient. But can the internal agent scheme come closer to resolving the principal-agent issues associated with the external agent scheme? In order to compare the two schemes, we again assume a single peaked symmetric distribution V. The details are relegated to the appendix, but it can be shown that greater bonuses elicit greater effort, shifting the e^i curve upward in figure 2 from curve *a* to *b*, for example. Thus, a sufficiently low bonus leads to lower internal agent effort than external agent effort, greater internal than external agent moral hazard; for example, when e^i is given by curve *a* in figure 2. But a higher bonus increases internal agent effort, which suggests it can ameliorate the external agent moral hazard. What this requires is that the bonus

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[2] When B is set too low, the first term in (15) is so small that $BV_w(q\text{-}wf)wf_e(e) < 1$ and the appropriate Kuhn-Tucker conditions imply $e = 0$: when the bonus is this low, the agent finds that it is not worth expending the effort required to obtain it.

be set sufficiently high to increase interior agent effort to curve *c* in figure 2. What the bonus cannot do, however, is mimic the outside agent equilibrium. The appendix demonstrates that the shape of the e^i curve in figure 2 ensures that the internal agent scheme can never fully replicate the outside agent scheme, just as it cannot replicate the efficient effort function.

Recall that greater external agent ability leads to upward shifts in both the external agent and efficient effort supply functions in figure 1. In the asymmetric information case considered here, this means that greater external agent ability makes it more costly for the developer to use a higher bonus to reduce internal agent moral hazard enough to dominate the external agent outcome. In terms of figure 2, greater outside agent ability shifts e^o upward say to curve *d*, thereby raising the bonus needed to induce the internal agent to match or exceed outside agent performance. Thus, the conclusions from the perfect information case considered earlier therefore extend to the asymmetric information situation: *higher selling prices and/or greater liquidity for external agents indicate that external agents are more productive than internal agents; in such cases developers find it too costly to increase bonuses enough to motivate internal agents to outperform external agents.*

3. Empirical Model

The recent empirical housing literature emphasizes the fact that price and liquidity are jointly determined in search markets. Consequently, changes in the underlying use value or buyers' valuations of property need not be fully reflected in transaction prices; they can also be reflected in changes in liquidity (Krainer, 2001; Zahirovic-Herbert and Turnbull, 2008). This is consistent with the theoretical framework examined in the preceding section, but it complicates the analysis of using internal agents to resolve the principle-agent problem associated with using commissions to reward independent or outside agents, since it requires that the effect of internal or external agents on prices and property liquidity should be evaluated using a simultaneous system comprising a hedonic price model and a liquidity equation.

Following the general approach suggested by Zahirovic-Herbert and Turnbull (2008), we use three-stage least squares to address the simultaneity of the equations while taking into account potential cross-equation correlation of the errors. This approach starts with the recognition that search theory implies both realized selling price and liquidity are determined by the same set of variables. Empirically, the system of equations is estimated based on transactions of individual units and therefore is a function of X_i, a vector the typical exogenous unit, project, transaction and time variables usually found in hedonic price functions. In addition, Turnbull and Dombrow (2006) argue that neighborhood market conditions also influence transactions outcomes. We therefore include their measure of local market conditions—total competition, *TOTCOMP*—a measure of total exposure of the subject unit to competing units that are also for sale. This variable is explained below. Finally, we include in the system of equations the variable *INTERNAL* indicating whether the selling agent is an internal or external agent. Summarizing, the system can be written for unit *i*

$$\ln(PRICE_i) = f\left(\widehat{LIQUIDITY}_i, X_i, TOTCOMP_i, INTERNAL_i\right) \quad (16)$$

$$LIQUIDITY_i = f\left(\widehat{\ln(PRICE_i)}, X_i, TOTCOMP_i, INTERNAL_i\right) \quad (17)$$

$PRICE_i$ represents the selling price of the *i*th unit. The liquidity measure ($LIQUIDITY_i$) captures the selling speed and is defined as the number of days the current sale is from a previous sale within the same development (lower values indicate faster sale or greater liquidity).[3] If multiple units are sold on the date of the current sale, the number of days from the previous sale is divided by the total number of units sold on the current sale date to find the measure of liquidity.

The problem is that the above set of equations is not identified. Note, however, that the effect of increasing *TOTCOMP* on ln*PRICE* while holding *LIQUIDITY* constant only reflects the effect of increasing the number of competing listings per day on the market, or increasing the competition density, which is the *COMPDENS* variable defined below (Zahirovic-Herbert and Turnbull, 2008). With this parametric restriction, the estimating system is identified and becomes

$$\ln(PRICE_i) = f\left(\widehat{LIQUIDITY}_i, X_i, COMPDENS_i, INTERNAL_i\right) \quad (18)$$

$$LIQUIDITY_i = f\left(\widehat{\ln(PRICE_i)}, X_i, TOTCOMP_i, INTERNAL_i\right) \quad (19)$$

To measure total competition ($TOTCOMP_i$) and competition density ($COMPDENS_i$), we adopt the empirical approach developed by Turnbull and Dombrow (2006) and used by Zahirovic-Herbert and Turnbull (2008) and others. The total competition measure takes into account the total number of units in other developments outside of the subject property's development that have overlapping days on the market (the empirical models include separate direct controls for the number of units on the market in the subject property's development). Let *L*(*i*) and *S*(*i*) denote the initial date the *i*th unit is

[3] The liquidity measure applies the standard definition of inventory turnover.

exposed to the market and the sales date, respectively. The overlapping days on the market for units j and i is defined as:

$$O(i, j) = \min [S(i), S(j)] - \max [L(i), L(j)] + 1$$

where units j are found in developments J not in development I (the development in which the ith unit is contained). Competing units are determined by their distance from the subject property. Calculate $D(i, j)$ as the straight-line distance between the subject unit i and other overlapping units j for sale; competing units are defined as units found in the developments J that fall within λ km of the ith unit's development. More formally, the set of competing units is defined as $K \equiv \{ j \mid D(i, j) \leq \lambda \text{ and } I \neq J\}$. The variable measuring total competition is defined as:

$$TOTCOMP_i^{\lambda} = \sum_{j \epsilon K} \left(1 - \left(\frac{D(i,j)}{\lambda}\right)^2\right) O(i,j).$$

Combine the total competition and liquidity measures to measure the amount of competition per day on the market for the subject property, or competition density

$$COMPDENS_i^{\lambda} = TOTCOMP_i^{\lambda} \, / \, LIQUIDITY_i.$$

This measure represents the average intensity of the competition in terms of competing units per day.

Nearby units for sale may reduce price and/or increase the liquidity measure, reflecting the effects of greater localized competition among sellers for potential buyers, or may increase price and/or reduce the liquidity measure, reflecting a stronger shopping externality effect from nearby houses for sale drawing additional interested buyers to the locale (Turnbull and Drombrow, 2006).

Finally, $INTERNAL_i$ is a variable identifying whether a development project is marketed internally by the developer or exclusively by external agents. Unlike the market of individual housing units (e.g. resale of single-family dwellings), developers have an inventory of housing units to sell. They are also likely to be repeat game players in the market; hence, reputation may be an important consideration. Developers likely also possess superior information and market expertise relative to nonprofessional private sellers of individual units. While we expect a developer's unit-specific information to equal or exceed that of an external brokerage firm, it is not clear that the same may be true about broader market information or selling expertise. These questions are relevant to understanding why some developers choose to appoint internal agents rather than market their units through external agents.

In order to gain insight into this question, in some of the empirical frameworks we also model the developer's choice of internal vs. external agents as a function of variables capturing developer characteristics, market conditions, and development attributes:

$$INTERNAL_i = g(DEVELOPER_i, MARKET_i, DEVELOPMENT_i) \quad (20)$$

We use probit to estimate this choice equation using data drawn from new development projects to reflect that the decision is made at the project level prior to offering units on the market.

4. Data

The sample used to estimate the empirical models is compiled from new residential condominium and apartment developments launched between 1996 (2nd Quarter) and 2005 (4th Quarter) in Singapore and the subsequent sale of their individual units. In effort to obtain a more homogenous sample of developments, we concentrate on newly developed residential projects all with at least 100 dwelling units. Within the study period, 188 such projects are launched.

New Developed Residential Projects - The main source of project level information for our study is the Urban Redevelopment Authority (URA) Property Market Information, which is published quarterly. It is considered the most objective source of data since developers are required by regulations to provide accurate information to the governing authority.[4] The URA publication contains the dates of written permission, building approval, grant of sale license, marketing launch, and completion of the individual developments. Statistics on the total number of uncompleted units launched and sold for every residential development are also reported together with the aggregate figures for the entire market. This data, when coupled with sales data on individual unit sales, provide a useful benchmark for a property's initial launch date, as well as the important milestone, namely when the particular

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[4] Press reports on property launches offer another source of information on the take-up rates. However, we decided not to rely on this source because of its potential bias and incompleteness. In particular, developers, for good publicity reasons, may manipulate their sales figures to report a higher take-up rate for their projects. Furthermore, poorly performing projects may not be reported.

project is physically completed. Over the study period, the newly launched developments contain 62,092 units with an average of 330 units per development.

Table 1 presents the summary statistics for developments. The developments in the sample are predominantly (66%) undertaken by publicly listed companies and 93% of developers have prior experience in the market. Only 14% of the projects are undertaken as joint ventures and nearly a third of the projects are marketed by an internal agent. Of the development projects in the sample, 86% are condominium complexes.[5] Approximately 52% of the sample properties have 99-year land leasehold tenure and the remaining 48% have freehold or leasehold tenure of 999 years.

The locational attributes of the projects reflect the relatively small physical area of the Singapore market. On average, developments are within 1 km of a metro station ($UMRT_i$) and have an average distance to the city center ($UCBD_i$) of 8.2 km. The furthest project is located only 22 km from the city center. Approximately 23% of the developments are in residential districts informally considered prime districts by buyers and sellers in Singapore's real estate market.

The project level data is used to estimate model (19), the developer's choice to market the development internally or exclusively by external agents.

Individual Unit Sales - Information related to the individual unit sales is obtained from the Real Estate Information System (REALIS), a database maintained by Singapore's national land use planning authority, the Urban Redevelopment Authority (URA). This transaction database is based on caveats lodged by the purchasers to protect their interest soon after an option to purchase a property is exercised. Caveats are legal documents filed by home purchasers through their lawyers with the Singapore Land Authority to register their legal interest in the property. Typically, caveats are lodged two to three weeks after a purchaser signs an option to purchase at the model unit. Since it is not mandatory to lodge a caveat, it is technically possible that the transaction database does not include all of the units sold directly by the developers. However, such omissions are likely few in practice since most home purchases involve mortgage loans, in which case the solicitors acting on behalf of the banks insist on lodging a caveat to protect their client's interest in the property. The high coverage ratio (observed unit sales to actual units) of this data source helps provide a more accurate measure of liquidity and competition.

[5] Condominium developments include specific additional amenities not present in what are identified as apartment developments in the Singapore market. Note that all condominium and apartment units in this sample are sold as individual units.

To determine the coverage ratio for the study, a first sale data set was constructed from the REALIS data based on transactions from the initial launch of a project through 2009 occurring in the 188 targeted projects. The unit sales are sorted by address (including unit number) and the contract date.[6] Properties with the same address but later contract dates are deleted from the sample. For properties with a first sale and a sub-sale (a sale subsequent to the first sale, occurring before project completion) on the same contract date, the sub-sale is removed from the data. The resulting data set contains 59,149 observations. Taking into account that some observations reflect multiple unit sales, the first sale data set represents 59,295, or 95.5%, of the 62,092 units launched. At the development level, the average coverage ratio (observed unit sales divided by total units) is slightly over 95% with three developments having full coverage. Four developments, however, have coverage ratios below 85%.

In addition to assuring a high coverage rate, we use the first sale data to derive specific dates for particular events in the development process. For example, it is possible to find the date of the first sale within each development rather than having to rely on the quarter of first sale reported in the URA Property Market Information. Within the REALIS data, properties sold after the issuance of the Certificate of Statutory Completion for the project are listed as a *Resale* regardless of whether it is the first time the unit has sold or not. The transaction record therefore allows us to identify a completion date for each development.

To calculate the measure of total competition from surrounding units on the market, the first sale data set is further refined to focus on transactions occurring prior to the competition of the development. Most new condominiums in Singapore are sold before project completion, which is a common practice in many of the Asian markets such as China, Hong Kong, Taiwan, South Korea, and Malaysia (Chang and Ward, 1993; Ong, 1997; Lai, et al., 2004). Nonetheless, the focus on units sold prior to completion is consistent with Sirmans, et al. (1997) who study the effect of development sequencing on the pricing of residential real estate. In this study, the authors suggest that early buyers are compensated for additional risk with lower house prices in the early stages of sellout and that prices converge to prices in competing, completed project as more units are sold. To make the calculation of the competition measure tractable, we use the pre-completion transactions and control for the type of sequence of sales effects identified by Sirmans, et al. (1997) when estimating the price and liquidity equations. Unit transactions occurring after the launch of the last development in the

[6] Note that prior to this sorting, unit addresses were verified to be consistent with the addresses for the development and typos in addresses were corrected as not to appear as a unique unit in the development.

study period are also removed from the data. It is necessary to remove these observations from the study, because we are unable to accurately control for new development entering the market. Thus, the competition measures for observation in the last development beyond the launch would likely underestimate the true level of competition**.** The resulting sample contains 48,044 observations, with 1.75% of these first sale observations being recorded as a *Subsale*.

Recall that a *Subsale* (as designated in the data source) is a sale subsequent to a first sale that occurs prior to Certificate of Statutory Completion, the formal project completion date. The *Subsale* appearing in the data may simply be a result of a data entry error; a random event. Another more likely answer may be that the new sale or first sale for the particular unit was not captured in the database because no caveat was lodged by the first buyer; an event noted as having a small occurrence rate given banks insist on lodging a caveat if the purchase involves a mortgage loan. One reason not to file a caveat is if the first buyer's intention is to quickly flip the unit, i.e. buy from the developer and sell to a third party within a relatively short period of time. In this scenario, we contend that the unit effectively remains on the market from the initial offering to the time the unit is sold as a subsale. Based on this contention, we include such *Subsale* observations in the calculation of the liquidity and competition measures.

The liquidity and sales measures are calculated based on unit transactions occurring within the study period. However, the sample must be adjusted further when estimating the price and liquidity equations. As currently calculated, the competition measure fails to capture competing units launched in developments prior to the beginning of the study window that remain on the market during our sample period. For example, units in a development launched one quarter prior to the beginning of the study are not included in the calculation of the competition measure. This means the competition measure for units near the beginning of the study underestimates the true competition from other units on the market at the same time. To take this into account, we impose a burn-in period to the beginning of the study period. In other words, while we use the entire sample to calculate the competition measure, the estimation is conducted on the sample excluding sales that occur during the burn-in period. In the current version of this study, we impose a 24 month burn-in period, which appears long enough to ensure that our calculation of the competition measure captures all relevant competing units. This burn-in period reflects the average time developments launched in 1996 and 1997 took to reach completion (30 months) adjusted 6 months to reflect prior knowledge of market participants of future development.

The final working sample reflects transactions of 30,867 new residential condominium and apartment units sold between March 1998 and December 2005 in developments launched between 1996 (2nd Quarter) and 2005 (4th Quarter). Table 2 contains the descriptive statistics and variable definitions of the unit sales sample used in the analysis. Monetary values are expressed in Singapore dollars throughout. The average price of the units in the full sample is S$ 797,380.[7] The average unit in the full sample is located on the ninth floor and has a floor area of 120 square meters (sqm). We expect that the purchase price will be related positively with the unit floor area and floor level. Ong and Koh (2000) and Tse (2002) show that flats located on higher floors in Singapore and Hong Kong are more desirable and command a price premium. Units on higher floors tend to have a better view, be more airy and be less exposed to visual intrusion from neighboring buildings. In addition, about 9% of the units in our full sample are located on "lucky" floors, which we define as those ending with number eight, namely the 8th floor, 18th floor, and 28th floor, while about 11.5% are on "unlucky" floors, defined as those ending with the number four, namely 4th floor, 14th floor, and 24th floor.[8] Several previous studies have found that, in areas with a relatively high concentration of Chinese households, superstitions may play a significant role in determining house prices. For example, in Hong Kong, Chau, Ma and Ho (2001) observed that flats located on "lucky" floors command a 2.8% price premium.

Whilst the relationship of many of these variables with house prices is well documented in the literature, their effect on the liquidity of new residential projects is less studied. The tenure of the property may impact its liquidity. If leasehold properties are less desirable than freehold properties, we predict the liquidity of leasehold properties will be lower, all else being equal. Locational attributes of the individual project, such as if the project is located in the prime residential district, or near the city center of a metro station may also impact a unit's liquidity.

5. Empirical Results

Table 3 reports the 3SLS estimates for the price-liquidity simultaneous system with the *INTERNAL* dummy variable for agent structure. The price equation results for characteristics resemble results from other studies for other markets. There are few relevant liquidity comparisons in the literature. Living area and the story on which the unit is located increase price and liquidity. We do

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[7] The recorded transaction price is the agreed purchase price of the property excluding stamp duties, legal and agency fees, and other professional fees.

[8] The number eight is considered a lucky number because it sounds like "prosperity" in Chinese. Conversely, the number four is considered an unlucky number because it sounds like the words "death" and "taxes".

not, however, find a lucky or unlucky floor effect on price. Location matters for both price and liquidity, although distance to nearest metro station increases price but has no significant liquidity effect. Condominium status increases value and liquidity, as does a freehold property interest. Larger developments have higher unit prices and faster sales.

The coefficients on *INTERNAL* are negative in the price and liquidity equations, implying both lower selling price and shorter time to sell. The significant lower price effect indicates that the use of internal agents does not successfully vitiate the principal-agent problem inherent in the external agent system. The liquidity estimates, however, indicate that internal agents lead to quicker sales, but the coefficient is not significant. Overall, these results are consistent with the high external agent productivity environment identified in the theoretical discussion, the environment in which external agents are more likely to outperform internal agents.

Before turning to the other models, note that the effects of competing overlapping units for sale varies depending upon whether the other units are inside or outside the same community (planning areas) as the subject property. The competition variables in the liquidity equation have significant positive coefficients, indicating that other units for sale both inside and outside the community but within 2 km are competing units with the subject property. The smaller coefficient on the outside competing units is consistent with the notion that units in other community areas are poorer substitutes than units in the same community area. Looking at the price equation, the competition density variable for surrounding units within 2 km and inside the community area tend to reduce price, as expected. The significant positive coefficient on the competition density variable for units outside the community indicates that these units exhibit stronger shopping externality effects, with a greater number of nearby units for sale outside the community area drawing more potential buyers to the subject property. This relationship is surprising as it indicates that buyers tend to shop across different community boundaries and are easily drawn to search in neighboring community areas when looking at units for sale nearby.

To push the analysis further, we also consider the influence of developer, market, and project characteristics on the choice of internal or external agent regime. Table 4 reports the probit estimates for the agent choice equation estimated on the project level data set described earlier. The variables in these models pertain to developer characteristics, market conditions, and project characteristics. The full model estimates reveal that only a few of the variables are significant. Therefore, we also estimate a trimmed model using a stepwise procedure in order to refine the full model.

The results indicate that *LISTED* companies tend to rely more on external agents, as do high volume developers who have launched a large number of units in the preceding two years. Greater vacancy rates in the previous period also tend to reduce the propensity of a developer to rely on internal agents. We find no significant project location, size or amenity affects on the choice of interior versus exterior agents.

Tables 5 and 6 report the price and liquidity model estimates using the predicted probabilities of internal agent derived from the models in table 4. Table 5 presents the estimates for the competition measures based on properties for sale within a 2 km radius. The estimates are similar to those reported for the dummy variable internal agent model in table 3, except for the *INTERNAL* coefficients themselves. In these models, relying on internal agents leads to significantly lower selling prices, as before, but also to significantly faster sales. Overall, the estimates are robust across the models based on full and trimmed predicted internal agent probabilities.

The analysis thus far assumes that only neighboring units within a 2 km radius represent competing units on the market. This distance approximates the 1 mile framework applied in earlier studies of neighborhood competition effects (Turnbull and Dombrow, 2006; Zahirovic-Herbert and Turnbull, 2008). As a robustness check, we recalculate the competition and competition density variables for greater distances. Given the relatively small size of the market,[9] table 6 reports the 10 km estimates for comparison with the 2 km results. Once again we see that most of the coefficient estimates are robust. Several important differences do arise, however, when the distance in the competing house variables is increased. The *INTERNAL* agent effects for the predicted internal agent probability models now resemble the dummy variable internal agent model results reported in table 3; all of the models in table 6 show that internal agents lead to significantly lower selling price but have no significant effect on liquidity. Additionally, other units on the market inside the same community area have strong competition effects on price and liquidity, as before, but now units on the market outside the community but within the 10 km radius of the subject property also exhibit significant competition effects. The latter result is a change from the shopping externalities implied by the 2 km estimates in tables 3 and 5.[10]

These results reveal that estimated internal agent liquidity effects are surprisingly sensitive to the specification of local competition for the predicted internal agent probability models, although the 10 km exhibits superior goodness-of-fit. Overall, internal agents lead to lower selling price in all of the

[9] Singapore is approximately 25x48 km and residential areas do not cover the entire island.
[10] The pattern of estimates shifts from the 2 km results to the 10 km results between 5 and 8 km. Overall, the 10 km results for the competition variables hold for distances greater than 10 km, with the exception of the competition density variable for units outside the community which falls insignificant beyond 12 km, but turns negative and significant beyond 16km. It should be noted, the competition measures become less meaningful as indicators of local market conditions at distances greater than 10 km given the small size of the total market area.

specifications while the weight of the evidence indicates no significant effect on liquidity. In terms of the theory, this combination of results is consistent with higher sales productivity for external agents, situations in which we would not expect internal agents to successfully ameliorate the principal-agent problem associated with external agents.

As a final robustness check, tables 7 and 8 report bootstrap estimates for the predicted internal agent probability models. The 95% confidence intervals are reported below the coefficient estimates. The results are surprisingly robust relative to the non-bootstrap estimates in tables 5 and 6. Importantly, the bootstrap estimates support the previous conclusions regarding the effects of competing units for sale both inside and outside the community and the impact of internal agents.

6. Conclusion

This paper offers empirical evidence concerning the principal-agent problem inherent in the seller-agent relationship in real estate. The empirical literature has been limited by available data and the general complexity of the problem. The existing evidence supports the notion that the commission contract structure typical in real estate leads to the agent moral hazard anticipated by principal-agent theory (Levitt and Syverson, 2008; Rutherford, et al., 2005). A departure from previous studies, this paper examines the case where the sellers are developers, investors, or other sophisticated market participants. These sophisticated sellers can rely on external agents or hire internal agents, a wider range of selling options than private sellers of individual houses enjoy. The theory shows that neither scheme eliminates agent moral hazard in asymmetric information environments. Further, agent moral hazard differences for the internal and external cases mean that while internal incentives can be structured to lead to superior internal agent performance over external agents, it nonetheless becomes increasingly difficult for the developer to do so when external agents enjoy inherent productivity advantages.

This is the first empirical study to measure agent moral hazard effects on both selling price and liquidity in a simultaneous systems approach. Data from Singapore multiple unit developments reveals that developers who rely on internal agents obtain lower selling prices. The weight of the evidence also indicates an insignificant effect of internal agents on liquidity or pace of sales. Overall, it appears that relying on internal agents does not fully resolve the principal-agent problem often associated with external agents.

The empirical results are consistent with the notion that external agents enjoy greater inherent selling ability or productivity, situations in which internal agent schemes have a more difficult time overcoming the persistent principal-agent information asymmetries confronting even sophisticated property sellers. The evidence also indicates that external agents are more attractive to the most active publicly listed developers in general.

Appendix

This appendix derives several properties of the equilibria and propositions used in the paper. The efficient effort $e^*(w)$ satisfies the marginal condition

$$wf_e(e) = 1 \tag{A.1}$$

Implicit differentiation yields the slope of the e^* trajectory or function in (w, e) space as

$$\frac{\partial e^*(w)}{\partial w} = \frac{f_e}{-wf_{ee}} > 0 \tag{A.2}$$

The e^* curve is upward sloped as depicted in figures 1 and 2.

The outside agent with ability *a* has equilibrium effort $e^o(w, a, c)$ satisfying the marginal condition

$$cwaf_e(e) = 1 \tag{A.3}$$

Implicit differentiation yields the properties of this function as

$$\frac{\partial e^o(w,a,c)}{\partial \omega} = \frac{f_e}{-wf_{ee}} > 0 \tag{A.4}$$

$$\frac{\partial e^o(w,a,c)}{\partial a} = \frac{f_e}{-af_{ee}} > 0 \tag{A.5}$$

$$\frac{\partial e^o(w,a,c)}{\partial c} = \frac{f_e}{-cf_{ee}} > 0 \tag{A.6}$$

The e^o curve is upward sloped in (*w*,*e*) space as in figures 1 and 2. Increases in ability *a* or the commission rate *c* induce parallel upward shifts in the curve as depicted in figure 1.

The inside agent in the asymmetric developer-agent information environment supplies sales effort $e^i(w, B, q)$ satisfying the marginal condition

$$Bwf_e(e)V_v\big(q - wf(e)\big) = 1 \tag{A.7}$$

Focusing on results used in the paper, implicit differentiation yields the slope and bonus shift properties

$$\frac{\partial e^i(w,B,q)}{\partial w} = \frac{V_v f_e - V_{vv} w f_e f}{-V_v w f_{ee} + V_{vv} w^2 f_e^2} \tag{A.8}$$

$$\frac{\partial e^i(w,B,q)}{\partial B} = \frac{V_v f_e}{-V_v w f_{ee}} > 0 \tag{A.9}$$

(A.9) establishes that increasing the bonus increases the effort supplied by the inside agent at each level of productivity, shifting the insides agent effort supply curve e^i upward in (w, e) space.

Finally, note that the application of the implicit function theorem in all three models yields continuous effort functions over the relevant regions. The continuity property plays a role in the proofs below.

The first result establishes that the inside agent cannot replicate the efficient outcome when V is a single-peaked symmetric distribution. The result holds for other distributions, but this particular case is a popular form in incentives theory that is easy to work with and, in this application, is sufficient to establish the property that efficiency can only be attained in special situations; efficiency is not a general property of the inside agent equilibrium and indeed is not attainable in most cases (as here). Here we establish that $e^i(w, B, q) = e^*(w)$ can hold at most two realized w; that is, the inside agent is inefficient almost everywhere.

Proposition 1 *For the single-peaked symmetric distribution* $V(\upsilon)$, $e^i(w, B, q) = e^*(w)$ *with measure zero.*

Proof. Consider the bonus B set such that the inside agent replicates the efficient effort. Define w' such that $Bw' f_e V_\upsilon(q - w' f) = 1$. In this case (A.7) satisfies (A.1) so that $e^i(w', B, q) = e^*(w')$. Thus w' represents an intersection of the inside agent and efficient effort functions in (w, e) space. To prove the proposition, show that there exist at most two such w'. Specifically, (i) there exists at most one w' such that $w' f\left(e^i(w')\right) < q$ (i.e., $\upsilon > 0$) and (ii) there exists at most one w'such that $w' f\left(e^i(w')\right) > q$ (i.e., $\upsilon < 0$). For the single-peaked symmetric distribution $V(\upsilon)$, by the law of probability $V_\upsilon(\upsilon) \geq 0$ for all υ within the support, and $V_{\upsilon\upsilon}(\upsilon) > 0$ for all $\upsilon < 0$ and $V_{\upsilon\upsilon}(\upsilon) < 0$ for all $\upsilon > 0$ (recall $E[\upsilon] = 0$), so that

$$V_{\upsilon\upsilon} > 0 \;\text{ for }\; wf > q \;\text{ (i.e., } \upsilon < 0) \tag{A.10}$$

$$V_{\upsilon\upsilon} < 0 \;\text{ for }\; wf < q \;\text{ (i.e., } \upsilon > 0) \tag{A.11}$$

Substituting $Bw' f_e V_\upsilon(q - w' f) = 1$ from (A.7) into the slope of the e^i function (A.8) at any w' and simplifying yields

$$\frac{\partial e^i(w)}{\partial w} = \frac{f_e - BV_{\upsilon\upsilon} w f_e f}{-w f_{ee} + BV_{\upsilon\upsilon} w^2 f_e^2} \tag{A.12}$$

Together with (A.2) and (A.10)-(A.11), this yields

$$\frac{\partial e^i(w')}{\partial w} \gtrless \frac{\partial e^*(w')}{\partial w} \;\text{ for }\; V_{\upsilon\upsilon}(\upsilon) \lesseqgtr 0, \;\text{ i.e., for } \upsilon \gtrless 0 \tag{A.13}$$

Result (A.13) establishes that the e^i function is shallower than the e^* function at any intersection in (w, e) space for $\upsilon < 0$; therefore, since both functions are continuous there can be at most only one such intersection for all $\upsilon < 0$ (i.e., $wf > q$). This establishes claim (i). Result (A.13) also establishes that the e^i function is steeper than the e^* function at any intersection in (w, e) space for $\upsilon > 0$; therefore, there can be at most only one such intersection for all $\upsilon > 0$ (i.e., $wf < q$). This establishes claim (ii). Together, the claims establish the proposition. ■

A similar result pertains to the effort of inside and outside agents. The following proposition shows that there is no inside agent bonus scheme that will induce the agent to replicate outside agent behavior in the developer-agent asymmetric information environment. The proposition is proved by showing that whenever the two effort curves intersect at a low realized w value, e^i must cut e^o from below and whenever the two effort curves intersect at a high realized w value, e^i must cut e^o from above, as depicted in figure 2.

Proposition 2 *Consider the bonus B set such that the inside agent replicates the effort of the outside agent. Define* ω' *such that* $Bw' f_e V_\upsilon(q - w'f) = ca$*, i.e.,* $e^i(w', B, q) = e^o(w', a, c)$*;* ω' *represents an intersection of the inside and outside agent effort functions in* (w, e) *space. For the single-peaked symmetric distribution* $V(\upsilon)$ *there exist at most two such* w'*. Specifically, (i) there exists at most one* w' *such that* $w'f\left(e^i(w')\right) < q$ *(i.e.,* $\upsilon > 0$*) and (ii) there exists at most one* w' *such that* $\omega' f\left(e^i(w')\right) > q$ *(i.e.,* $\upsilon < 0$*).*

Proof. Substitute $Bw' f_e V_\upsilon(q - w'f) = ca$ into the slope of the e^i function (A.8) at any w' to obtain

$$\frac{\partial e^i(w)}{\partial w} = \frac{caf_e - BV_{\upsilon\upsilon} w f_e f}{-caw f_{ee} + BV_{\upsilon\upsilon} w^2 f_e^2} \tag{A.14}$$

Together with (A.4) and (A.10)-(A.11), this yields

$$\frac{\partial e^i(w')}{\partial w} \gtrless \frac{\partial e^o(w')}{\partial w} \text{ for } V_{\upsilon\upsilon}(\upsilon) \lesseqgtr 0, \text{ i.e., for } \upsilon \gtrless 0 \tag{A.15}$$

Result (A.15) establishes that the e^i function is shallower than the e^o function at any intersection in (w, e) space for $\upsilon < 0$; therefore, applying continuity there can be at most only one such intersection for all $\upsilon < 0$ (i.e., $wf > q$). This establishes claim (i). Result (A.15) also establishes that the e^i function is steeper than the e^o function at any intersection in (w, e) space for $\upsilon > 0$; therefore, there can be at most only one such intersection for all $\upsilon > 0$ (i.e., $wf < q$). This establishes claim (ii) and the proposition. ■

Table 1: Summary statistics of residential development projects launched by developers in Singapore 1996Q2 through 2005Q4 (N = 188)

Developer Profile		Mean	Std. Dev.	Min.	Max.
$JOINT_i$	*1, if joint venture; 0, else*	0.1436	0.3516	0.00	1.00
$EXPERIENCE_i$	*1, if developer has prior experience; 0, else*	0.9309	0.2544	0.00	1.00
$LISTED_i$	*1, if publically listed company; 0, else*	0.6649	0.4733	0.00	1.00
$LAUNCHED_i$	*Ranking of developer according to number of units launched in prior two years (1 most active)*	5.0266	3.6701	1.00	15.00
$QUALITY_i$	*Average the Conquas Score (a construction quality index) for projects in the previous years by the same developer*	79.919	4.1978	69.60	92.30
Market Condition		Mean	Std. Dev.	Min.	Max.
$\Delta RPI(t\text{-}1)_i$	*Change in Residential Price Index (RPI) lagged one period*	0.0004	0.0380	-0.09	0.12
$MKT\_VAC(t\text{-}1)_i$	*Market vacancy rate lagged one period*	0.0770	0.0102	0.06	0.10
$PRIMERATE_i$	*Prime lending rate at launch*	5.7964	0.5334	5.30	7.77
$UNIT\_SUPPLY_i$	*Supply of units in the entire Singapore market*	2195.070	861.559	506.00	3560.00
$COMPETITION_i$	*Number of residential projects by the* ***other*** *developers in the same planning area and year.*	0.4043	0.4921	0.00	1.00
Project Attributes		Mean	Std. Dev.	Min.	Max.
$FREEHOLD_i$	*1, indicating freehold tenure; 0, else*	0.4840	0.5011	0.00	1.00
$PRIME_i$	*1, if unit is located in prime location; 0, else*	0.2287	0.4211	0.00	1.00
$UCBD_i$	*Distance to CBD (km)*	8.1969	4.6071	0.36	22.10
$UMRT_i$	*Distance to the nearest metro station (km)*	1.0440	0.7470	0.05	3.30
$NEAR\_WATER_i$	*1, if within 500m of sea/lake/river; 0, else*	0.1011	0.3022	0.00	1.00
DEV_SZ_i	*Number of units in development*	330.277	207.548	100.00	1111.00
$CONDO_i$	*1, if located within condominium dev.; 0, else*	0.8564	0.3516	0.00	1.00
Marketing		Mean	Std. Dev.	Min.	Max.
$INTERNAL_i^{(0,1)}$	*1, if the project is marketed by an internal agent*	0.3245	0.4694	0.00	1.00

Table 2: Summary statistics of new unit transactions

Units Attributes		Mean	Std. Dev.
$PRICE_i$	*Selling price of unit*	797380	515886
$AREA_i$	*Area (sqm) of the i^{th} unit.*	119.2822	57.4255
$FLOOR_i$	*Floor level of the unit*	9.7474	8.4126
$LUCKY_i$	1, *if unit is located a floor ending with an 8;* 0, *else*	0.0876	0.2827
$UNLUCKY_i$	1, *if unit is located a floor ending with a 4;* 0, *else*	0.1157	0.3198
GRD_F_i	1, *if unit is located on the ground level;* 0, *else*	0.0636	0.2441
TOP_F_i	1, *if unit is located on the top most floor;* 0, *else*	0.0608	0.2389
Transaction Char.		Mean	Std. Dev.
$NUM\_OF\_UNITS_i$	*Number of units in the recorded transaction*	1.0033	0.1249
SUB_SALE_i	1, *A sale of a unit prior to project completion where a caveat was not filed by the first buyer;* 0, *else*	NA	NA
Marketing		Mean	Std. Dev.
$INTERNAL_i^{(0,1)}$	1, *if located in project using internal agent,* 0, *else*	0.2413	0.4279
$INTERNAL_i^{FULL}$	*Estimated probability project is marketed by an internal agent using the full probit model specification*	0.2615	0.2154
$INTERNAL_i^{TRIM}$	*Estimated probability project is marketed by an internal agent using the reduced or trimmed probit model specification*	0.2976	0.1996
Liquidity and Competition		Mean	Std. Dev.
$LIQUIDITY_i$	*Number of days since last sale in project*	3.8822	19.7126
$TOTCOMP\_IN_i^{02}$	*The sum of the total units available each day over the liquidity period within 2 km & the unit's planning area*	465.752	2208.840
$TOTCOMP\_OUT_i^{02}$	*The sum of the total units available each day over the liquidity period within 2 km & outside of the unit's planning area*	158.048	1320.568
$COMPDENS\_IN_i^{02}$	*$TOTCOMP\_IN_i^{02}$ divided by daily liquidity measure*	633.754	2471.426
$COMPDENS\_OUT_i^{02}$	*$TOTCOMP\_OUT_i^{02}$ divided by daily liquidity measure*	122.267	389.3871
$TOTCOMP\_IN_i^{10}$	*The sum of the total units available each day over the liquidity period within 10 km & the unit's planning area*	1467.267	6251.305
$TOTCOMP\_OUT_i^{10}$	*The sum of the total units available each day over the liquidity period within 10 km & outside of the unit's planning area*	5255.211	21446.148
$COMPDENS\_IN_i^{10}$	*$TOTCOMP\_IN_i^{20}$ divided by daily liquidity measure*	1905.238	5512.167
$COMPDENS\_OUT_i^{10}$	*$TOTCOMP\_OUT_i^{20}$ divided by daily liquidity measure*	7887.084	13139.267
Observations		30867	

Note: The sample of *New Sales* (transactions occurring prior to completion) includes all transactions that fall 24 months after the first sale of the study period through the fourth quarter of 2005.

Table 3: 3SLS Estimation results for price and liquidity equations with fixed effects internal agent variable

Variable	Price Equation	Liquidity Equation
Intercept	8.8584	-196.4428
	(506.99)	(6.12)
$LIQUIDITY_i$	5.3E-04	
Number of days since last sale in project	(6.02)	
$\ln(PRICE_i)$		23.1436
Natural logarithm of selling price		(6.40)
$\ln(AREA_i)$	0.9153	-21.4061
Area (sqm) of the i^{th} *unit.*	(258.06)	(6.41)
$LUCKY_i$	-1.5E-04	-0.2575
1, if unit is located a floor ending with an 8; 0, else	(0.05)	(0.73)
$UNLUCKY_i$	0.0031	0.3738
1, if unit is located a floor ending with a 4; 0, else	(1.12)	(1.19)
$\ln(FLOOR_i)$	0.0473	-1.4539
Floor level of the unit	(34.08)	(6.32)
GRD_F_i	-0.0299	1.0051
1, if unit is located on the ground level; 0, else	(6.69)	(1.93)
TOP_F_i	-0.1132	2.5101
1, if unit is located on the top most floor; 0, else	(17.57)	(3.02)
$TOP\_F_i * DEV\_HEIGHT_i$	0.0025	-0.0134
Interaction term	(5.32)	(0.25)
$PRIME_i$	0.2818	-7.0882
1, if unit is located in prime location; 0, else	(84.21)	(6.39)
$UCBD_i$	-0.0190	0.4656
Distance to CBD (km)	(82.51)	(6.60)
$UMRT_i$	0.0254	0.0680
Distance to the nearest metro station (km)	(18.7)	(0.37)
$NEAR\_WATER_i$	0.1158	-1.5200
1, if located within 500m of sea/lake/river; 0, else	(41.58)	(2.70)
$CONDO_i$	0.1145	-3.8976
1, if located within condominium complex; 0, else	(33.52)	(6.98)
$FREEHOLD_i$	0.1645	-4.8021
1, indicating freehold tenure; 0, else	(73.41)	(7.41)
DEV_SZ_i	7.2E-05	-0.0063
Total number of units in development	(14.81)	(10.73)
$REMAINING_i$	0.0315	-6.4059
Proportion of total units remaining	(8.67)	(15.32)
$NUM\_OF\_UNITS_i$	0.0803	-1.6878
Number of units in the recorded transaction	(11.48)	(1.98)
$INTERNAL_i^{(0,1)}$	-0.0237	-0.2672
1, if located in project using internal agent, 0 , else	(11.17)	(1.04)
$TOTCOMP\_IN_i^{02}$		0.0037
The sum of the total units available each day over the liquidity period within 2 km & the unit's planning area		(79.45)
$TOTCOMP\_OUT_i^{02}$		0.0024
The sum of the total units available each day over the liquidity period within 2 km & outside of unit's planning area		(27.83)
$COMPDENS\_IN_i^{02}$	-1.3E-05	
$TOTCOMP\_IN_i^{02}$ *divided by daily liquidity measure*	(30.65)	
$COMPDENS\_OUT_i^{02}$	1.7E-05	
$TOTCOMP\_OUT_i^{02}$ *divided by daily liquidity measure*	(6.70)	
Year of Sale Fixed Effects:	Yes	Yes
System Weighted R-Square		0.7269

Note: Asymptotic t-statistics are reported in parentheses.

Table 4: Estimation results for agent choice equation (development level)

Variable	Full Model	Trimmed Model
Intercept	1.6289	3.2628
	(0.69)	(<.01)
$JOINT_i$	-0.2751	
1, if joint venture; 0, else	(0.41)	
$EXPERIENCE_i$	0.3562	
1, if developer has prior experience; 0, else	(0.51)	
$LISTED_i$	0.3562	-0.9017
1, if publically listed company; 0, else	(0.51)	(<.01)
$LAUNCHED_i$	-0.1504	-0.1363
Ranking of developer according to number of units launched in prior two years (1 most active)	(<.01)	(<.01)
$QUALITY_i$	-0.0025	
Average the Conquas Score (a construction quality index) for projects in the previous years by the same developer	(0.94)	
$\Delta RPI(t\text{-}1)_i$	1.4260	
Change in Residential Price Index (RPI) lagged one period	(0.66)	
$MKT\_VAC(t\text{-}1)_i$	-27.8910	-33.0261
Market vacancy rate lagged one period	(0.04)	(<.01)
$PRIMERATE_i$	0.1933	
Prime lending rate at launch	(0.45)	
$UNIT\_SUPPLY_i$	7.6E-05	
Supply of units in the entire Singapore market	(0.62)	
$COMPETITION_i$	0.3207	
Number of residential projects by the **other** *developers in the same planning area and year.*	(0.18)	
$FREEHOLD_i$	0.1138	
1, indicating freehold tenure; 0, else	(0.67)	
$PRIME_i$	0.0495	
1, if unit is located in prime location; 0, else	(0.89)	
$UCBD_i$	-0.0511	
Distance to CBD (km)	(0.13)	
$UMRT_i$	0.1991	
Distance to the nearest metro station (km)	(0.23)	
$NEAR\_WATER_i$	0.4173	
1, if located within 500m of sea/lake/river; 0, else	(0.29)	
DEV_SZ_i	-3.2E-04	
Number of units in development	(0.63)	
$CONDO_i$	0.1197	
1, if located within condominium complex; 0, else	(0.73)	
Likelihood Ratio	59.6675	47.7015
	(0.01)	(0.01)

Notes: Dependent variable is defined as 1 if internal agent. Also note that p-values are reported in parentheses.

Table 5: 3SLS Estimation results for price and liquidity equations with 2 km competition radius and *estimated* internal agent variable

Variable	Full Model Price Equation	Full Model Liquidity Equation	Trimmed Model Price Equation	Trimmed Model Liquidity Equation
Intercept	8.8728	-194.4103	8.8615	-200.6602
	(505.99)	(6.08)	(503.41)	(6.28)
$LIQUIDITY_i$	5.4E-04		5.0E-04	
Number of days since last sale in project	(6.12)		(5.72)	
$\ln(PRICE_i)$		22.9594		23.6801
Natural logarithm of selling price		(6.38)		(6.57)
$\ln(AREA_i)$	0.9155	-21.2616	0.9162	-21.9532
Area (sqm) of the i^{th} unit.	(258.69)	(6.41)	(257.91)	(6.60)
$LUCKY_i$	-3.5E-04	-0.2598	-3.2E-04	-0.2605
1, if unit is located a floor ending with an 8; 0, else	(0.11)	(0.74)	(0.10)	(0.74)
$UNLUCKY_i$	0.0035	3.8E-01	0.0033	0.3775
1, *if unit is located a floor ending with a 4;* 0, *else*	(1.26)	(1.21)	(1.20)	(1.20)
$\ln(FLOOR_i)$	0.0471	-1.4444	0.0469	-1.4759
Floor level of the unit	(33.97)	(6.32)	(33.79)	(6.46)
GRD_F_i	-0.0295	1.0061	-0.0291	1.0409
1, if unit is located on the ground level; 0, else	(6.59)	(1.94)	(6.50)	(2.00)
TOP_F_i	-0.1111	2.5013	-0.1103	2.5915
1, if unit is located on the top most floor; 0, else	(17.28)	(3.03)	(17.11)	(3.14)
$TOP\_F_i * DEV\_HEIGHT_i$	0.0024	-0.0134	0.0023	-0.0154
Interaction term	(5.06)	(0.25)	(4.96)	(0.29)
$PRIME_i$	0.2802	-7.0176	0.2780	-7.2755
1, if unit is located in prime location; 0, else	(84.14)	(6.39)	(83.41)	(6.66)
$UCBD_i$	-0.0194	0.4573	-0.0190	0.4857
Distance to CBD (km)	(85.76)	(6.40)	(81.85)	(6.87)
$UMRT_i$	0.0266	0.1074	0.0242	0.0496
Distance to the nearest metro station (km)	(19.45)	(0.58)	(17.87)	(0.28)
$NEAR\_WATER_i$	0.1210	-1.3628	0.1135	-1.5886
1, if located within 500m of sea/lake/river; 0, else	(42.72)	(2.36)	(40.89)	(2.87)
$CONDO_i$	0.1148	-3.8811	0.1144	-3.9994
1, if located within condominium complex; 0, else	(33.66)	(6.96)	(33.43)	(7.17)
$FREEHOLD_i$	0.1647	-4.7883	0.1650	-4.9427
1, indicating freehold tenure; 0, else	(73.74)	(7.42)	(73.42)	(7.62)
DEV_SZ_i	6.9E-05	-6.4E-03	7.5E-05	-0.0063
Total number of units in development	(14.07)	(10.92)	(15.29)	(10.67)
$REMAINING_i$	0.0285	-6.4433	0.0292	-6.4476
Proportion of total units remaining	(7.86)	(15.52)	(8.03)	(15.49)
$NUM\_OF\_UNITS_i$	0.0800	-1.6750	0.0805	-1.7089
Number of units in the recorded transaction	(11.44)	(1.97)	(11.49)	(2.01)
$INTERNAL_i^k$	-0.0591	-1.1508	-0.0362	-1.3860
Probability of choosing internal agent	(13.8)	(2.18)	(7.63)	(2.52)
$TOTCOMP\_IN_i^{02}$		3.8E-03		0.0037
The sum of the total units available each day over the liquidity period within 2 km & the unit's planning area		(79.64)		(79.40)
$TOTCOMP\_OUT_i^{02}$		2.4E-03		0.0024
The sum of the total units available each day over the liquidity period within 2 km & outside of the unit's planning area		(27.85)		(27.79)
$COMPDENS\_IN_i^{02}$	-1.3E-05		-1.3E-05	
$TOTCOMP\_IN_i^{02}$ divided by daily liquidity measure	(30.92)		(30.71)	
$COMPDENS\_OUT_i^{02}$	1.8E-05		1.7E-05	
$TOTCOMP\_OUT_i^{02}$ divided by daily liquidity measure	(7.07)		(6.51)	
Year of Sale Fixed Effects:	Yes	Yes	Yes	Yes
System Weighted R-Square		0.7275		0.7266

Note: t-statistics are reported in parentheses.

Table 6: 3SLS Estimation results for price and liquidity equations with 10 km competition radius and *estimated* internal agent variable

	Fixed Effect		Full Prob.		Trimmed Prob.	
	Price Equation	**Liquidity Equation**	**Price Equation**	**Liquidity Equation**	**Price Equation**	**Liquidity Equation**
Intercept	8.8623	-114.408	8.8782	-103.617	8.8671	-107.931
	(506.68)	(5.36)	(506.06)	(4.96)	(503.29)	(5.12)
$LIQUIDITY_i$	4.7E-04		4.7E-04		4.7E-04	
Number of days since last sale in project	(9.08)		(9.00)		(8.92)	
$\ln(PRICE_i)$		12.7976		11.5651		12.0732
Natural logarithm of selling price		(5.32)		(4.92)		(5.08)
$\ln(AREA_i)$	0.9145	-11.4178	0.9145	-10.2773	0.9151	-10.7632
Area (sqm) of the i^{th} unit.	(257.35)	(5.16)	(258.03)	(4.75)	(257.11)	(4.91)
$LUCKY_i$	7.3E-05	-0.4128	-1.3E-04	-0.4122	-1.3E-04	-0.4125
1, if unit is located a floor ending with an 8; 0, else	(0.02)	(1.90)	(0.04)	(1.91)	(0.04)	(1.91)
$UNLUCKY_i$	0.0029	0.1133	0.0034	0.1169	0.0032	0.1163
1, if unit is located a floor ending with a 4; 0, else	(1.06)	(0.59)	(1.23)	(0.61)	(1.17)	(0.60)
$\ln(FLOOR_i)$	0.0480	-0.9603	0.0477	-0.9052	0.0475	-0.9259
Floor level of the unit	(34.43)	(6.51)	(34.26)	(6.24)	(34.08)	(6.36)
GRD_F_i	-0.0292	0.4496	-0.0288	0.4142	-0.0284	0.4301
1, if unit is located on the ground level; 0, else	(6.51)	(1.40)	(6.44)	(1.30)	(6.32)	(1.35)
TOP_F_i	-0.1146	2.4204	-0.1125	2.2937	-0.1113	2.3406
1, if unit is located on the top most floor; 0, else	(17.75)	(4.65)	(17.48)	(4.47)	(17.26)	(4.55)
$TOP\_F_i * DEV\_HEIGHT_i$	0.0026	-0.1093	0.0025	-0.1069	0.0024	-0.1075
Interaction term	(5.50)	(3.29)	(5.27)	(3.24)	(5.13)	(3.25)
$PRIME_i$	0.2839	-5.5371	0.2822	-5.1865	0.2796	-5.3238
1, if unit is located in prime location; 0, else	(86.81)	(7.53)	(86.83)	(7.23)	(85.93)	(7.41)
$UCBD_i$	-0.0187	0.4353	-0.0191	0.4130	-0.0186	0.4237
Distance to CBD (km)	(80.49)	(9.46)	(83.55)	(8.99)	(79.42)	(9.26)
$UMRT_i$	0.0250	0.4541	0.0264	0.4759	0.0238	0.4743
Distance to the nearest metro station (km)	(18.25)	(3.98)	(19.20)	(4.14)	(17.44)	(4.25)
$NEAR\_WATER_i$	0.1195	-1.1778	0.1248	-1.0511	0.1167	-1.0808
1, if located within 500m of sea/lake/river; 0, else	(42.78)	(3.23)	(44.00)	(2.83)	(41.94)	(3.03)
$CONDO_i$	0.1190	-1.9283	0.1197	-1.7857	0.1190	-1.8524
1, if located within condominium complex; 0, else	(34.71)	(5.33)	(34.96)	(5.00)	(34.63)	(5.16)
$FREEHOLD_i$	0.1626	-2.6437	0.1624	-2.4294	0.1627	-2.5314
1, indicating freehold tenure; 0, else	(72.13)	(6.19)	(72.27)	(5.80)	(71.89)	(5.97)
DEV_SZ_i	5.3E-05	-8.0E-04	4.7E-05	-7.1E-04	5.4E-05	-7.6E-04
Total number of units in development	(10.55)	(2.20)	(9.35)	(1.96)	(10.83)	(2.07)
$REMAINING_i$	0.0322	-3.9842	0.0292	-3.9462	0.0301	-3.9645
Proportion of total units remaining	(8.91)	(15.36)	(8.11)	(15.41)	(8.34)	(15.42)
$NUM\_OF\_UNITS_i$	0.0808	-1.2851	0.0804	-1.1853	0.0810	-1.2231
Number of units in the recorded transaction	(11.52)	(2.44)	(11.48)	(2.26)	(11.54)	(2.33)
$INTERNAL_i^k$	-0.0252	0.0154	-0.0643	0.2169	-0.0420	-0.1302
Fixed effect or est. probability (model dependent)	(11.85)	(0.10)	(14.99)	(0.66)	(8.81)	(0.38)
$TOTCOMP\_IN_i^{10}$		7.2E-04		7.2E-04		7.2E-04
The sum of the total units available each day over the liquidity period within 10 km & the unit's planning area		(56.98)		(57.08)		(56.95)
$TOTCOMP\_OUT_i^{10}$		6.3E-04		6.3E-04		6.3E-04
The sum of the total units available each day over the liquidity period within 10 km & outside the unit's planning area		(159.16)		(160.28)		(159.73)
$COMPDENS\_IN_i^{10}$	-5.0E-06		-5.1E-06		-5.1E-06	
$TOTCOMP\_IN_i^{10}$ divided by daily liquidity measure	(29.44)		(30.07)		(29.74)	
$COMPDENS\_OUT_i^{10}$	5.4E-07		6.4E-07		6.1E-07	
$TOTCOMP\_OUT_i^{10}$ divided by daily liquidity measure	(7.14)		(8.56)		(8.09)	
Year of Sale Fixed Effects:	Yes	Yes	Yes	Yes	Yes	Yes
System Weighted R-Square	0.7939		0.7938		0.7933	

Note: t-statistics are reported in parentheses.

Table 7: Confidence intervals based on bootstrap percentiles - 3SLS estimation results for price and liquidity equations with 2 km competition radius and *estimated* internal agent variable

Variable	Full Model Price Equation	Full Model Liquidity Equation	Trimmed Model Price Equation	Trimmed Model Liquidity Equation
Intercept	8.8728	-194.4103	8.8615	-200.6602
	[8.823, 8.917]	[-243.2, -148.1]	[8.812, 8.906]	[-249.0, -153.7]
$LIQUIDITY_i$	5.4E-04		5.0E-04	
Number of days since last sale in project	[2.7E-4, 9.0E-4]		[2.4E-4, 8.6E-4]	
$\ln(PRICE_i)$		22.9594		23.6801
Natural logarithm of selling price		[17.914, 28.353]		[18.679, 28.969]
$\ln(AREA_i)$	0.9155	-21.2616	0.9162	-21.9532
Area (sqm) of the i^{th} *unit.*	[0.906, 0.926]	[-26.333, -16.786]	[0.907, 0.927]	[-26.997, -17.421]
$LUCKY_i$	-3.5E-04	-0.2598	-3.2E-04	-0.2605
1, if unit is located a floor ending with an 8; 0, else	[-0.006, 0.006]	[-0.935, 0.608]	[-0.006, 0.006]	[-0.939, 0.609]
$UNLUCKY_i$	0.0035	3.8E-01	0.0033	0.3775
1*, if unit is located a floor ending with a 4;* 0*, else*	[-0.002, 0.009]	[-0.300, 1.110]	[-0.002, 0.009]	[-0.303, 1.109]
$\ln(FLOOR_i)$	0.0471	-1.4444	0.0469	-1.4759
Floor level of the unit	[0.044, 0.050]	[-1.915, -1.031]	[0.044, 0.050]	[-1.951, -1.065]
GRD_F_i	-0.0295	1.0061	-0.0291	1.0409
1, if unit is located on the ground level; 0, else	[-0.039, -0.020]	[-0.080, 2.061]	[-0.039, -0.020]	[-0.041, 2.110]
TOP_F_i	-0.1111	2.5013	-0.1103	2.5915
1, if unit is located on the top most floor; 0, else	[-0.129, -0.095]	[1.050, 4.055]	[-0.128, -0.094]	[1.117, 4.145]
$TOP\_F_i * DEV\_HEIGHT_i$	0.0024	-0.0134	0.0023	-0.0154
Interaction term	[0.001, 0.004]	[-0.109, 0.076]	[0.001, 0.004]	[-0.112, 0.074]
$PRIME_i$	0.2802	-7.0176	0.2780	-7.2755
1, if unit is located in prime location; 0, else	[0.273, 0.287]	[-8.997, -5.171]	[0.270, 0.285]	[-9.252, -5.414]
$UCBD_i$	-0.0194	0.4573	-0.0190	0.4857
Distance to CBD (km)	[-0.020, -0.019]	[0.357, 0.567]	[-0.020, -0.019]	[0.381, 0.595]
$UMRT_i$	0.0266	0.1074	0.0242	0.0496
Distance to the nearest metro station (km)	[0.024, 0.029]	[-0.319, 0.524]	[0.021, 0.027]	[-0.373, 0.459]
$NEAR\_WATER_i$	0.1210	-1.3628	0.1135	-1.5886
1, if located within 500m of sea/lake/river; 0, else	[0.114, 0.127]	[-2.225, -0.357]	[0.107, 0.120]	[-2.417, -0.643]
$CONDO_i$	0.1148	-3.8811	0.1144	-3.9994
1, if located within condominium complex; 0, else	[0.109, 0.121]	[-5.438, -2.492]	[0.109, 0.121]	[-5.589, -2.623]
$FREEHOLD_i$	0.1647	-4.7883	0.1650	-4.9427
1, indicating freehold tenure; 0, else	[0.160, 0.169]	[-5.764, -3.842]	[0.161, 0.169]	[-5.902, -3.986]
DEV_SZ_i	6.9E-05	-6.4E-03	7.5E-05	-0.0063
Total number of units in development	[5.9E-5, 8.0E-5]	[-0.008, -0.005]	[6.4E-5, 8.6E-5]	[-0.008, -0.005]
$REMAINING_i$	0.0285	-6.4433	0.0292	-6.4476
Proportion of total units remaining	[0.021, 0.037]	[-7.508, -5.413]	[0.021, 0.038]	[-7.515, -5.414]
$NUM\_OF\_UNITS_i$	0.0800	-1.6750	0.0805	-1.7089
Number of units in the recorded transaction	[0.069, 0.093]	[-2.440, -0.935]	[0.070, 0.093]	[-2.476, -0.970]
$INTERNAL_i^k$	-0.0591	-1.1508	-0.0362	-1.3860
Probability of choosing internal agent	[-0.068, -0.050]	[-2.181, -0.215]	[-0.045, -0.028]	[-2.489, -0.355]
$TOTCOMP\_IN_i^{02}$		3.8E-03		0.0037
The sum of the total units available each day over the liquidity period within 2 km & the unit's planning area		[3.0E-3, 4.6E-3]		[3.0E-3, 4.6E-3]
$TOTCOMP\_OUT_i^{02}$		2.4E-03		0.0024
The sum of the total units available each day over the liquidity period within 2 km & outside of the unit's planning area		[1.2E-3, 4.2E-3]		[1.2E-3, 4.2E-3]
$COMPDENS\_IN_i^{02}$	-1.3E-05		-1.3E-05	
	[-1.4E-5, -1.2E-5]		[-1.4E-5, -1.2E-5]	
$TOTCOMP\_IN_i^{02}$ *divided by daily liquidity measure*				
$COMPDENS\_OUT_i^{02}$	1.8E-05		1.7E-05	
$TOTCOMP\_OUT_i^{02}$ *divided by daily liquidity measure*	[1.2E-5, 2.4E-5]		[1.1E-5, 2.3E-5]	
Year of Sale Fixed Effects:	Yes	Yes	Yes	Yes

Note: The parentheses contain a 95% confidence interval for the parameter estimate based on bootstrap replications are generated on 1000 independent samples of 30867 observations..

Table 8: Confidence intervals based on bootstrap percentiles - 3SLS estimation results for price and liquidity equations with 10 km competition radius and *estimated* internal agent variable

	Full Prob.		Trimmed Prob.	
	Price Equation	**Liquidity Equation**	**Price Equation**	**Liquidity Equation**
Intercept	8.8782 [8.830, 8.923]	-103.617 [-146.58, -53.81]	8.8671 [8.818, 8.911]	-107.931 [-151.29, -57.67]
$LIQUIDITY_i$ *Number of days since last sale in project*	4.7E-04 [2.9E-4, 6.9E-4]		4.7E-04 [2.8E-4, 6.8E-4]	
$\ln(PRICE_i)$ *Natural logarithm of selling price*		11.5651 [6.034, 16.459]		12.0732 [6.468, 16.952]
$\ln(AREA_i)$ *Area (sqm) of the i^{th} unit.*	0.9145 [0.905, 0.925]	-10.2773 [-14.715, -5.489]	0.9151 [0.905, 0.925]	-10.7632 [-15.208, -5.925]
$LUCKY_i$ *1, if unit is located a floor ending with an 8; 0, else*	-1.3E-04 [-0.006, 0.006]	-0.4122 [-0.899, 0.064]	-1.3E-04 [-0.006, 0.006]	-0.4125 [-0.900, 0.065]
$UNLUCKY_i$ *1, if unit is located a floor ending with a 4; 0, else*	0.0034 [-0.002, 0.008]	0.1169 [-0.231, 0.478]	0.0032 [-0.002, 0.008]	0.1163 [-0.231, 0.478]
$\ln(FLOOR_i)$ *Floor level of the unit*	0.0477 [0.045, 0.050]	-0.9052 [-1.147, -0.605]	0.0475 [0.045, 0.050]	-0.9259 [-1.170, -0.624]
GRD_F_i *1, if unit is located on the ground level; 0, else*	-0.0288 [-0.039, -0.019]	0.4142 [-0.239, 1.095]	-0.0284 [-0.038, -0.019]	0.4301 [-0.221, 1.120]
TOP_F_i *1, if unit is located on the top most floor; 0, else*	-0.1125 [-0.131, -0.096]	2.2937 [1.530, 3.085]	-0.1113 [-0.130, -0.095]	2.3406 [1.569, 3.134]
$TOP\_F_i * DEV\_HEIGHT_i$ *Interaction term*	0.0025 [0.001, 0.004]	-0.1069 [-0.185, -0.030]	0.0024 [0.001, 0.004]	-0.1075 [-0.186, -0.031]
$PRIME_i$ *1, if unit is located in prime location; 0, else*	0.2822 [0.275, 0.290]	-5.1865 [-6.388, -4.086]	0.2796 [0.272, 0.287]	-5.3238 [-6.524, -4.217]
$UCBD_i$ *Distance to CBD (km)*	-0.0191 [-0.020, -0.019]	0.4130 [0.326, 0.500]	-0.0186 [-0.019, -0.018]	0.4237 [0.338, 0.508]
$UMRT_i$ *Distance to the nearest metro station (km)*	0.0264 [0.023, 0.029]	0.4759 [0.266, 0.670]	0.0238 [0.021, 0.027]	0.4743 [0.275, 0.663]
$NEAR\_WATER_i$ *1, if located within 500m of sea/lake/river; 0, else*	0.1248 [0.118, 0.131]	-1.0511 [-1.783, -0.215]	0.1167 [0.111, 0.123]	-1.0808 [-1.800, -0.277]
$CONDO_i$ *1, if located within condominium complex; 0, else*	0.1197 [0.113, 0.126]	-1.7857 [-2.624, -0.883]	0.1190 [0.113, 0.125]	-1.8524 [-2.685, -0.966]
$FREEHOLD_i$ *1, indicating freehold tenure; 0, else*	0.1624 [0.158, 0.167]	-2.4294 [-3.302, -1.476]	0.1627 [0.158, 0.167]	-2.5314 [-3.406, -1.590]
DEV_SZ_i *Total number of units in development*	4.7E-05 [3.6E-5, 5.8E-5]	-7.1E-04 [-0.002, 0.001]	5.4E-05 [4.3E-5, 6.5E-5]	-7.6E-04 [-0.002, 0.001]
$REMAINING_i$ *Proportion of total units remaining*	0.0292 [0.022, 0.037]	-3.9462 [-4.811, -2.986]	0.0301 [0.023, 0.038]	-3.9645 [-4.819, -3.005]
$NUM\_OF\_UNITS_i$ *Number of units in the recorded transaction*	0.0804 [0.070, 0.093]	-1.1853 [-1.763, -0.600]	0.0810 [0.071, 0.094]	-1.2231 [-1.818, -0.627]
$INTERNAL_i^k$ *Fixed effect or est. probability (model dependent)*	-0.0643 [-0.073, -0.056]	0.2169 [-0.433, 0.894]	-0.0420 [-0.051, -0.034]	-0.1302 [-0.834, 0.581]
$TOTCOMP\_IN_i^{10}$ *The sum of the total units available each day over the liquidity period within 10 km & the unit's planning area*		7.2E-04 [4.1E-4, 9.5E-4]		7.2E-04 [4.1E-4, 9.5E-4]
$TOTCOMP\_OUT_i^{10}$ *The sum of the total units available each day over the liquidity period within 10 km & outside the unit's planning area*		6.3E-04 [5.0E-4, 8.0E-4]		6.3E-04 [5.0E-4, 8.0E-4]
$COMPDENS\_IN_i^{10}$ *$TOTCOMP\_IN_i^{10}$ divided by daily liquidity measure*	-5.1E-06 [-5.5E-6, -4.8E-6]		-5.1E-06 [-5.5E-6, -4.8E-6]	
$COMPDENS\_OUT_i^{10}$ *$TOTCOMP\_OUT_i^{10}$ divided by daily liquidity measure*	6.4E-07 [3.7E-7, 8.9E-7]		6.1E-07 [3.3E-7, 8.6E-7]	
Year of Sale Fixed Effects:	Yes	Yes	Yes	Yes

Note: The parentheses contain a 95% confidence interval for the parameter estimate based on bootstrap replications are generated on 1000 independent samples of 30867 observations.

Figure 1. Agent effort supply as functions of realized productivity. External agent effort supply e^o lies below the efficient effort supply e^*. Internal agent effort supply r replicates the efficient effort supply e^* under symmetric information. Greater external agent ability shifts effort supply upwards to e' or e'' and the efficient effort supply to e^{**}.

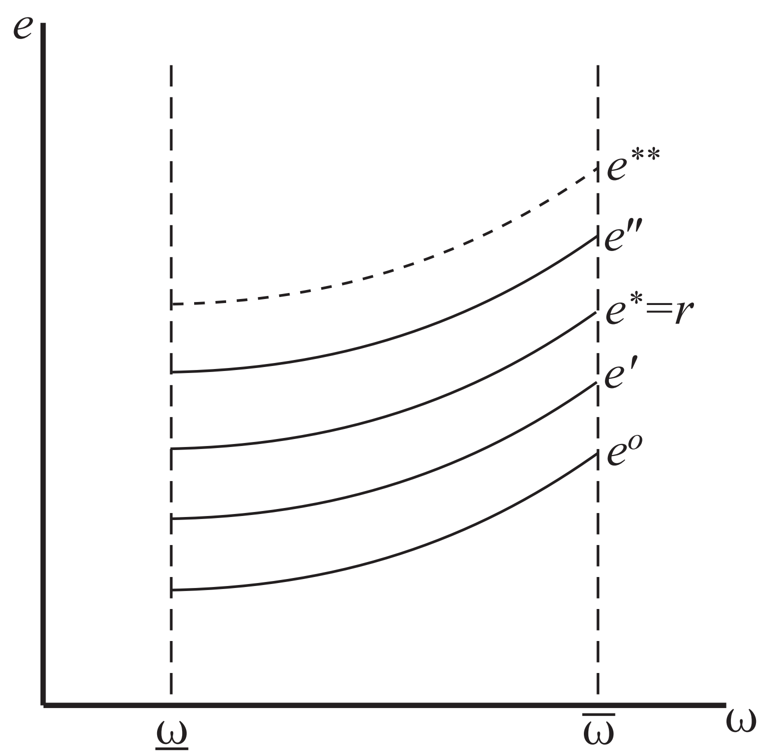
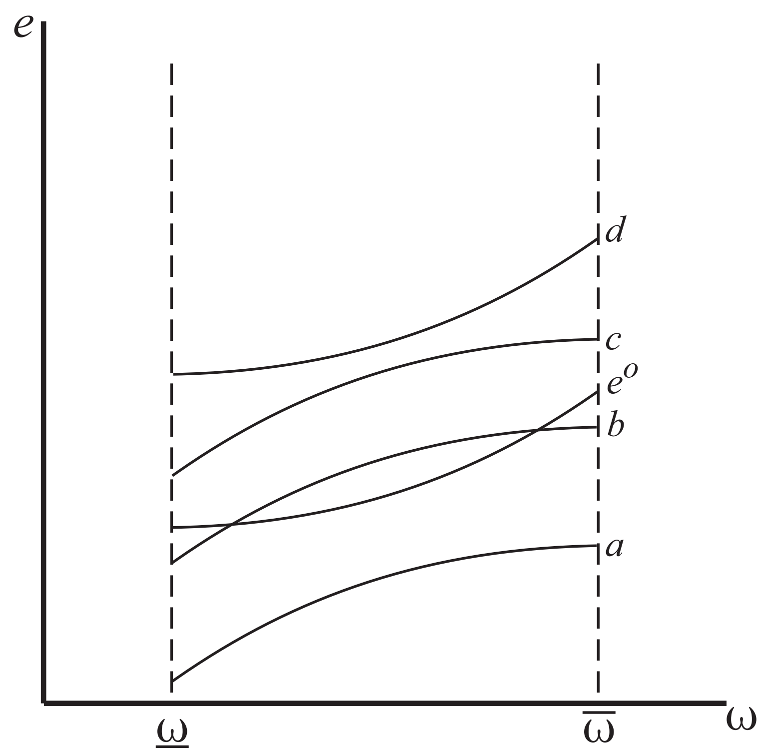


Figure 2. Internal agent effort supply under asymmetric information. Larger bonus shifts internal agent effort supply shifts upwards from *a* to *b* or *c*. Internal agent effort *b* cannot replicate external agent effort e^o but can dominate as *c*. Greater ability shifts external agent effort to *d*, increasing bonus required to induce internal agent effort *c* to rise above *d*.



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