INTERNATIONAL REAL ESTATE REVIEW

2017 Vol. 20 No. 1: pp. 75 – 104

Do Reserve Prices Yield Reference Price Effects in Korean Court Auctions of Residential Real Estate?

Han-Jang No
National Pension Service Gyeongin Regional Headquarter, Gyeonggi-do 442-766, South Korea. Phone: 82-10-9132-6410. Email: nhjangnhj@hanmail.net.

Dai-Won Kim
School of Urban Planning & Real Estate Studies, Dankook University, Gyeonggi-do 448-701, South Korea. Phone: 82-10-5350-2613. Email: dw2613@gmail.com.

Jung-Suk Yu*
School of Urban Planning & Real Estate Studies, College of Social Science, Dankook University 152, Jukjeon-ro, Suji-gu, Yongin-si, Gyeonggi-do 448-701, South Korea. Phone: 82-31-8005-3338. Email: jsyu@dankook.ac.kr

This study examines whether the reserve prices in court auctions of residential real estate in Seoul, Korea result in reference price effects by influencing the amount of the successful bid. We also explore whether the sensitivity of these reference price effects differ with housing size and assess whether the expected rate of the selling price can be predicted based on the different reserve price levels.

The panel data estimates presented herein show that reserve prices positively influence the final property transfer prices; in other words, the reserve prices yield strong reference price effects. The results of the ordinary least square regressions show that the sensitivity of the reference price effects differs with housing size, albeit in an inconsistent manner. Finally, the response surface methodology analysis indicates

* Corresponding author

that different reserve prices lead to different reference price effects with locality across the Seoul metropolitan area. The study thus provides courts and bidders with the means to predict the potential rate of the selling price, which will be useful for decision making in auctions.

Keywords

Reference Price Effect, Reserve Price, Auctions of Residential Real Estate, Panel Regression, Response Surface Methodology

1. Introduction

Court auctions of residential real estate are ambiguous in nature with incomplete information so that bidders lack insight in both the value evaluations made by other bidders and the properties for sale. Despite this information asymmetry, potential bidders in court auctions of residential real estate in Korea are compelled to submit their bids quickly because the operation time of an auction is only an hour or so. Under time constraints, competing bidders are likely to be psychologically influenced by reserve prices (i.e., minimum prices) that had been previously announced by the court.

According to the seminal prospect theory put forth by Kahneman and Tversky (1979), when people respond to stimuli such as brightness, loudness, or temperature, the past and present contexts of the experience defines the reference point so that the stimuli are perceived in relation to the reference point. The seminal prospect theory has convinced behavioral economists to shift the basis of their insights on auctions from the use of expected utility to reference-based utility, namely, people are not always rationale and often evaluate utilities with the use of reference points (Rosenkranz and Schmitz, 2007). For example, the value perception of bidders in court auctions of residential real estate on the properties for sale are established with reference to the designated reserve prices. Accordingly, the reserve prices in all practicality, are used as the reference point. There is a large volume of theoretical and experimental research work on these so-called reference price effects, but the results of these studies are inconclusive in terms of the psychological effect of reserve prices: whether they are positive, negative, or have no effect (Trautmann and Traxler, 2010).

Against the background provided above, whether the reserve prices of residential real estate in court administered auctions in Korea result in reference price effects will be examined in this study. Specifically, we explore whether reserve prices have a positive psychological influence on final transfer prices, analyze the sensitivity of the reference price effects of reserve prices to housing size, and predict the expected selling price based on the different reserve prices. In order to meet these research objectives, panel data estimates (to assess the existence of reference price effects), log ordinary least squares (LOLS) (to determine the sensitivity of the reference price effects), and response surface methodology (RSM) (to forecast the anticipated selling price) are used in this study. With the use of these methods, the present paper broadens studies on the reference price effects of reserve prices by using comparative static analysis (e.g., static analysis that measures sensitivity and able to make predictions), whereas the majority of previous work (Ariely and Simonson, 2003; Trautmann and Traxler, 2010) have only used static analysis to examine reference price effects. An empirical analysis on first-price sealed-bid auctions on real estate is novel because most of the literature have only used experimental analysis in terms of related auctions, or examined real estate auctions in the western context, or dealt with non-real estate items.

Korea is one of the top three investment venues in the Asia-Pacific region, but its real estate market is still in the process of maturing.[1] This paper will provide useful information to overseas investors who have growing concerns about the characteristics of the residential markets of Korea as well as the unique court auction process. In Korea, court auctions of residential real estate have their own peculiarities and the process can be divided into three stages: pre-bidding, actual bidding, and post-bidding. In the pre-bidding stage, the courts must set the initial reserve prices based on reported values from the appraisers. During the actual bidding stage, the courts receive sealed bids from the auction participants with a 10% deposit of the reserve prices. The bidders usually establish their bids by adding a certain amount of money to the reserve price based on their own evaluation. The courts then close the bidding process after the auction has commenced for one hour. The highest bidder wins the auction and must pay the bidding amount in full within 30 days. If bidders do not meet the reserve price, the courts continue the process at one-month intervals, and reduce the reserve price by 20–30% each time. During the court auction process, bidders do not know the bidding prices of the other competitors. Finally, the post-bidding stage deals with payment of the purchase price and distribution of the proceeds after the authorization of the sale (see Appendix and Figure 1).

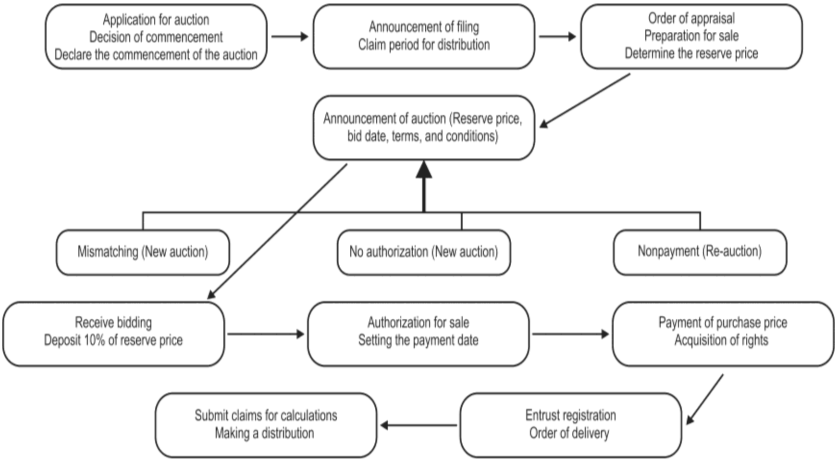
The residential real estate markets in Korea also have certain unique characteristics. For example, the dense and crowded environments in Seoul constitute a characteristic of housing value in that the citizens naturally accept higher housing price premiums for proximity to subway stations, shopping malls, and schools. Accordingly, the reverse or nonlinear problem of proximity premiums for being right next to these spatial entities is not so much an issue as far as the housing market in Seoul is concerned. The parents and homeowners in Seoul attach the greatest importance to distance, such as whether their son or daughter is able to go to school on foot or by bicycle. The prices of high-rise apartment units on higher floors are more expensive and vice versa. The traditionally large families and continual increase of house prices have

---

[1] Bae, H.J. "Korean real estate market highly attractive for investors," *The Korean Herald*, July 16, 2013. (http://www.koreaherald.com).

established the tendency to prefer larger dwellings. Yet these may seem strange to those who are not familiar with the Korean context.

Figure 1 Court Auction Process of Residential Real Estate in Korea



Source: Supreme Court of Korea (http://www.courtauction.go.kr)

The remainder of this paper is organized as follows. Section 2 provides a more detailed discussion on the reference price effects of reserve prices by way of a literature review. Section 3 is a description of the methods, data, and variables used. Section 4 presents the results of an empirical analysis. Section 5 summarizes the findings of this work and provides policy suggestions and directions for future study.

2. Literature Review

From a theoretical perspective, although early studies on reserve prices did not fully account for reference price effects, they recognized how reserve prices influence the property valuation and willingness-to-pay (WTP) of bidders (Milgrom and Weber, 1982; Vincent, 1995). Mayer (1998) also indicates that reserve prices are set low in order to provide little information to sellers and not place binding constraint on bids, even though the units with a published reserve price should theoretically elicit slightly higher prices. One of the first theoretical models of reserve prices in auctions is that proposed by Rosenkranz and Schmitz (2007). They consider the public reserve prices set by auctioneers as reference points that have significant impacts on bidders and thus have modified pre-existing expected utility models by assuming that bidders have a reference-based utility.

The work of Rosenkranz and Schmitz (2007) comprises a stream of research imported from psychology, termed behavioral economics, which explores the implications of assuming that human behavior is based on insights. By supposing that reserve prices have psychological effects on the price-level decision-making of bidders, behavioral economists assume that price estimations tend to be made based on publicly announced reserve prices. They thus recommend that sellers could increase their expected payoff if they set higher reserve prices because this action subsequently raises the WTP of bidders, thereby reducing the disparity between the prices paid by the bidders and the reserve prices set by the sellers.

Similarly, early experimental studies on reserve prices also failed to directly incorporate reference price effects. Nevertheless, the researchers recognized their positive influence on successful transfer prices in auctions. For example, Lin (2005) argues that reserve price has the greatest effect on auction price in court auctions of residential real estate of the Taipei metropolitan housing market. Reiley (2005) also indicates that bidders seem to exhibit strategic behavior to reserve prices, and reserve prices increase the revenues received for sold goods.

Indeed, there have been increasingly more experimental studies on the reference price effects of reserve prices. However, the findings of these works show discrepancies and the overall body of evidence on this topic is inconclusive. Some authors claim that reserve prices in auctions have positive psychological influences on the final transfer prices (i.e., starting high and ending high) (Ariely and Simonson, 2003). Popkowski, Qiu, and He (2009) focus on the effect of buy-it now prices, which is used as the reference point, on the WTP of the bidders. Their experiments on the eBay auction site show that the existence of reserve prices generates a strong reference price effect for different types of consumer goods, thus resulting in an increase in the WTP of bidders. Many similar works have also obtained such affirmative results (Kristensen and Gärling, 1997; Kamins, Dréze, and Folkes, 2004).

However, it is argued in other studies that lower reserve prices ultimately lead to higher sale prices (i.e., starting low but ending high). For instance, Walley and Fortin (2005) present a conceptual model of the decision-making process of consumers in online auctions, and show that a low reserve price results in a higher final sale price compared with a high reserve price. Ku, Galinsky, and Murnighan (2006) draw a similar conclusion and argue that this phenomenon is epitomized by three processes: fewer barriers to entry, escalation of commitment, and increased value from more traffic. However, a third category has not managed to draw consistent conclusions about the reference price effects on reserve prices, that is, studies that focus on the online auction format (Dewally and Ederington, 2004; Trautmann and Traxler, 2010).

3. Data, Variables, and Methods

3.1 Data Source and Summary Statistics

The time-series and cross-sectional data used in this study consist of 9,631 apartments sold in court auctions of residences in the Seoul metropolitan area (SMA) from January 2006 to June 2010. We have extracted 9,631 successful cases out of 25,413 cases posted by five district courts in the city[2] because our study requires information on the sold prices. The average annual number of apartment auctions in the SMA is 6,062, which comprises 7.1% of the total number of apartments in the country (i.e., 85,953 apartments).

In the analysis of the behavior of the residential markets, the criterion for segmenting subordinate markets is influential because the research outcomes could be affected resultant of the demarcation of this subdivision (Bourassa et al., 1999). Nonetheless, previous research on court auctions of residential real estate has subdivided markets in accordance with the jurisdictions of the district courts, which thus fails to reflect the possible differences in the preference for a district, the quality, and the price of housing within this district. To overcome this shortcoming, we have subdivided the study area into five zones by following the 2020 City Planning of the SMA: central, northeastern, southeastern, northwestern, and southwestern (Figure 2 and Table 1).

Figure 2 Administrative Districts of the SMA

Source: Seoul Metropolitan Government. (2013). http://english.seoul.go.kr/gtk/cg/cityhall.php?pidx=5.
Note: There are 25 autonomous districts in the SMA. In the Vision 2020 of Seoul City, these 25 autonomous districts are classified into five zones.

---

[2] In Seoul, there are five district courts (Central, Northern, Eastern, Western, and Southern). The jurisdictions of these district courts are divided in accordance with formal administrative divisions.

Table 1 Five Zones of the SMA

Zone	Main Function	Autonomous Districts
Central zone	International finance center, central business center	Jung-gu, Jongno-gu, Yongsan-gu
Northeastern Zone	Old residential district, base for employment	Dongdaemun-gu, Seongdong-gu, Gwangjin-gu, Jungrang-gu, Seongbuk-gu, Gangbuk-gu, Dobong-gu, Nowon-gu
Southeastern Zone	International business, venture, IT	Seocho-gu, Gangnam-gu, Songpa-gu, Gangdong-gu
Northwestern Zone	Nature-friendly residential district	Eunpyeong-gu, Seodaemun-gu, Mapo-gu
Southwestern Zone	High-tech industry, physical distribution	Gangseo-gu, Yangcheon-gu, Guro-gu, Geumcheon-gu, Yeongdeungpo-gu, Dongjak-gu, Gwanak-gu

Source: Seoul Metropolitan Government. (2013). http://urban.seoul.go.kr/DUPIS/sub3/sub3_1.jsp.
Note: The 2020 City Master plan of the SMA was established under the regulation of the Act on the Planning and Use of the National Territory. This plan is effective for 20 years from 2000 to 2020, although it can be amended every five years.

We then classify our data sample into these five categories as well as the SMA as a whole. Differences in the scope and local characteristics between the five zones are largely responsible for the considerable discrepancies in the number of apartments. The central zone, for example, is in the relatively small central business district of the SMA, while the southwestern and northeastern zones are the traditional residential areas from the sub-center to the outskirts of the city. Table 2 presents the summary statistics by zone.

Table 2 Summary Statistics by Zone

Stats	*SOL*	*RES*	*BID*	*SQU*	*TFL*	*FLO*
SMA						
Mean	89.53	78.25	6.36	92.23	14.20	7.00
S.D.	11.47	9.71	4.03	25.97	4.24	3.25
Min	22.67	17.00	1.00	13.31	5.00	-1.00
Max	144.25	100.00	44.00	352.02	29.00	22.00
Central Zone						
Mean	90.42	78.29	5.50	102.29	13.02	6.91
S.D.	16.48	12.40	4.98	44.26	5.11	4.11
Min	22.67	17.00	1.00	31.17	5.00	-1.00
Max	144.25	100.00	30.00	352.02	29.00	21.00

(Continued…)

(Table 2 Continued)

Stats	*SOL*	*RES*	*BID*	*SQU*	*TFL*	*FLO*
Northeastern Zone						
Mean	91.16	79.81	6.95	83.50	15.94	7.41
S.D.	10.88	9.09	4.11	18.72	3.67	3.07
Min	29.07	27.00	1.00	13.31	5.00	1.00
Max	133.10	100.00	34.00	178.71	27.50	22.00
Southeastern Zone						
Mean	87.93	76.94	6.38	106.01	13.33	6.77
S.D.	10.47	8.68	3.70	26.84	3.75	2.60
Min	43.75	41.00	1.00	48.30	5.00	1.00
Max	133.36	100.00	44.00	204.38	27.50	18.00
Northwestern Zone						
Mean	87.55	76.22	5.60	93.64	11.98	6.06
S.D.	11.52	10.33	4.16	24.06	3.67	2.84
Min	44.80	33.00	1.00	42.96	5.00	1.00
Max	124.08	100.00	30.00	222.36	24.50	16.00
Southwestern Zone						
Mean	89.68	78.58	6.45	87.24	14.60	7.22
S.D.	10.21	9.32	3.65	17.33	4.22	3.49
Min	47.02	41.00	1.00	39.48	5.00	1.00
Max	142.82	100.00	26.00	197.48	28.70	22.00

3.2 Variables

Although researchers, including Nunes and Boatwright (2001), have indicated that reserve prices influence the WTP of bidders in auctions, the selling prices in the court auctions of residential real estate are determined by interactions among numerous factors. Our dependent measure is *LSOL* (log of rate of selling price), which is calculated by the ratio of the selling price to the appraised price. Accordingly, *LSOL* represents the marginal change in the WTP of bidders in terms of auction outcomes. We extract 10 independent variables from auction attributes, building structure, and location conditions that prior researchers agree serve as the key factors that affect selling prices in housing auctions.

The first category of variables, such as the *LRES* (log of the rate of the reserve price)[3] and *LBID* (log of the number of bidders), are auction attributes. The *LRES,* the percentage of the difference between the reserve price and the appraisal price, illustrates the marginal difference in the reference point. In Korean court auctions, tenants (*TENA*) and lien holders (*LIEN*) greatly affect the transfer prices because special laws that allow the lease and lien of residential buildings give "opposing power" despite that they are no longer registered on the record system. In other words, even though the residence is

[3] *RES* (Rate of Reserve Price) = (Reserve Price /Appraisal Price) × 100.

not registered, if the lessee has completed the delivery of a house and the resident registration, the lease shall take effect against the third person from the following day thereof (Article 3(1) of the Housing Lease Protection Act) [4]. Liens are also not registered on the record system. However, a successful bidder is responsible for reimbursing to the lien holder the claims that are secured by the lien (Article 91(5) of the Civil Execution Act). For this reason, *TENA* (tenants with opposing power) and *LIEN* (occupants with opposing power) tend to greatly influence the selling prices in auctions so we have included them as variables that are auction attributes.

The second category of variables is derived from the characteristics of the building structure: the *LSQU* (log of the square meters of the relevant property), *LTFL* (log of the total number of floors of an apartment building), and *LFLO* (log of the relevant floor of the apartment unit). In Seoul, the traditionally large family system and continual increase in house prices have established the tendency to prefer larger dwellings[5]. The people in the city of Seoul tend to believe that units on higher floors in apartment buildings mean a higher price.[6] They also strongly prefer the royal floors, i.e. the best floor for residence. This is not a very unique phenomenon. Similarly, Lin (2005) indicates that the house size, total number of floors, and floor of the residence influence the house prices both in auction and traditional search markets in Taipei.

The third category of variables is taken from the location conditions: *SUBW* (availability of subways), and *MART* (availability of shopping malls), and

---

[4] Ministry of Government Legislation (2015). Korean Laws in English. (http://www.moleg.go.kr/english/korLawEng?).

[5] According to Statistics Korea (http://www.index.go.kr/potal/), households with four and more individual comprise about 72.2% of the population in 1980, and 30.6% in 2010, respectively. The larger family size demands larger sized houses so that people in Seoul prefer larger sized housing. The continuous increase in house prices has also resulted in preference for large apartments because these will provide a greater marginal profit.

[6] Until the 1990s, the highest residential houses had at most 10-15 stories and the 1/4 rule was accepted for determining the royal floors in Seoul. The traditional '1/4 rule' in Korea means that the 'royal floors' in high-rise housing tend to be defined as the middle floors except for the 1/4 top and bottom floors of the building respectively. For example, the 'royal floors' in a 20-story apartment are the 6th through to the 15th floors. The 'royal floors' represent the preferred floors of a building by users and investors. Their prices are usually higher by 5% to 10% than the other floors. The term '1/4 rule' is neither a legal term nor an official standard criterion. However, it is a widespread common practice of transactions in Korean high-rise apartment markets up until the 1990s. The primary reasons for the preference of the middle floors in high rise apartments are attributed to various complex factors, including noise, privacy, insulation, etc. In other words, the bottom floors are vulnerable to lack of privacy and the top floors are disadvantageous due to the heating problem, which at that time with high oil prices, was a matter of concern because Korea is a non-oil nation. However, in the 2000s, there was an increase in super high-rise apartments and the royal floors were extended to the higher floors, which was also due to their abundance of natural light. These super high-rise apartments were also regarded as a symbol of wealth.

SCHO (availability of schools). Dummy values are then selected, with these variables taking 1 to represent the availability of schools, subways, and shopping malls within a vicinity of 1 km or 10 minutes by foot, and 0 otherwise. In Seoul, the accessibility premiums overwhelmingly offset the negative amenities from bad externalities such as noise and crime, as proven by empirical studies on proximity premiums to subway stations and shopping malls (see Bae et al., 2003; Kim et al., 2005). With 16,500 inhabitants per square kilometer as of 2003, Seoul is one of the world's most populated cities. Seoul is 1.3 times greater in density than Tokyo and twice as much as New York (Pucher et al., 2005). Accordingly, the reverse or nonlinear problem of proximity premiums for being right next to subway stations and shopping malls is not such a decisive factor as far as the analysis of the housing market in Seoul is concerned[7]. According to 2012 Seoul Statistics (Seoul Metropolitan Government, 2015), the passing speed of a passenger car is 18.7 km per hour, and that of a bus is 20.0 km in downtown Seoul. The modal share of daily travel transportation by subway is 38.2% (12,275 thousand volume of traffic passing (use)). The traffic congestion and preference for the subway mean that Seoul citizens accept high housing price premiums for accessibility to subway stations. The same applies to shopping malls. In Seoul, shopping centers are usually located near (in) the subway stations and have evolved to become a focal point for the neighborhoods, aside from retail services.

Contrary to other nations[8], entrance exams and school reputation in Seoul do not pose as serious problems due to the equalization policy and extreme density. The "equalization policy (*pyong-jun-hwa)"* and "school district (*hak-gun-je)"* of secondary schools have replaced the traditional entrance examinations at individual high schools for placement of students, and instead, lotteries are used to randomly assign middle school graduates to high schools within school districts (Kim, 2004). The average time to travel to school in Seoul is 34.4 minutes. Only 0.6% of the students in Seoul go to school in a private car while 56.5% use public transportation, such as taking the bus or subway. About 31.8% of the students go to school on foot or by bicycle. For parents and homeowners, the most important factor that influences house prices is not the equalization policy or the school quality, but the availability of schools nearby their residence (Seoul Metropolitan Government, 2014).

---

[7] Studies that have indicated a net negative relationship between house prices and proximity to subway stations have been conducted in San Diego (Duncan, 2008) and Chengdu (Cong et al., 2014). However, proximity to rail transit stations can also impose nuisance effects, like crime and noise to nearby neighborhoods. Some studies have shown mixed (nonlinear) relationships, such as in Ottawa (Hewitt and Hewitt, 2012). The same is found for proximity to a shopping mall (see Kim and Zhang, 2005; Matthews, 2006).

[8] Researchers have often applied the hedonic pricing model, in which the house price premium is assumed constant because the effect of the quality of schools on house prices is constrained to be linear (Haurin and Brasington, 1996). However, some researchers have recently proposed the nonlinear effects of school quality from externalities such as racial composition, crime rate etc. (Chiodo et al., 2010).

3.3 Methods

3.3.1 Panel Data Estimation Model

To examine whether reserve prices influence the final selling prices, we performed a panel data analysis. The primary motivation for using a panel data method is to address the problem of omitted variables and examine whether the unobserved effect is uncorrelated with the explanatory variables (Wooldridge, 2002). A regression model is applied for analysis of the basic panel data as follows:

$$y_{it} = X_{it}\beta + z_i\alpha + \varepsilon_{it} \tag{1}$$

There are K regressors in X_{it}, not including a constant term. The individual effect is $z_i\alpha$, where z_i contains a constant term and a set of individual- or group-specific variables.

Under the assumption of z_i, three models are applied to analyze the panel data as follows: pooled OLS (POLS), fixed effects, and random effects. The POLS model considers that z_i is observed for all individuals and contains only a constant term. Thus, the entire OLS model can sufficiently estimate both the common α and the slope vector β. The fixed effects model assumes that z_i is unobserved but correlated with X_{it}. Therefore, the OLS estimator of β is biased and cannot provide consistent estimates. In this model, $z_i\alpha$ (= α_i) represents all of the observable effects and taken to be a group-specific constant term. Finally, the random effects model postulates that the unobserved individual heterogeneity can be considered to be uncorrelated with the included variables.

The quality of a property and the location tend to exhibit highly autoregressive correlations because of spatial dependence and heterogeneity, while there is also a relationship between housing prices and unobservable location factors (Tse, 2002). In addition, housing prices evolve over time because the housing market is dynamic. Thus, we compare the statistical results of the POLS and fixed effects models with a double log form in order to estimate the panel data regression. In contrast to the POLS model, two unobservable variables that exemplify individual effects (γ_i) and time effects (γ_t) are added into the fixed effects model. Our POLS (fixed) model can thus be expressed as follows:

$$\begin{aligned} LSOL_{it} &= \beta_0 + \beta_1 LRES_{it} + \beta_2 LBID_{it} + \beta_3 LSQU_{it} + \beta_4 LTFL_{it} + \beta_5 LFLO_{it} \\ &+ \beta_6 SCHO_{it} + \beta_7 SUBW_{it} + \beta_8 MART_{it} + \beta_9 TENA_{it} + \beta_{10} LIEN_{it} \\ &+ (\gamma_i) + (\gamma_t) + \varepsilon_{it} \end{aligned} \tag{2}$$

where

Assets (*i)*: Individual apartments

Period (t): Time (years)
Rate of selling ($LSOL_{it}$): Log of rate of selling price to appraised price (%)
Reserve price rate ($LRES_{it}$): Log of rate of reserve price to appraised price (%)
Bidders ($LBID_{it}$): Log of the number of participating bidders (persons)
Square ($LSQU_{it}$): Log of the total square meters of an apartment (m^2)
Total floor ($LTFL_{it}$): Log of the total number of floors in an apartment building (floors)
Floor ($LFLO_{it}$): Log of the relative floor of an apartment (floor)
School ($SCHO_{it}$): School available (1); otherwise (0)
Subway ($SUBW_{it}$): Subway available (1); otherwise (0)
Mart ($MART_{it}$): Shopping mall available (1); otherwise (0)
Tenant ($TENA_{it}$): Opposing tenants (1); otherwise (0)
Lien ($LIEN_{it}$): Opposing occupants (1); otherwise (0)
$\beta_1, \beta_2, \beta_3, \ldots, \beta_{10}$: Coefficients of the independent and control variables
γ_i : Characteristics of an individual asset
γ_t : Characteristics of time
ε_{it} : Remaining stochastic *disturbance* terms which are interpreted as the effect of unspecified variables of the characteristics of individual assets and time

3.3.2 Double LOLS Model

We introduce the LOLS[9] model to examine how the reference price effects of reserve prices differ according to housing size. We transform a simple OLS model into a double LOLS model to remedy the possible violation of the normal distribution assumption on the unobserved error terms (Hardin and Wolverton, 1996). In the case of the housing market, a double log function is preferred to a linear function because the former measures the elasticity of each characteristic, while the WTP for an additional unit of the characteristic is not fixed but rather decreases. The specification of the double log model in this study used to assess the sensitivity of reference price effects is

$$LSOL_j = \beta_0 + \beta_1 LRES_j + \beta_2 LBID_j + \beta_3 LSQU_j + \beta_4 LTFL_j + \beta_5 LFLO_j + \beta_6 SCHO_j + \beta_7 SUBW_j + \beta_8 MART_j + \beta_9 TENA_j + \beta_{10} LIEN_j + \varepsilon_j \quad (3)$$

3.3.3 RSM Model

[9] We use the OLS regression model in lieu of a panel regression in the analysis of the sensitivity of the reference price effects of reserve prices. A panel estimation is unsuitable in this case because of its lopsided sample size and the time characteristics when our data are classified in accordance with the scale and period of time.

We use the RSM to predict the expected rate of the selling price in accordance with fluctuations in the reserve prices. RSM is defined as a collection of mathematical and statistical methods that are used to develop, improve, or optimize a product or process (Myers and Brenneman, 2010). Accordingly, RSM is typically used to locate the optimum response of a dependent variable or predict how the dependent variable changes in a given direction by conjecturing the functional relation from the data. The relation between price and the characteristics of housing properties is likely to be nonlinear. Thus, a nonparametric estimation analysis such as the RSM allows us to effectively estimate this nonlinearity.

The true RSM form of the function ∫ is unknown because the relationship between the dependent and independent variables is usually unknown. The RSM is widely used when input factors may affect the outputs; thus, the former is often called the response, while the latter are the independent variables. In most statistical analyses, the RSM function is formulated by using coded variables, namely x_1 , x_2 , …, and x_k which are typically defined to be dimensionless with a mean zero and the same standard deviation (Carley, Kamneva, and Reminga, 2004). The RSM function with coded variables can thus be represented as

$$\eta = f\left(x_1, x_2, \ldots, x_k\right) \tag{4}$$

A fundamental method for assessing quantitative variables involves the fitting of the first-order or second-order functions of the predictors to one or more response variables and then examining the characteristics of the fitted surface to decide what action is appropriate (Lenth, 2009). The first-order model approximation of the function ∫ is suitable under the condition that it is not too curved. Therefore, a polynomial model is usually sufficient and the first-order model is assumed to be an adequate approximation of the true surface in a small region of *x*s (Bradley, 2007). However, the first-order model is not sufficient when the curvature in the response surface is too strong, meaning that a second-order-model is likely to be required (Carley, Kamneva, and Reminga, 2004). In general, the second-order model can be expressed as (Montgomery, 2005):

$$Y = \beta_0 + \sum_{i=1}^{n} \beta_i x_i + \sum_{i=1}^{n} \beta_{ii} x_i^2 + \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \beta_{ij} x_i x_j \qquad i = 1, 2, \ldots, n \tag{5}$$

where Y is the predicted response by the model, β_0 is a constant, β_i is the linear coefficient, β_{ii} the second-order coefficient, β_{ij} the interaction coefficient, and x_i and x_j are the coded values that correspond to the tested variables (Kalali et al., 2011).

In this study, we use the second-order model because of its distinct advantages[10]. Thus, our fundamental RSM model can be expressed as follows:

$$Y_i = \alpha_i + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_1^2 + \beta_4 X_2 X_1 + \beta_5 X_2^2 + \varepsilon_i \tag{6}$$

where Y_i = rate of sold price, α_i = constant, X_1 = rate of reserve price, X_2 = number of bidders, and ε_i = error term. This second-order RSM model is useful for approximating a proportion of the true response surface by using a parabolic curvature. It includes all the terms in the first-order model as well as all the quadratic terms (e.g., $\beta_3 X_1^2$) and cross-product terms (e.g., $\beta_4 X_2 X_1$) (Bradley, 2007).

In our model, the coefficient β_1 represents the slope of the linear response curve to the rate of the reserve price (X_1) and β_2 is the slope of the linear response curve to the number of bidders (X_2). The coefficients β_3 and β_5 represent the response curvatures that are related to X_1^2 and X_2^2, respectively, while β_4 expresses the synergy effect of the interaction between X_2 and X_1 (Bettinger and Chinnici, 1991). For simplicity and clarity, we have omitted X_1 and X_2 from the presented analyses.

4. Empirical Results

4.1 Reference Price Effects of Reserve Prices

For the panel data estimates, we must perform a unit root test to verify the stationarity of the time-series data. The results of the unit root test for the SMA panel data reject the null hypothesis of all the panels that contain unit roots at the 1% significance level (Table 3), that is, the panel data are stationary. Before the panel data analysis, we must also perform the Hausman test to select the estimation method for the fixed and random effects models. The Hausman test results presented in Table 4 show that the initial hypothesis, which states that the random effects model is adequate, is rejected at the 1% significance level. Based on the results of the Hausman test, we examine the panel data by using the fixed effects model.

---

[10] The second-order model is widely used in RSM for several reasons. First, its flexibility allows the model to take on a wide variety of functional forms, which means that it will often work well as an approximation of the true response surface. Second, it is easy to estimate the parameters (the βs) in the second-order model by using the method of least squares. Finally, considerable practical experience indicates that second-order models work well in solving real response surface problems (Carley, Kamneva, and Reminga, 2004).

Table 3 Unit Root Test for the Panel Data

	LSOL	***LRES***	***LBID***	***LSQU***	***LTFL***	***LFLO***
Inverse x^2	485.2549***	502.6076***	845.3829***	911.0499***	939.7198***	950.4041***
Inverse normal	-18.5014***	-19.0732***	-25.9423***	-27.5187***	-27.9919***	-28.0786***
Inverse logit t	-27.9769***	-29.0037***	-48.7983***	-52.5904***	-54.2454***	-54.8621***
Modified inv. x^2	45.7955***	47.6046***	83.3414***	90.1877***	93.1767***	94.2906***

Note: 1) We perform Fisher-type unit root tests for the unbalanced panel data based on augmented Dickey–Fuller tests.
2) H0: All panels contain unit roots, H_a: At least one panel is stationary.
3) ***, **, and * represent a significance levels of 1%, 5%, and 10%, respectively.

Table 4 Hausman Test for the Panel Data

Variable	Fixed Effects (β_c)	Random Effects (β_e)	Difference (βc- βe)	S.E. sqrt(diag(Vc-Ve))
LRES	0.905065	0.905136	-0.0000708	0.0015869
LBID	0.054339	0.0525	0.0018391	0.0004041
LSQU	-0.01285	-0.01159	-0.0012558	0.0029247
LTFL	-0.02609	-0.03154	0.0054507	0.0020532
LFLO	-0.00103	-0.0011	0.0000685	0.0003239
SCHO	-0.00696	-0.00991	0.0029521	0.0008442
SUBW	0.000337	0.001204	-0.0008676	0.0011871
MART	-0.01566	-0.00667	-0.0089906	0.0029947
TENA	-0.00868	-0.00998	0.0012971	0.0004474
LIEN	-0.00244	-0.00334	0.0008987	0.0006243
$x^2(2) = (\beta c\text{-} \beta e)' (Vc\text{-}Ve)^{-1} (\beta c\text{-} \beta e) = 37.69$ Prob > x^2 0.0000				

Note: 1) We perform the Hausman test for the panel data by using the Seoul metropolis as a whole
2) β_c is the coefficient vector from the consistent estimator
3) β_e is the coefficient vector from the efficient estimator
4) V_c is the covariance matrix of the consistent estimator
5) V_e is the covariance matrix of the efficient estimator
6) H_0: difference in coefficients not systematic

We report the parameter estimates for the POLS and unbalanced panel regression with fixed effects in Table 5. We find that *LRES* (rate of the reserve price) and *LBID* (number of bidders) exert a meaningful positive influence onto *LSOL* (rate of the selling price) at the 1% significance level. On the contrary, *LSQU* (size of the apartment), *LTFL* (total number of floors of the apartment building), *SCHO* (school availability), *MART* (shopping mall availability), and *TENA* (tenants with opposing power) have a significant negative effect on the *LSOL* in both models. However, the remaining independent variables, the *LFLO* (relevant floor of the apartment), *SUBW* (subway availability), and *LIEN* (occupants with opposing power) do not have a significant effect on the *LSOL* at the same level of statistical significance.

The influence of a certain independent variable on the dependent variable in a double log regression model reflects its elasticity under the control of the remaining independent variables. Consequently, the coefficients 0.9052 and 0.9051 of *LRES* in the outcomes of the POLS and fixed effects models indicate the existence of reference price effects. In other words, if the district courts are to increase the reserve price by 1%, the selling price would increase by 0.9052% with the POLS model and by 0.9051% with the fixed effects model (Rosen, 1974).

Table 5 Parameter Estimates for the OLS and Panel Regression

Variable	SMA		Central Zone		Northeastern Zone		Southeastern Zone		Northwestern Zone		Southwestern Zone	
	POLS	Fixed Effects	POLS	Fixed Effects	POLS	Fixed Effects	POLS	Fixed Effects	POLS	Fixed Effects	POLS	Fixed Effects
LRES	**0.9052 (91.38)*** **	**0.9051 (91.14)*** **	**0.9353 (29.99)*** **	**0.9332 (29.16)*** **	**0.9551 (52.25)*** **	**0.9542 (51.62)*** **	**0.9449 (43.72)*** **	**0.9453 (43.49)*** **	**0.8563 (31.82)*** **	**0.8605 (32.30)*** **	**0.8619 (47.32)*** **	**0.8571 (46.52)*** **
LBID	0.0524 (26.71)***	0.0543 (27.38)***	0.0707 (10.77)***	0.0715 (10.83)***	0.0603 (17.87)***	0.0605 (17.65)***	0.069 (15.20)***	0.0685 (15.05)***	0.0463 (9.05)***	0.0446 (8.70)***	0.0346 (9.38)***	0.0347 (9.36)***
LSQU	-0.0116 (-2.29)**	-0.0128 (-2.21)**	-0.0248 (-1.57)	-0.0324 (-1.85)*	-0.0141 (-1.50)	-0.0127 (-1.22)	-0.0122 (-1.17)	-0.0157 (-1.28)	0.016 (-0.95)	0.0308 (1.74)*	-0.018 (-1.51)	-0.0177 (-1.47)
LTFL	-0.0317 (-6.94)***	-0.0261 (-5.25)***	-0.0211 (-1.26)	-0.0204 (-1.21)	-0.0155 (-1.66)*	-0.0174 (-1.80)*	-0.0299 (-2.95)***	-0.0284 (-2.74)***	-0.0242 (-1.69)*	-0.018 (-1.25)	-0.033 (-3.99)***	-0.0331 (-3.79)***
LFLO	-0.0011 (-0.40)	-0.001 (-0.38)	0.01 (-1.09)	0.0103 (-1.11)	-0.0199 (-4.53)***	-0.0194 (-4.37)***	-0.0034 (-0.52)	-0.004 (-0.60)	-0.0019 (-0.22)	-0.0024 (-0.29)	0.0119 (2.53)**	0.0115 (2.44)**
SCHO	-0.01 (-1.81)*	-0.007 (-1.26)	-0.0142 (-0.78)	-0.0159 (-0.87)	0.0343 (1.82)*	0.0353 (1.85)*	0.0088 (-0.54)	0.0089 (-0.54)	-0.0064 (-0.51)	-0.0104 (-0.82)	-0.0104 (-1.32)	-0.009 (-1.13)
SUBW	0.0012 (-0.27)	0.0003 (-0.07)	-0.0143 (-0.82)	-0.0172 (-0.96)	-0.0258 (-1.71)	-0.026 (-1.68)*	0.0493 (3.01)***	0.0478 (2.91)***	0.018 (1.78)*	0.0144 (-1.43)	-0.002 (-0.33)	-0.0016 (-0.26)

(Continued…)

(Table 5 Continued)

Variable	SMA		Central Zone		Northeastern Zone		Southeastern Zone		Northwestern Zone		Southwestern Zone	
	POLS	**Fixed Effects**	**POLS**	**Fixed Effects**	**POLS**	**Fixed Effects**	**POLS**	**Fixed Effects**	**POLS**	**Fixed Effects**	**POLS**	**Fixed Effects**
MART	-0.0065 (-2.33)**	-0.0157 (-3.86)***	-0.0238 (-1.69)*	-0.0235 (-1.66)*	-0.0342 (-3.54)***	-0.035 (-3.54)***	-0.0408 (-4.29)***	-0.0433 (-4.51)***	-0.0008 (-0.09)	-0.0163 (-1.53)	-0.0041 (-0.74)	-0.0053 (-0.81)
TENA	-0.01 (-3.89)***	-0.0087 (-3.35)***	-0.0049 (-0.41)	-0.0069 (-0.57)	-0.0055 (-1.25)	-0.0063 (-1.41)	-0.0145 (-3.02)***	-0.0145 (-3.03)***	-0.0098 (-1.32)	-0.0055 (-0.73)	-0.003 (-0.70)	-0.0019 (-0.45)
LIEN	-0.0034 (-1.05)	-0.0024 (-0.75)	0.0041 (-0.23)	0.0046 (-0.26)	0.0004 (-0.07)	-0.0005 (-0.08)	-0.0028 (-0.51)	-0.0023 (-0.41)	-0.0054 (-0.65)	-0.0044 (-0.53)	0.0005 (-0.09)	0.0001 (-0.02)
Cons	0.6142 (11.66)***	0.6046 (11.03)***	0.5138 (3.09)***	0.5578 (3.09)***	0.39 (4.13)***	0.3927 (4.04)***	0.381 (3.16)***	0.3972 (3.13)***	0.679 (4.37)***	0.5901 (3.71)***	0.8341 (8.46)***	0.8526 (8.49)***
Adj. R^2 / overall R^2	0.8768	0.8765	0.8951	0.9021	0.8976	0.9003	0.9033	0.9068	0.8819	0.8845	0.8529	0.8562
F / Wald	1010.49***	986.82***	125.61***	123.11***	325.42***	308.43***	251.23***	247.62***	139.93***	141.62***	258.43***	245.71***

Note: The dependent variable is the log rate of the selling price to the appraised price (*SOL*).

The zonal results show that *LRES* and *LBID* have strong positive effects on the rate of the selling price (*LSOL*) at the 1% significance level in all five zones of the SMA. However, the parameter estimates differ by zone. For the POLS model, the largest coefficient of *LRES* is 0.9551 (northeastern), while the weakest is 0.8563 (northwestern); for the fixed effects model, the strongest coefficient of *LRES* is 0.9542 (northeastern) and the weakest is 0.8571 (southwestern). The remaining independent and dummy variables (*LSQU, LTFL, LFLO, SCHO, SUBW, MART, TENA,* and *LIEN*) show inconsistent signs (+ or –) and statistical significances according to the zone under study.

The panel regression estimates show that the basic reference price effects of reserve prices exist in housing auctions both across the SMA as a whole and in its five zones. We also find that the coefficients of both the POLS and the fixed effects models are almost identical. Therefore, by analyzing the reference price effects with the use of the panel data, we infer that the reference price effects of *LRES* on *LSOL* are very strong even though regional differences exist.

4.2 Sensitivity of Reference Price Effects

According to the seminal prospect theory, the marginal value of both gains and losses in monetary changes generally decreases with their magnitude. Contrary to the expectations of utility theorists, behavioral economics theorists suggest that value should thus be treated as a function of the asset position that serves as the reference point and the magnitude of the change from that reference point (Kahneman and Tversky, 1979). In practice, the perceived price is greater when for example, the price of a vehicle increases from $10,000 to $11,000 compared to $100,000 to $101,000 (i.e., the same difference of $1000). Against this background, we perform an LOLS regression to investigate whether the sensitivity of the reference price effects differs with housing size. If the arguments of the behavioral economics theorists are sound, we may find greater sensitivity of the reference price effects of reserve prices for smaller apartments compared to the larger ones.

Table 6 summarizes the parameter estimates for the sensitivity analysis with the LOLS regression. The parameter estimates of *LRES* are positive, thus implying that reserve prices influence selling prices in all apartment size groups. In other words, there are consistently reference price effects on the reserve prices regardless of the apartment size. On the contrary, the sensitivity of the reference price effects derived from the LOLS regression is somewhat different. Among the six apartment size groups, the reference price effects are the strongest for the 111–132 m^2 apartments and weakest for the 133–164 m^2 apartments. The results of the sensitivity analysis, however, do not provide coherent information on the reference price effects of the reserve prices.

Table 6 Parameter Estimates for Sensitivity Analysis with OLS Regression (SMA)

Variable	Under 60 m^2 18 pyeong type	61–84 m^2 25 pyeong type	85–110 m^2 33 pyeong type	111–132 m^2 40 pyeong type	133–164 m^2 50 pyeong type	Over 165 m^2 Over 60 pyeong
LRES	**0.900(29.19)*** **	**0.938(52.35)*** **	**0.867(46.50)*** **	**0.98432.95)*** **	**0.828(11.95)*** **	**0.921(12.92)*** **
LBID	0.065(7.29)***	0.057(18.86)***	0.041(12.85)***	0.047(8.67)***	0.056(6.04)***	0.073(2.92)***
LSQU	0.032(-0.82)	0.004(-0.19)	0.003(-0.15)	-0.026(-0.44)	0.095(-0.77)	0.032(-0.3)
LTFL	-0.074(-3.83)***	-0.020(-2.78)***	-0.040(-5.36)***	-0.031(-2.56)**	0.004(-0.17)	-0.015(-0.27)
LFLO	-0.012(-1.08)	-0.003(-0.77)	0.000(-0.01)	-0.000(-0.05)	-0.019(-1.27)	0.034(-1.26)
SCHO	0.016(-0.77)	-0.025(-2.83)***	-0.018(-1.79)*	-0.005(-0.34)	-0.022(-0.57)	0.053 (-1.37)
SUBW	-0.006(-0.31)	-0.001(-0.20)	-0.000(-0.05)	0.020(1.72)*	0.032(-1.11)	0.016(-0.35)
MART	0.037(1.75)*	-0.005(-1.14)	-0.001(-0.36)	-0.022(-2.98)***	-0.031(-1.37)	-0.052(-1.51)
TENA	-0.013(-0.70)	-0.009(-2.20)**	-0.006(-1.83)*	-0.003(-0.47)	-0.018(-1.30)	-0.037(-0.89)
LIEN	0.048(1.68)*	-0.003(-0.53)	-0.003(-0.86)	0.001(-0.22)	-0.016(-0.90)	0.004(-0.12)
Constant	0.536(2.63)**	0.382(2.92)***	0.752(5.15)***	0.330(-1.05)	0.349(-0.44)	0.164(-0.24)
Sample	82	581	514	157	56	29
Adj. R^2	0.928	0.8409	0.824	0.8857	0.8893	0.9001
***F*-stat**	105.44***	307.56***	241.25***	121.91***	45.20***	26.22***

Note: 1) The dependent variable is the log rate of the selling price to the appraised price (*LSOL*).
2) ( ) implies *t*-statistics and ***, **, and * represent a significance level of 1%, 5%, and 10%, respectively.
3) Pyeong is a unit in Korea that is used to measure the size of the floor space and land (1 pyeong = 3.3 m^2 (1.818 m × 1.818 m).

4.3 Predicting Expected Reference Price Effects

In Korean court auctions of residential real estate, the rate of the selling price (*SOL*) is the most important indicator of the likely price of similar properties in the neighboring area. Bidders thus decide their bids based on their own estimations of the expected rate of the selling price, which dictate the success of their bidding. Hence, in this study, a statistical technique is proposed for predicting the rate of the selling price, namely, a nonparametric RSM. By using panel data regression and sensitivity analysis, we find that the reserve price (*RES*) and number of bidders (*BID*) strongly influence the rate of the selling price (*SOL*) compared to other factors. For simplicity, we have carried out the RSM analysis by using *RES* and *BID* as the independent variables and *SOL* as the dependent variable to approximate the expected rate of the selling price (i.e., reference price effects) in accordance with the changes in the rate of the reserve price.

Table 7 presents the parameter estimates for the RSM. In the SMA, all the parameter estimates of the *X*s (X_1, X_2, X_1X_1, X_2X_1, X_2X_2) are significant at the 1% level. However, the magnitude and direction of these estimates are different. The rate of the reserve price (X_1) has a significant positive effect (+0.6724) on the rate of the selling price (Y_i), whereas the number of bidders (X_2) have a negative influence (-0.6085) on Y_i . The parameter estimate of X_2X_1 also indicates the existence of a positive synergistic effect (+0.0200) of the interactions between the rate of the reserve price (X_1) and the number of bidders (X_2) over the rate of the selling price (Y_i).

Table 8 shows the expected rates of the selling prices. These results could be very useful for formulating an appropriate auction strategy. For example, auctioneers (courts) could easily find a reasonable approximation of the *RES* without repeated auction rounds of conflicting prices while bidders may be able to decide their entry point more objectively in order to avoid the winner's curse[12]. Figure 3 presents the contours of the RSM estimations, which show dynamic stimulus–response relationships between the rate of the reserve price (*RES*) and the rate of the selling price (*SOL*). The highly irregular curvatures and intervals of the contours suggest that the reference price effects of reserve prices differ by locality and reserve price.

[12] The winner's curse is where the winning bidders tend to overpay compared with the objective value of auctioned properties. If this happens, the winner of the auction is likely to be a loser. The winner can be said to be 'cursed' in one of two ways: (1) the winning bid exceeds the value of the tract, so the firm loses money or (2) the value of the tract is less than the expert's estimate, meaning that the winning firm is disappointed. However, because the winner's curse cannot occur if all bidders are rational, evidence in market settings would constitute an anomaly. The winner's curse is a problem that is amenable to investigation by using modern behavioral economics, a combination of cognitive psychology and microeconomics (Thaler, 1988).

Table 7 Parameter Estimates for RSM

Area	Parameter estimate					
	Intercept	X_1(RES)	X_2(BID)	X_1(RES)*X_1(RES)	X_2(BID)*X_2(BID)	X_1(RES)*X_2(BID)
SMA	21.012 (5.86)***	0.672 (7.28)***	-0.608 (-2.79)***	0.001 (2.72)***	-0.009 (-3.43)***	0.020 (7.55)***
Central Zone	12.190 (-1.32)	0.740 (2.98)***	0.177 (-0.24)	0.001 (-1.07)	-0.044 (-3.54)***	0.023 (2.96)***
Northeastern Zone	18.321 (2.57)**	0.735 (4.07)***	-0.500 (-1.23)	0.001 (-0.83)	-0.029 (-5.79)***	0.023 (4.99)***
Southeastern Zone	27.204 (3.11)***	0.427 (1.87)*	-0.507 (-0.90)	0.003 (2.30)**	-0.003 (-1.13)	0.020 (2.84)***
Northwestern Zone	21.709 (2.51)**	0.600 (2.60)**	0.497 (-0.97)	0.002 (-1.59)	-0.025 (-2.85)***	0.008 (-1.33)
Southwestern Zone	26.661 (3.30)***	0.597 (2.99)***	-0.69 (-1.52)	0.002 (-1.55)	-0.004 (-0.54)	0.016 (3.17)***

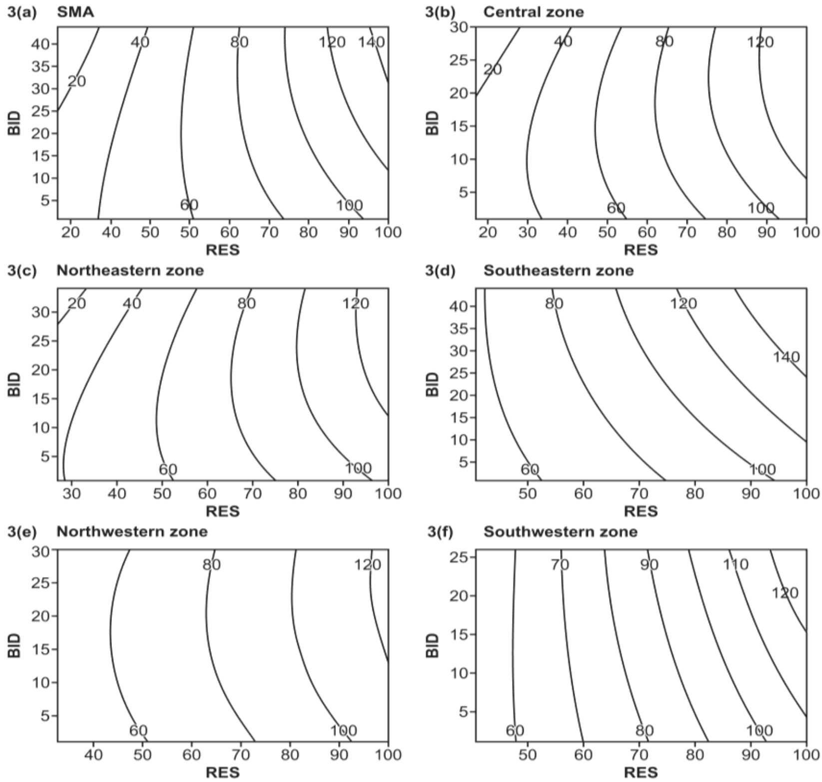
Note: 1) The dependent variable is the rate of the selling price to the appraised price (*SOL*).
2) ( ) implies *t*-statistics and ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

Table 8 Prediction of the Expected Rates of Selling Price

Area	Rate of reserve price (RES: %)	Average number of bidders (BID: persons)	Expected rate of selling price (SOL: %)
SMA	100	5.68	112.862
	80	5.844	91.168
	72	6.727	83.42
	64	7.132	75.335
	51	4.7	61.459
Central Zone	100	5.906	117.557
	80	5.117	92.278
	72	7.4	86.187
	64	6.475	75.943
	51	3	58.361
Northeastern Zone	100	5.333	111.086
	80	6.038	90.994
	72	6.909	83.475
	64	6.991	75.236
	51	3	60.309
Southeastern Zone	100	0.75	106.129
	80	6.957	91.514
	72	6.071	81.881
	64	7.94	75.06
	51	5	60.715
Northwestern Zone	100	6.5	114.388
	80	5.915	91.785
	72	6.542	84.041
	64	7.048	76.43
	51	1	59.733
Southwestern Zone	100	5.135	111.458
	80	5.76	90.954
	72	6.505	83.317
	64	7.713	75.882
	51	6.667	63.31

Note: The expected rate of the selling price (SOL) is calculated by using estimated RSM functions.

Figure 3 Contours of the RSM Estimation



Note: 1) The horizontal axis is the rate of the reserve price (%).
2) The vertical axis is the number of bidders.
3) The contour is the rate of the selling price for the SMA and the five zones of the SMA.

5. Conclusion

Recently, a number of theoretical auction studies have acknowledged that reserve prices serve as a reference point which may influence the WTP of bidders. However, both the theoretical and the empirical results of research work that explored the reference price effects of reserve prices in auctions are inconclusive (Trautmann and Traxler, 2010). Nevertheless, the reserve prices created by the courts substantially affect the interests of the parties concerned. By reducing the reserve prices, for example, the courts can shorten the bid timings and avoid breaking down of tenders (Lin, 2005). However, extremely low selling prices would reduce the benefits for both creditors and debtors. On the contrary, higher reserve prices may inhibit the possibility of a sale and result in repeated auctions (McAfee, Quan, and Vincent, 2002).

Based on the foregoing, the effects of reserve prices in court auctions of residential real estate in Korea have been examined in this study. The results of the panel data estimates presented herein show that the reserve price level has significant reference price effects on transfer prices, thus suggesting that there are strong reference price effects in the court auctions of residential real estate of the SMA as a whole as well as in its five zones. However, the magnitude of the reference price effects of reserve prices differs by zone. Furthermore, we find that the sensitivity of the reference price effects derived from the LOLS regression differs with housing size. Among the six groups of apartment size analyzed, reference price effects are shown to be the strongest for the 111–132 m^2 apartments and weakest for the 133–164 m^2 apartments. The results of the sensitivity analysis, therefore, are not able to provide coherent information on the reference price effects of the reserve prices.

Finally, the prediction analysis which uses a nonparametric RSM proposes that varying reserve prices leads to differences in the expected reference price effects with locality. Therefore, courts and bidders may be able to approximate the expected rate of the selling price by using the RSM simulations described in this study, which would allow them to set reserve prices and decide on the bid levels.

Resultant of the study findings, some policy suggestions are recommended to improve the court auction process of residential real estate in Korea. First, current prices should be appropriately appraised and reserve prices reasonably stipulated because these control the outcome of auctions through the reference price effects described herein. During the period of this study, only one-third (32.7%) of the court auctions of real estate examined are successfully carried out. The low probability of selling (i.e., high degree of discrepancy between reserve and reference prices) suggests that the reserve prices are not being established at a reasonable amount by appraisers and/or the courts. Second, the cutoff intervals (20–30%) of the reserve prices in cases of discrepancies between the reserve and reference prices must be reduced (e.g., to 5–10%). Such a wide gap between auction rounds means that there is susceptibility to bias with the drawing of artificial reference points. For instance, it is suggested that Korean tax offices reduce reserve prices by 10% when public sales fail in delinquency dispositions.

Finally, some future directions for research are provided. First, researchers can carry out more studies on real estate auction markets. In the course of performing this study, we found that the literature on real estate auctions is still lacking despite the numerous available sources. Second, there should be a balance in the research on first-price sealed-bid auctions. Previous works on reserve prices have focused on auctions in the western context; thus, increasing the scope of the research on sealed-bid auctions would be desirable to provide researchers with generalized theories and practices in other countries that have adopted the first-price sealed-bid auction system (e.g., Taiwan, Nigeria, Singapore, and the US).

Acknowledgement

This work was supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2012S1A3A2033330).

References

Ariely, D. and Simonson, I. (2003). Buying, Bidding, Playing, or Competing? Value Assessment and Decision Dynamics in Online Auctions, *Journal of Consumer Psychology*, 13, 1&2, 113–123.

Bae, C.H.C., Jun, M.J. and Park, H. (2003). The Impact of Seoul's Subway Line 5 on Residential Property Values, *Transport Policy*, 10, 2, 85-94.

Bae, H.J. (2013) Korean Real Estate Market Highly Attractive for Investors, *The Korea Herald*, July 16, 2013. Available at: http://www.koreaherald.com.

Bettinger, D. and Chinnici, J.P. (1991). Utilization of Response Surface Modeling to Evaluate Interaction between Aflatoxin B_1 and Caffeine on Egg-Adult Viability in Drosophila Melanogaster, *Virginia Journal of Science*, 42, 311–320.

Bourassa, S., Hamelink, F., Hoesli, M. and MacGregor, B. (1999). Defining housing submarkets, *Journal of Housing Economics*, 8, 2, 160–183.

Bradley, N. (2007). The Response Surface Methodology, Master's dissertation, Indiana University of South Bend.

Carley, K.M., Kamneva, N.Y., and Reminga, J. (2004). Response Surface Methodology, CASOS Technical Report, CMU-ISRI-04-136, 1–26.

Chiodo, A.J., Hernández-Murillo, R., and Owyang, M.T. (2010). Nonlinear Effects of School Quality on House Prices. *Federal Reserve Bank of St. Louis Review*, 92, 3, 185-204.

Cong, S., Zheng, S., and Han, R. (2014). Proceedings of the 17th International Symposium on Advancement of Construction Management and Real Estate: The Effects of Subway Construction on Housing Premium: A Macro-data

Analysis in Chengdu's Housing Market, ISBN, 78-3-642-35548-6, Springer-Verlag, Berlin Heidelberg, 445-454.

Dewally, M. and Louis Ederington, L. (2004). What Attracts Bidders to Online Auctions and What Is Their Incremental Price Impact? Available at SSRN: http://ssrn.com/abstract=589861 or http://dx.doi.org/10.2139/ssrn.589861.

Duncan, M. (2008). Comparing Rail Transit Capitalization Benefits for Single-Family and Condominium Units in San Diego, California, *Transportation Research Record*, 2067, 120–130.

Hardin, W. and Wolverton, M. (1996). The Relationship between Foreclosure Status and Apartment Price, *Journal of Real Estate Research*, 12, 1, 101–109.

Haurin, D.R. and Brasington, D. (1996). School Quality and Real House Prices: Inter-and Intra-meTropolitan Effects, *Journal of Housing Economics*, 5, 351-368.

Hewitt, C.M. and Hewitt, W.E. (2012). The Effect of Proximity to Urban Rail on Housing Prices in Ottawa, *Journal of Public Transportation*, 15, 4, 43–65.

Kamins, M., Dréze, X., and Folkes, V. (2004). Effects of Seller Supplied Prices on Buyers' Product Evaluations: Reference Prices in An Internet Auction On Text, *Journal of Consumer Research*, 30, 4, 622–628.

Kahneman, D. and Tversky, A. (1979). Prospect theory: An Analysis of Decision under Risk, *Econometrica*, 47, 2, 263–292.

Kalali, A., Ebadi, T., Rabbani, A., and Moghaddam, S. (2011). Response Surface Methodology Approach to the Optimization of oil Hydrocarbon Polluted Soil Remediation Using Enhanced Soil Washing, *International Journal of Environmental Science and Technology*, 8, 2, 389–400.

Kim, J. and Zhang, M. (2005). Determining Transit's Impact on Seoul Commercial Land Values: An Application of Spatial Econometrics, *International Real Estate Review*, 8, 1, 1-26.

Kim, T. (2004). Shadow Education: School Quality and Demand for Private Tutoring in Korea, KDI School of Pub Policy & Management Paper No. 04-21, 1-22. Available at SSRN: http://ssrn.com/abstract=635864

Kristensen, H. and Gärling, T. (1997). Anchor Points, Reference Points, and Counter Offers in Negotiation, *Göteborg Psychological Reports*, 27, 1–11.

Ku, G., Galinsky, A., and Murnighan, K. (2006). Starting Low But Ending High: A Reversal of the Anchoring Effect in Auctions, *Journal of Personality and Social Psychology*, 90, 6, 975–986.

Lenth, R. (2009). Response-Surface Methods in R, Using RSM, *Journal of Statistical Software*, 32, 7, 1–17.

Lin, V. (2005). Hedonic Model of Court Auction Residential Housing Market in the Taipei Metropolitan Area, The Queensland University of Technology Research Week 2005 Conference Proceedings, 1–19.

Matthews, W. (2006). The Effect of Proximity to Commercial Uses on Residential Prices, Ph.D. Dissertation, Georgia State University and Georgia Institute of Technology, 1-188.

Mayer, C. (1998). Assessing the Performance of Real Estate Auctions, *Real Estate Economics*, 26, 1, 41–66.

McAfee, P., Quan, D., and Vincent, D. (2002). How to Set Minimum Acceptable Bids, with An Application to Real Estate Auctions, *Journal of Industrial Economics*, 50, 4, 391–416.

Milgrom, P. and Weber, R. (1982). A Theory of Auctions and Competitive Bidding, *Econometrica*, 50, 5, 1089–1122.

Montgomery, D. (2005). Design and Analysis of Experiments: Response Surface Method and Designs, New Jersey, John Wiley and Sons.

Myers, W. and Brenneman, W. (2010). Encyclopedia of Biopharmaceutical Statistics, 3rd ed., London, UK, Information Healthcare.

Nunes, J. and Boatwright, P. (2001). Incidental Prices and Their Effect on Consumer Willingness to Pay, Working Paper, 1–47.

Popkowski Leszczyc, P., Qiu, C., and He, Y.F. (2009). Empirical Testing of the Reference-Price Effect of Buy-Now Prices in Internet Auctions, *Journal of Retailing*, 85, 2, 211–221.

Pucher, J., Park, H.Y., Kim, M.H., and Song, J.M. (2005). Public Transport in Seoul: Meeting the Burgeoning Travel Demands of A Megacity, *Public Transport International*, 54, 3, 54-61.

Reiley, D.H. (2005). Field Experiments on the Effects of Reserve Prices in Auctions: More Magic on the Internet, *The RAND Journal of Economics*, 37, 1, 195-211.

Rosen, S. (1974). Hedonic Price and Implicit Markets: Product Differentiation in Pure Competition, *The Journal of Political Economy*, 82, 1, 34–55.

Rosenkranz, S. and Schmitz, P. (2007). Reserve Prices in Auctions as Reference Points, *Economic Journal*, 117, 520, 637–653.

Thaler, R. (1988). The Winner's Curse, *Journal of Economic Perspectives*, 2, 1, 191–202.

Trautmann, S. and Traxler, C. (2010). Reserve Prices as Reference Points – Evidence from Auctions for Football Players at Hattrick.org, *Journal of Economic Psychology*, 31, 2, 230–240.

Tse, R. (2002). Estimating Neighborhood Effects in House Prices: Towards a New Hedonic Model Approach, *Urban Studies*, 39, 7, 1165–1180.

Vincent, D. (1995). Bidding Off the Wall: Why Reserve Prices May Be Kept Secret, *Journal of Economic Theory*, 65, 2, 575–584.

Walley, M. and Fortin, D. (2005). Behavioral Outcomes from Online Auctions: Reserve Price, Reserve Disclosure, and Initial Bidding Influences in the Decision Process, Journal of Business Research, 58, 10, 1409–1418.

Wooldridge, J. (2002). Econometric Analysis of Cross Section and Panel Data, Cambridge, Mass., The MIT Press.

Attorneys at Law YULCHON (2012). How the Auction Procedure Works in Korea, Real Estate And Finance Newsletter, 1-2. http://www.yulchon.com)

Ministry of Government Legislation (2015). Korean Laws in English. http://www.moleg.go.kr/english/korLawEng?.

Seoul Metropolitan Government. (2013).
http://urban.seoul.go.kr/DUPIS/sub3/sub3_1.jsp.

Seoul Metropolitan Government (2014). 2012 Seoul Survey http: //stat.seoul.go.kr//pdf/e-webzine75/pdf.

Seoul Metropolitan Government. (2015). Seoul Statistics in 2012 http://stat.seoul.go.kr/.

Statistics Korea (2015). http://www.kostat.go.kr/eng/.

Supreme Court of Korea http://www.courtauction.go.kr/.

Appendix The Court Auction Process of Residential Real Estate in Korea

In Korea, the court auctions of residential real estate are exclusively controlled by the district courts in accordance with the process shown in Figure 1. Under Korean laws, there are two types of auctions available to creditors: compulsory judicial and court-administered auctions. The former is where the creditor obtains a monetary judgment from a court against a debtor but the debtor does not voluntarily address the judgment or order. The latter is where the creditor holds a lien or mortgage on a relevant real estate property of a debtor and the debtor defaults on his/her obligations. These two kinds of auction processes are very similar.

The **court auction process of residential real estate in Korea** can be divided into three stages: pre-bidding, actual bidding, and post-bidding. In the pre-bidding stage, the courts order the appraisers to estimate the current price of the auction items. The courts must then set the initial reserve prices based on the reported value from the appraisers. After the filing period, the courts publicly announce the auction date and reserve prices in detail for two weeks in newspapers and on the webpage of the Supreme Court of Korea (http://eng.scourt.go.kr). During the actual bidding stage, the courts receive sealed bids from the auction participants with a 10% deposit of the reserve prices. Bidders usually establish their bids by adding a certain amount of money to the reserve price based on their own evaluations. Accordingly, the reserve price in all practicality assumes the important role of a reference point. The courts then close the bidding process after an hour. The highest bidder wins the auction and must pay the bid amount in full within 30 days. If the bidders do not meet the reserve prices, the courts continue the process at one-month intervals, and reduce the reserve prices by 20–30% each time. During the court auction process, bidders do not know the bids of other competitors. Therefore, the court auction process of residential real estate in Korea is a first-price sealed-bid type of auction. Finally, the post-bidding stage deals with the payment of the purchase price and distribution of the proceeds after the authorization of the sale. The deadline for the payment period will be generally set as one month after the authorization of the sale (Attorneys at Law YULCHON, 2012).