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Housing Prices and the Role of Speculation: The Case of Seoul

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Donghyun Park and Qin Xiao

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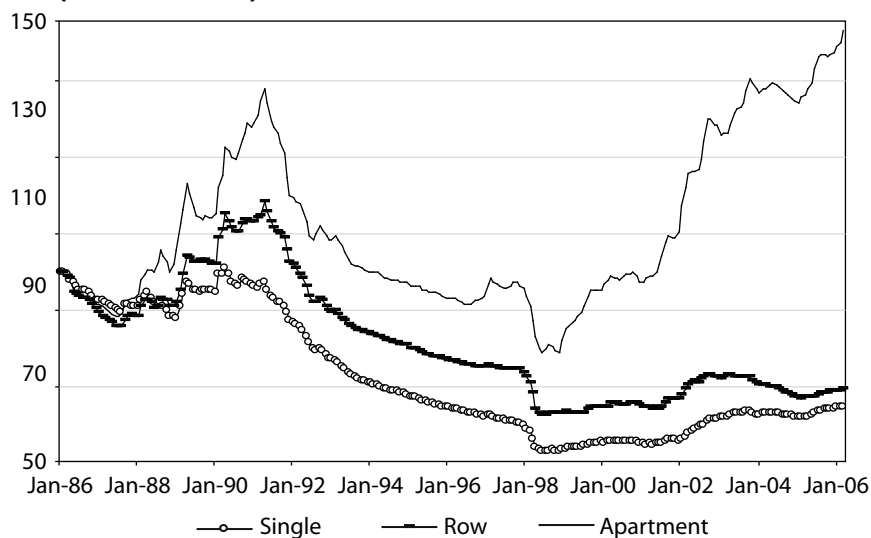
Abstract

Between June 1998 and March 2006, the price index of apartment housing in Seoul, Republic of Korea more than doubled, while **fundamentals such as** gross domestic product, wage, and population increased by less than 35%. This study **examines the role of a rational speculative bubble in this price surge. We** find that unobservable information explains part of the price volatility, and that a rational bubble proxy is a significant driver of prices. However, neither latent information nor rational bubble **is enough to explain the recent housing price** appreciation, even in conjunction with observable fundamentals.

I. Introduction

The three main types of housing in Seoul, Republic of Korea (henceforth Korea) are apartment houses (or apartments), single houses, and row houses. Housing prices in Seoul have gone through boom-and-bust cycles in the past 20 years, especially in the apartment sector. Between August 1987 and April 1991, the real price index of apartments rose by 66.61%, while that of row houses and single houses rose by only 38.50% and 8.52% respectively. This bull run was followed by a 7-year long bear market. By June 1998, the price indices had dropped to about half of their respective peak values. Since then the markets have recaptured some of their losses. Between June 1998 and March 2006, the apartment housing price index has increased by 106.29%, while the row house and single house price indices increased by only 11.14% and 22.30%, respectively (Figure 1).

**Figure 1: Seoul Housing Price Indices Deflated by CPI (housing)
(Jan 1986=100)**



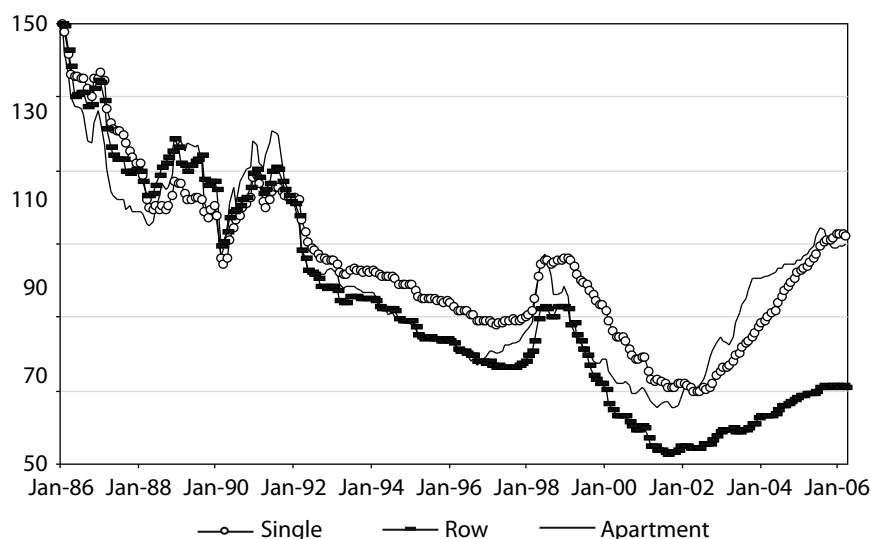
The divergent behavior of the price indices of different types of housing is striking. In a housing market with supply rigidity,¹ such as that of Seoul, price volatility is largely a result of demand volatility. What could have caused such large differences in demand across housing types, fundamentals or speculation? If fundamentals, theory suggests

¹ See Section II for details on supply rigidity in Korea.

that the value of a house to a buyer depends on the expected value of the stream of services the house can deliver within its life time. That value is usually gauged by the prevailing future market rents. However, since future rents are unknown, the current or the most recent rent is usually used as a proxy. This line of thinking suggests that the price–rent ratio should not change substantially over time in the absence of policy or macroeconomic shocks. As shown in Figure 2, the price–rent ratio for all three housing sectors fell until early 2002. This is the result of a supply surge in 1988–1998 (refer to Section II below).

However, there is no significant difference across housing types in terms of the decline of the price–rent ratio. After 1998, the price–rent ratio of row houses behaved differently from that of apartments and single houses. Yet there was virtually no difference in behavior between apartments and single houses. This means that the price–rent ratio alone cannot explain the divergence in prices among the different housing types. If prices are influenced by macroeconomic variables, such as interest rate, we can expect a variable that affects apartments to have a similar impact on the other types of housing. Furthermore, there is no discriminatory supply or demand policy against a particular type of housing (as discussed in Section II below). Is it then possible that a rational speculative bubble explains the divergent price behavior of different housing types? But why should apartments be the preferred vehicle of speculation?

Figure 2: Price–Rent Ratio (Jan 1986=100)



To answer these questions, we will **adopt the asset-price approach to housing price determination. The rationale for using this approach is given in the passage above** and will be further elaborated on in **Section IV. Our study compares two variants of the present value model.** One assumes that only fundamentals drive the housing market while the other assumes that a rational speculative bubble plays an important role. According to the positive feedback theory (Shiller 1990), this bubble is approximated by lagged price appreciation. Xiao (2008) explicitly modeled the mechanism that rationalizes this approximation. Empirical analysis shows that the coefficient on the rational speculative bubble is highly significant, and has the correct sign and magnitude suggested by Shiller (1990) and Xiao (2008). **The inclusion of this variable boosts the in-sample fitting as well as the predictive power of the model.** To capture some private information missing from both models, a latent state variable is included. Our study shows that this variable helps to explain part of the price volatilities.

II. State of the Korean and Seoul Housing Markets

A bubble is the deviation of a price from its fundamental value. Since the fundamental value is inherently subject to a great deal of uncertainty, price will in general contain a bubble element. In the absence of speculation, the rise and fall of that bubble **should be purely random, and hence should be more correctly called market noise.** On the other hand, a systematic deviation of a price from its fundamental value over sustained periods of time can only be the result of speculation. Such deviation constitutes a speculative bubble.

The primary motive for speculation is expected capital gain. While some argue that high transaction costs in the housing market will hinder speculation, Levin and Wright (1997), Caginalp et al. (2000), and Lei et al. (2001) show these costs may not have much of a deterrent effect. Malpezzi and Wachter (2005) point out that restricted supply is the key driver behind speculation in the housing market. In markets with elastic supply, speculative demand will have little impact on price. **This fact should dampen the incentive to speculate in the first place.**

The rigidity of housing supply in Korea is well documented in the literature. The government exercises almost full control over the housing supply, through its monopoly of the supply of land that can be developed for residential use. In the early stages of economic growth and development, the Korean government discouraged scarce capital from flowing into the housing sector. The underlying assumption was that the housing sector **yields lower returns than the manufacturing or export industry.** The government has the lion's share of the supply of housing credit, and this further strengthened its grip on the housing market. To keep demand within supply, the government also imposed punitive taxes and restricted housing market transactions (Kim 1993, Renaud 1993, Kim 2004a).

By 1988, the government came to realize the severity of the housing shortage that resulted from its policies. In response, it decided to build two million new dwellings in five years. In the next 10 years, the average annual production of houses jumped from 200,000–250,000 units to 500,000–600,000. The total number of dwellings stood at 6.1 million by 1985. The number rose to 9.21 million by 1995 and 10.96 million by 2000 (Kim 2004, Kim and Kim 2002). This increased supply is the major cause of the housing price decline between 1991 and 1998.

However, the increase in the number of houses represents a one-time right-shifting of a very steep supply curve rather than flattening of the supply curve. There are still more than 100 regulations regarding land use in Korea. For instance, the green belt in the city of Seoul takes up 50% of its developable land.² At the same time, controlling the growth of the Capital Region,³ which covers 11% of the nation's territory but is home to 46% of its population, remains a top government priority (Kim and Kim 2002). Rigid supply, coupled with concentrated demand, makes Seoul the perfect breeding ground for speculation.

Be that as it may, speculation had been tame before the deregulation of the 1990s, largely due to the underdeveloped state of the formal mortgage market. With limited supply of housing credit, speculators do not have the financial wherewithal to speculate. The primary mortgage market used to be dominated by the National Housing Fund, which provided below-market rate loans to low- or moderate-income households, and the Korea Housing Bank, which served a somewhat higher income clientele. Credit rationing was also in place. A ceiling on loan amount per household was strictly enforced so that the loan-to-value ratio was typically below 30%. Furthermore, only new houses were eligible for loans. There were rules that restricted the eligibility of borrowers as well. As late as 1999, the percentage of households with access to housing loan was only 50.8% (Kim 2004a).

In this situation, an informal housing finance arrangement known as *chonsei* emerged to fill the gap. Under this arrangement, the tenant gives the landlord a lump sum deposit (about 50% of the value of the house on average) in lieu of monthly rental payments. Owners can then use this deposit to finance the purchase of a second house. The deposit is fully refunded at the end of the lease. In 1997 total *chonsei* deposits were estimated to be 107.8 trillion won, about twice as large as the 64 trillion won of outstanding total mortgage loans. *Chonsei* claims on apartments alone amounted to 63.4 trillion won in mid-2001, compared with 54 trillion won of total outstanding housing loans (Kim and Suh 2002, Kim 2004a). According to the Population and Housing Census of

² Under the Urban Planning Act (1971), green belts were designated around major Korean cities between 1971 and 1977. The Act and its accompanying decrees prohibit land-use conversions, land subdivisions, and construction activities other than rebuilding or altering existing structures inside the green belts without prior approval from the relevant government offices. Green belts in medium-sized cities were lifted in 1999, while those in the Capital Region and six other large metropolitan areas are in the process of being reviewed for partial liberalization.

³ The Seoul Capital Region consists of the city of Seoul, the city of Incheon, and the Kyong-gi Province. Conversion of agricultural and forest land is not allowed for large-scale residential and industrial developments in this region.

2000, 41% of housing stock in urban areas is owner-occupied, 41% rented on *chonsei* contracts, and 16% rented on monthly rental contracts.⁴ *Chonsei* represents about 60% of new rental contracts in Seoul (Kim 2004a).

In January 2003, the Comprehensive Planning and Land Use Act took effect, marking the onset of deregulation in the Korean real estate market. The essence of the new law is “no development without planning”, which, according to Kim and Kim (2002), could make the supply of land in the suburbs that can be developed even less elastic. On the other hand, financial deregulation related to the real estate sector has made substantial progress since the early 1990s. The size of the primary mortgage market has increased substantially, more innovative products have been developed, and the loan-to-value ratio has increased.⁵ In 1997, the outstanding balance of mortgage loans amounted to 11.7% of gross domestic product (GDP), but rose to 13.4% by 2001. These figures are estimates, because the Bank of Korea publishes data only on the housing loans made to consumers but not those to developers. Many lenders underreport housing loans as they declare loans with housing collateral as consumer loans. The figure also excludes the informal *chonsei* market. While supply rigidity has sown the seed of speculation, the upsurge in housing credit has created a conducive climate for that seed to grow.

Hwang et al. (2006) and Kim (2004a) provide excellent in-depth descriptions of the current state of the housing markets in Korea and Seoul. The distinctive *chonsei* rental contract, described above, is the defining feature of the Korean housing market. The *chonsei* contract has a legal term of 2 years and combines two separate transactions. The first transaction is the interest-free loan made by the tenant to the landlord. The second transaction is the lease that gives the tenant the use of the landlord’s residence in exchange for the implicit rent, i.e., the interest income the landlord earns on the *chonsei* deposit. The implicit rent can thus be computed by multiplying the deposit by the prevailing market interest rate.⁶ *Chonsei* contracts still dominate the rental market in Seoul, despite the growing popularity of monthly rental contracts in recent years. This is especially true in the rental market for mid- and upper-level residences. Therefore, the Korean housing market is essentially a two-pillar market consisting of owner-occupiers and *chonsei* renters. Finally, owner-occupiers do contribute to the housing price inflation since many owners who have only one home buy their home partly as an investment. However, it is unlikely that they drive and dominate the market in light of the large numbers of renters, which implies substantial numbers of multiple home owners. Indeed some owners use the *chonsei* deposit to invest in additional homes.

⁴ Some monthly rental contracts also require a separate key money deposit.

⁵ The loan-to-value ratio is still relatively low. In 2003, the loan-to-value ratio was merely 32.4% (Kim 2004a).

⁶ In fact, the rent index, taken from the CEIC Database and used in this study, is computed using *chonsei* contracts.

III. Literature Review

Economists have long been fascinated by speculative bubbles in the real estate market. Perhaps due to the great deal of uncertainty surrounding the fundamental value, empirical studies often produce mixed evidence on the existence of bubbles (Abraham and Hendershott 1996, Levin and Wright 1997, Brooks et al. 2001, Bjorklund and Soderberg 1999, Bourassa and Hendershott 2001, Roche 2001, Himmelberg et al. 2005, Ito and Iwaisako 1995, Chan et al. 2000).

There are quite a number of studies by Korean economists on the volatile behavior of the Korean housing market. Many believe that the boom in the housing market from the late 1980s to the early 1990s was largely driven by speculative demand. Kim and Suh (1993) show that a bubble existed in both the nominal and relative price of land price between 1974 and 1989. Lee (1997) also rejects the hypothesis that land prices were driven solely by market fundamentals in Korea between 1964 and 1994.

Kim and Lee (2000) adapt the idea that the existence of an equilibrium relationship excludes the possibility of a price bubble. They conclude that Korea's nominal and real land prices are cointegrated with market fundamentals (approximated by nominal and real GDP respectively) in the long run. However, such a cointegration relationship does not exist in the short run.

Lim (2003) conducted two bubble tests based on the present value relation on the housing price of Korea. One is a modified volatility test (MRS test) suggested by Mankiw et al. (1985), and the other combines the unit root test of Diba and Grossman (1988) and the cointegration test of Campbell and Shiller (1987). The MRS test shows that the null hypothesis of market efficiency is rejected, implying the existence of an irrational bubble. However, the unit root test and cointegration test does not support the existence of a bubble. This result is in contrast with the findings of Xiao (2005), which employs a Markov switching ADF approach. The variable Xiao uses in her analysis is the narrower Seoul housing price index, which perhaps explains the difference. This is because speculation in housing markets is usually concentrated in areas with limited land supply (Malpezzi and Wachter 2005). The other part of the explanation may be methodological. Blanchard and Watson (1982) argue that a speculative bubble could collapse periodically. In that case, Evans (1991) shows that the usual unit root test has little power.

Korean housing prices have experienced sustained, rapid increase since the end of the 1990s. It is commonly believed that the primary driving force behind this price inflation is speculation (Chung and Kim 2004). In response, the government has imposed a number of antispeculation measures. These include prohibiting the sale of housing pre-sale contracts, adjusting property taxes upward, and sharply raising capital gains tax. Banning the sale of pre-sale contracts should discourage speculation since such contracts were widely used by speculators to buy housing they will not live in. Likewise, the increase in

capital gains tax rate from 9% to 36% to a flat rate of 50% for owners of two properties; and from 60% to 82% for owners of three or more properties, can also be expected to have a deterrent effect on speculation. The gradual increase in the property tax rate from the current 0.15% to 1% by 2019 should also help to discourage speculation.

In principle, anti-speculation measures should promote housing price stability. In practice, they have failed to do so. This fact echoes the observations by Levin and Wright (1997), Caginalp et al. (2000), and Lei et al. (2001). **Although most of the antispeculation** measures are applicable to both the apartment sector and nonapartment sector, it was widely expected that their impact would fall primarily on the apartment sector. This is because apartments, especially apartments in the upscale Gangnam area of Seoul, have been the main arena for speculative activity. In this context, some antispeculative measures were targeted specifically at Gangnam and other areas characterized by large-scale speculation. Examples of such targeted measures include a higher capital gains tax and regulations against reconstructing old apartments for profit. The continued rise in housing prices, especially in the apartment sector, attests to the ineffectiveness of the antispeculation measures in reining in the speculative activities. The slower growth of nonapartment prices is more likely due to relative lack of speculation rather than greater effectiveness of antispeculative measures on the nonapartment sector.⁷

To repeat, the antispeculation measures have not resulted in stability of housing prices. Chung and Kim (2004) point out that their ineffectiveness can partly be explained by the very low price elasticity of housing demand. As such, a good part of the increase in the capital tax has simply fuelled a further rise in housing prices. Chung and Kim (2004) estimate a simple model relating housing price to income and bond yield, the two representing “normal” demand variables. “Speculative” demand is captured by the lagged value of the housing price in the regression equation, as in Abraham and Hendershott (1996). Their results show that “what determines housing price hike in South Korea is not ‘normal’ demand but ‘speculative’ demand.” The ratio of speculative demand to normal demand is 1.24 for Korea as a whole and 2.85 for Seoul. The higher ratio for Seoul supports the notion that speculation has a bigger impact on demand and hence price in Seoul than in the rest of the country. Chung and Kim cite low interest rates and easy credit as two of the major reasons behind the increased speculation in the Korean housing market.

⁷ Xiao (2007) and Xiao and Liu (forthcoming) have also observed that the premium residential sector in Hong Kong, China is far more prone to speculation than the nonpremium one. They explain that buyers of upscale houses are wealthier individuals or institutional investors who have much better access to credit. Hence when they have the will to speculate, they also have the financial power to do so. **The experience of Singapore in 2005–2007 also paints** a similar picture. In that period, housing prices nearly doubled in certain areas of the upscale residential market but hardly moved at all in other areas.

IV. Theory and Model

The price of housing in any market is ultimately determined by supply and demand. When supply is rigid, as is the case in Korea, this market price is largely demand-driven.

What drives the demand for housing? A housing market can be divided into owner-occupied and rental sectors. So the demand for housing includes the demand for both owner-occupied and rental housing. For a renter, the housing space he rents is a consumable good; for an owner, the house he owns is an asset that provides a stream of housing services. The market value of the stream of services is the return to this housing asset. The demand for rental housing depends on the cost of housing services relative to that of other consumption goods. On the other hand, the demand for owner-occupied housing depends on the return to housing assets relative to that from other types of assets. The rental sector determines the rents while the owner-occupied sector determines the prices. The two sectors are linked by household choice between renting and buying.

To illustrate, consider an economy with N identical households, each living for T periods and each desiring exactly one unit of housing services. The total supply of rental and owner-occupied housing services is fixed and equal to the number of households. At time t , each new generation of households chooses to be either a renter or an owner. This generation of households exits at time $t+T$, and is replaced by another generation with identical characteristics. The choice between renting and owning depends on their relative cost. The cost of renting, CR , and the cost of owning, CO , are respectively:

$$CR_t = D_t + \sum_{i=1}^{T-1} \left(\prod_{j=1}^i \delta_{t+j} \right) \tilde{D}_{t+i} \quad (1)$$

$$CO_t = P_t - \left(\prod_{j=1}^T \delta_{t+j} \right) \tilde{P}_{t+T} \quad (2)$$

where δ is a discounting factor that depends on the risk-free rate of return, $\delta \in (0, 1)$; D is the rental payment; and P is the purchase price of housing space. The subscript t denotes the time the cost is incurred, and \tilde{X} means that X is a random variable.

Suppose households are risk-neutral, and suppose there exists no liquidity constraint.⁸ In a steady state, or the state in which none of the variables in the system has a tendency to deviate,

$$E_t[CO_t] = E_t[CR_t] + RP_t \quad (3)$$

⁸ Korean house buyers overcame the liquidity constraint by an ingenious *chonsei* arrangement. See Section II for details on *chonsei* contracts.

where $E_t[\cdot]$ is the rational expectation operator conditional on Θ , or information available at time t – i.e., $\Theta = [D_t, D_{t-1}, \dots, D_0; P_t, P_{t-1}, \dots, P_0]$, and RP_t is the excess risk premium of renting over owning. To see why equation (3) constitutes a steady state, suppose $E_t[CO_t] < E_t[CR_t] + RP_t$. In this case, it will be profitable for renters to become owners. Hence the demand for owner-occupied housing will rise, driving up housing prices. At the same time, the demand for rental housing will fall, driving down rents. The process will continue until the condition in equation (3) is satisfied. For ease of argument, the term RP_t will be dropped from now on. The central message will not be altered by doing so.

The *steady state price*, defined as the price that results after all the necessary adjustments have taken place in response to an exogenous shock to the system, will hence satisfy the following condition:

$$\begin{aligned} P_t^f &= E_t[CR_t] + \left(\prod_{j=1}^T \delta_{t+j} \right) E_t[P_{t+T}] \\ &= D_t + \sum_{i=1}^{T-1} \left(\prod_{j=1}^i \delta_{t+j} \right) E[\tilde{D}_{t+i}] + \left(\prod_{j=1}^T \delta_{t+j} \right) E_t[P_{t+T}] \end{aligned} \quad (4)$$

This essentially describes the asset pricing model.

The asset pricing model is widely used to model the behavior of housing prices. Indeed a large and well-established theoretical and empirical literature has emerged to explain house price dynamics on the basis of the asset pricing model. Recent examples of this literature include Flavin and Nakagawa (2008), Piazzesi et al. (2007), Guirguis et al. (2005), Yao and Zhang (2005), and Weeken (2004). The asset pricing model version used in this study is based on Campbell and Shiller (1988 a and b) and described in detail below.

If economic agents are risk-neutral,

$$P_t = \frac{E_t[P_{t+1} + D_t + \alpha C_t]}{1 + R_t}, \quad (5)$$

where P_t = the real price of the property asset at time t ; D_t = the real rent received during period t ; R_t = the time varying real discount rate; C_t = other economic variables that may impact the expectation formation; and α = coefficient showing how C_t relates to P_t . Without any loss of generality and for the sake of simplicity, the coefficient α will be omitted for the rest of the derivation. Define

$$r_t \equiv \log(1 + R_t); \quad (6)$$

Hence,

$$r_t = \log(E_t[P_{t+1} + D_t + C_t]) - \log(P_t). \quad (7)$$

In a static world, the rent grows at a constant rate. The log of C_t -to-price ratio and the log of rent-to-price ratio are also constants. In such a world, the log of the gross discount rate, r_t , would also be a constant and linear in the logs of the variables in equation (3). If the transversality condition, $\lim_{i \rightarrow \infty} \rho^i E_t[p_{t+i}] = 0$, is satisfied, we would have the following

fundamental solution for the price:

$$p_t = p_t^f = \frac{\kappa - \xi}{1 - \rho} + (1 - \rho) \sum_{j=0}^{\infty} \rho^j E_t[d_{t+j} + c_{t+j}]. \quad (8)$$

where p = the log of P ; d = the log of D ; and c = the log of C .

However, the transversality condition may fail to hold. In this case, we expect the price to contain a *rational speculative bubble*, b

$$p_t = p_t^f + b_t, \quad (9)$$

where the bubble component

$$E_t[b_{t+i}] = \frac{1}{\rho^i} b_t. \quad (10)$$

This implies that

$$E_t[b_{t+1}] = \frac{1}{\rho} b_t. \quad (11)$$

If the log of the property prices, rents and the other relevant economic variables are I(1), the following model may be estimated instead:

$$\begin{aligned} \Delta p_t^f &= p_t^f - p_{t-1}^f \\ &= (1 - \rho) \sum_{j=0}^{\infty} \rho^j \left\{ [E_t[d_{t+j}] - E_{t-1}[d_{t+j-1}]] + [E_t[c_{t+j}] - E_{t-1}[c_{t+j-1}]] \right\}. \end{aligned} \quad (12)$$

Suppose the growth of the rents and the other relevant economic variables follow $AR(p)$ and $AR(q)$, respectively, then

$$\Delta p_t^f = \sum_{i=0}^p \theta_i \Delta d_{t-i} + \sum_{j=0}^q \psi_j \Delta c_{t-j}. \quad (13)$$

where θ and ψ are functions of the coefficients of the underlying processes of the price, the rent, and the other relevant variable. In the case when $p = 1$ and c is absent, we have

$$\Delta p_t^f = \frac{1}{1-\phi\rho} \Delta d_t - \frac{\phi\rho}{1-\phi\rho} \Delta d_{t-1} \equiv \psi \Delta d_t + (1-\psi) \Delta d_{t-1}. \quad (14)$$

If a bubble is present,

$$\Delta p_t = \Delta p_t^f + \Delta b_t, \quad (15)$$

and

$$E_t[\Delta b_{t+1}] = \frac{1}{\rho} \Delta b_t \quad (16)$$

Suppose there is some private information unavailable to the researcher and hence not included in equation (9). Let s_t denotes this specification error, so

$$\Delta p_t = s_t + \sum_{i=0}^p \theta_i \Delta d_{t-i} + \sum_{j=0}^q \psi_j \Delta c_{t-j} + \Delta b_t \quad (17)$$

and

$$\Delta s_{t+1} = \beta \Delta s_t \quad (18)$$

This error is unobserved but can be inferred using the Kalman filter (refer to Harvey 1989, Hamilton 1994, and Xiao 2005 for technical details on this filter and the estimation procedure of the model).

V. Empirical Analysis

In this section, we describe our empirical methodology and report our main empirical results. The central objective of our empirical analysis, which is grounded in the theory and model of Section IV, is to test for the presence of speculative bubbles in the three different types of housing in Seoul.

A. Apartment, Single, and Row Houses

In this subsection, we examine apartment, row, and single house price indices using monthly observations from January 1986 to March 2006. Between June 1998 and March 2006, the apartment housing price index increased by 106.29% in real terms. The corresponding values for single and row houses are 22.30% and 11.14%. During the same period, real earning, nonfarm population and real GDP increased by 32.56%, 13.09%, and 33.09%, respectively.

According to the Population and Housing Census of Korea in 2000, the total number of houses stood at 10.9 million units, of which single houses accounted for 37.1%, apartments 47.7%, and row houses only 7.4%. Kim et al. (2000) show that the average single house-dwelling household had 4.64 family members and a monthly income of 2.15 million won. The average age of the household head was 52.1. On the other hand, the average apartment-dwelling household had 4.14 members and a monthly income of 2.31 million won. The average age of the household head was 47.2. Therefore, apartments are preferred by the relatively young and better off. There is no specific policy or regulation that discriminates against one particular housing type, as explained in Section II. Therefore, there are no fundamental differences in the broader supply or macroeconomic conditions that can adequately explain the recent price divergence among the different housing types. Since the supply of housing is highly rigid in Korea, the origins of this divergence must lie in demand. This justifies the use of the model developed in Section IV.

B. Building the Empirical Model

To decide between equations (9) and (15) as the basis of the model to be estimated, we use a Phillips-Perron test for unit root. At the conventional levels of significance, the null hypothesis of unit root can be accepted for the logarithm of each series but is rejected for the first log difference (please refer to the Appendix). Therefore, we estimate a model based on equation (15). Overall, the LR test rejects the restriction imposed by equation (14) that the coefficients on the current and the lagged changes of log real rent should add up to 1 (please refer to Table 1). It was earlier argued that further lagged rents should be included as regressors if the rent process is $AR(p)$, with $p > 1$. However, the F test shows that although a regression of the changes in log real price on the changes in log real rent is significant with higher lags, there is only marginal increase in R^2 . For instance, increasing the number of lags from 1 to 11 raises the R-square of the row house series by a meager 0.07 and that of the other two series by less than 0.05. This observation echoes the comments Shiller (1990, 59) made on the regression of changes in log real stock price on the changes in log real dividends.

Table 1: LR Test for Parameter Restrictions

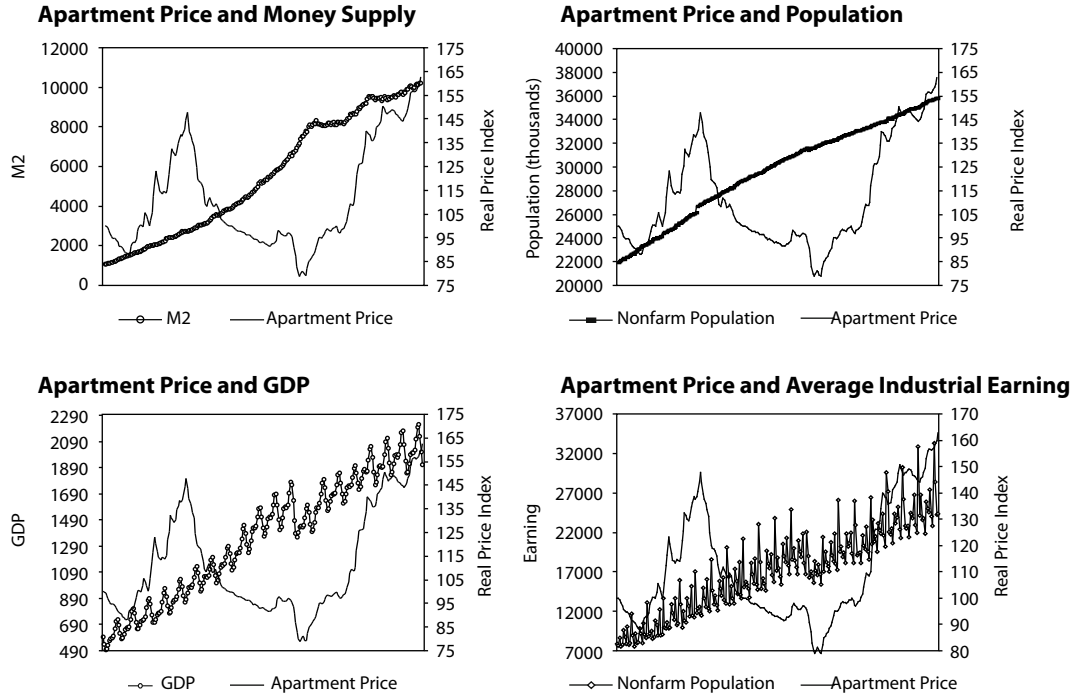
	Single House	Row House	Apartment
H0: $\psi + \psi_{-1} = 1$	350.74*	278.04*	167.12*
H0: $\lambda = 0$	93.70*	76.13*	106.79*

* indicates significance at 10%.

Note: The LR statistic is distributed $\chi(1)$ with critical values 2.71, 3.84, and 6.63 at 10%, 5%, and 1%, respectively. The test rejects the null hypothesis that the coefficients on the current and the lagged rent add up to unity at 10% level. It also rejects the null hypothesis that the coefficient on the lagged price appreciation is insignificant.

It is also argued that other variables capturing public information may be used as additional explanatory variables. There are a large number of such variables that could affect the housing price via the expectation effect, including population, GDP, and wage. However, as discussed earlier in this section, these variables can hardly explain the recent surge in apartment prices. Figure 3 also makes it plain that these variables bear no resemblance to the zigzags of apartment prices observed during the sample period.⁹

Figure 3: Preliminary Analysis



Hence the empirical measurement equation estimated is

$$\begin{pmatrix} \Delta p_t \\ \Delta d_t \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \end{pmatrix} \Delta s_t + \begin{pmatrix} \psi & \psi - 1 & \lambda \\ 0 & \phi & 0 \end{pmatrix} \begin{pmatrix} \Delta d_t \\ \Delta d_{t-1} \\ \Delta p_{t-1} \end{pmatrix} + \begin{pmatrix} \omega_t \\ \delta_t \end{pmatrix} \quad (19)$$

and the empirical transition equation is

$$\Delta s_{t+1} = \beta \Delta s_t + \zeta_t \quad (20)$$

⁹ Although the plots suggest that a long-run relationship may exist, the current study is interested in the short-run drivers of the housing price.

where Δp_t and Δd_t are the first differences of the log real housing price and rent indices, respectively. It is assumed that ω_t , δ_t and ξ_t are uncorrelated, and hence

$$R = \begin{pmatrix} \sigma_\omega^2 & 0 \\ 0 & \sigma_\delta^2 \end{pmatrix}, \quad V = \sigma_\xi^2. \quad (21)$$

C. Estimation Results

We collect the parameters to be estimated in θ , so that $\theta = \{\psi, \psi_{-1}, \lambda, \beta, \phi, \sigma_\omega^2, \sigma_\delta^2, \sigma_\xi^2\}$, where $\lambda = 0$ in Model I. The estimates of these parameters are reported in Tables 2 and 3.

Table 2: Parameter Estimates (Model I)

	ψ	ψ_{-1}	β	ϕ	σ_ω^2	σ_δ^2	σ_ξ^2
Apartment	0.4700 (14.07*)	0.0103 (0.31)	0.0003 (0.02)	0.0000 (0.00)	0.0001 (0.25)	0.0006 (1.26)	0.0001 (0.20)
Row	0.3980 (16.27*)	0.0419 (1.71)	0.0001 (0.02)	0.0000 (0.00)	0.0001 (0.16)	0.0005 (1.05)	0.00002 (0.06)
Single	0.3915 (17.38*)	-0.0264 (-1.17)	0.0001 (0.02)	0.0000 (0.00)	0.00003 (0.10)	0.0003 (0.81)	0.00001 (0.04)

Note: Values in parentheses are t-values.

Table 3: Parameter Estimates (Model II)

	ψ	ψ_{-1}	λ	β	ϕ	σ_ω^2	σ_δ^2	σ_ξ^2
Apartment	0.4401 (16.42*)	-0.2541 (-9.48*)	0.5983 (15.69*)	0.0003 (0.01)	0.0000 (0.00)	0.0001 (0.16)	0.0006 (1.26)	0.0001 (0.15)
Row	0.4054 (19.40*)	-0.1777 (-8.51*)	0.5182 (14.03*)	0.0001 (0.02)	0.0000 (0.00)	0.00004 (0.12)	0.0005 (1.05)	0.00001 (0.04)
Single	0.3888 (20.98*)	-0.2381 (-12.85*)	0.5661 (15.73*)	0.0001 (0.02)	0.0000 (0.0000)	0.00002 (0.07)	0.0003 (0.81)	0.00001 (0.03)

Note: Values in parentheses are t-values.

The coefficients in the estimated models generally have the correct sign and magnitude. The coefficient of the lagged changes in log real rent is insignificant in Model I. When the lagged price appreciation is included, it becomes significant and negative in value (Tables 2 and 3). Shiller (1990) also finds the coefficient of the lagged log real dividends to be negative. The coefficient of the current changes in log real rent is less than 1. This is in contrast to the findings of Shiller (1990) and Campbell (1990). They find that investors in the stock market tend to overreact to current dividend changes. In terms of Shiller's analysis, the fact that $\psi < 1$ might indicate that the rent series itself is not infected by the speculative bubble.

The coefficient of the lagged price appreciation is expected to be positive and less than 1. According to the feedback theory of speculative bubbles (Shiller 1990, 60), a positive λ implies that past price increases encourage investment and thus further raises price,

while past price drops discourage investment and further reduce price. A value of less than 1 is required to rule out irrational investor behavior. The estimate of this coefficient is highly significant, and has the expected magnitude and sign. Furthermore, it is larger in magnitude than ψ and ψ_1 , implying that the bubble has a bigger impact on housing prices than the fundamentals. This result is consistent with Chung and Kim (2004), who find that the ratio of speculative demand to normal demand is larger than 1.

Overall, λ has the largest value for apartment, suggesting that apartments are more prone to speculation than the other two types of housing. The absolute values of ψ and ψ_1 are also larger for apartments, which suggest that apartment prices are also more responsive to fundamentals (see Table 2 and 3). These observations explain why the price of apartments is much more volatile than the prices of row or single houses.

A Wald test shows that the parameters are jointly significant (see Table 5). Since the Koenker and Bassett (1982) LM test statistics indicate the presence of heteroscedasticity (see Table 4), the Wald test is more appropriate than the F test (Greene 1997, 548). The models also pass the postsample predictive test (see Table 6).

Table 4: LM Test for Heteroscedasticity

	Model I			Model II		
	$\sigma\omega^2$	$\sigma\delta^2$	$\sigma\zeta^2$	$\sigma\omega^2$	$\sigma\delta^2$	$\sigma\zeta^2$
Apartment	37.73 *	0.83	5.31*	29.89*	0.83	10.00*
Row	46.06 *	0.22	8.63*	31.96*	0.22	0.07
Single	12.71*	0.15	10.08*	10.26*	0.15	0.004

Note: The LM statistic is distributed ($\chi^2(4)$). The critical values for it are 13.30, 9.49, and 7.78 at 1%, 5%, and 10%, respectively.

Table 5: Goodness of Fit and Significance Test

	Apartment		Row House		Single House	
	Model I	Model II	Model I	Model II	Model I	Model II
R_D^2	0.45	0.65	0.54	0.67	0.52	0.68
AIC	0.00017	0.00010	0.00007	0.00005	0.00004	0.00003
BIC	0.00018	0.00011	0.00007	0.00005	0.00004	0.00003
Wald	343.64*	1428.25*	215.83*	524.87*	215.46*	978.19*

Note: R_D^2 , AIC and BIC are based on Harvey (1989, 268–70). The Wald statistics in Model I is distributed ($\chi^2(5)$), used for the evaluation of joint parameter significance. Its critical values are 15.09, 11.07, and 9.24 at 1%, 5%, and 10% level, respectively. The Wald statistics in Model II is distributed ($\chi^2(6)$), with critical values 16.80, 12.60, and 10.60 at 1%, 5%, and 10% level, respectively.

Table 6: Post Sample Predictive Test

	Apartment		Row House		Single House	
	$\xi(1)$	ESS	$\xi(1)$	ESS	$\xi(1)$	ESS
Model I	0.6170	0.0012	0.1335	0.00011	0.5808	0.0003
Model II	0.4594	0.0006	0.0884	0.00006	0.2790	0.0001

ESS = explained sum of squares.

Note: $\xi(1)$ is distributed $F(12,229)$. Accept all models. ESS is extrapolative (12-step-ahead) sum of squared errors calculated using equation (5.6.7) in Harvey (1989, 273). **Model II (with price lag) generates smaller ESS for all.**

The inclusion of a bubble proxy, the lagged price appreciation, boosts the R^2 for apartment, row, and single houses from 0.45, 0.54, and 0.52 to 0.65, 0.67, and 0.68, respectively. It also reduces the 12-step-ahead sum of squared forecast errors by half or more (see Tables 5 and 6). If we view Model I as a special case of Model II that results from restricting λ to be zero, the LR test would reject this restriction (see Table 1).

Figure 4 plots the paths of the inferred bubble in the three housing sectors. It shows that the bubble is an important driving force behind the movement of apartment prices. However, the two do not necessarily synchronize. For example, the price of the apartment sector started to recover in the second half of 1998. On the other hand, the bubble, proxied by lagged price appreciation, continued to fall until mid-2001, after which the apartment sector was rapidly engulfed by a bubble.

Figure 4: Price Move Explained by the Rational Bubble (approximated by lagged price depreciation)

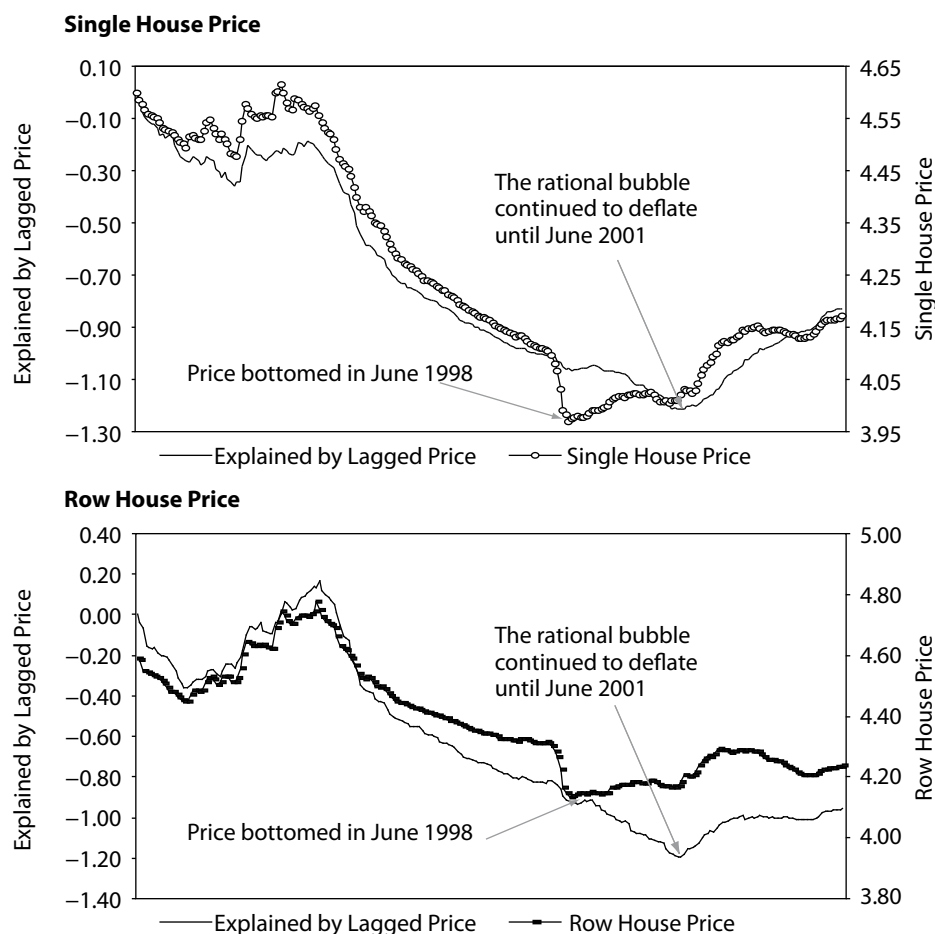
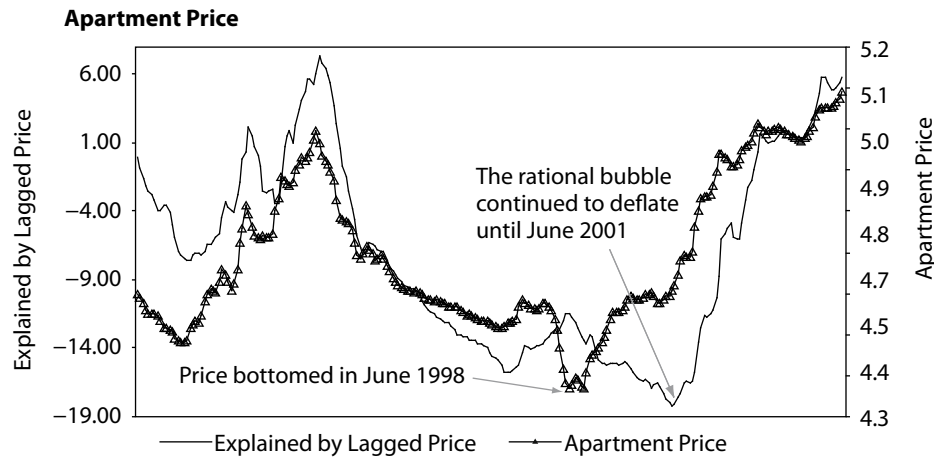


Figure 4. continued.

The latent variable, representing unobservable information, explains part of the price volatilities (see Figure 5). But the standardized plot (defined in Harvey 1989,257) for both models show clustering in volatility, which suggests that none of these models is adequate (see Figure 6). Including more lagged rent and price growths does not mitigate the problem. Neither do variables shown in Figure 3, which are fairly stable compared with housing prices.

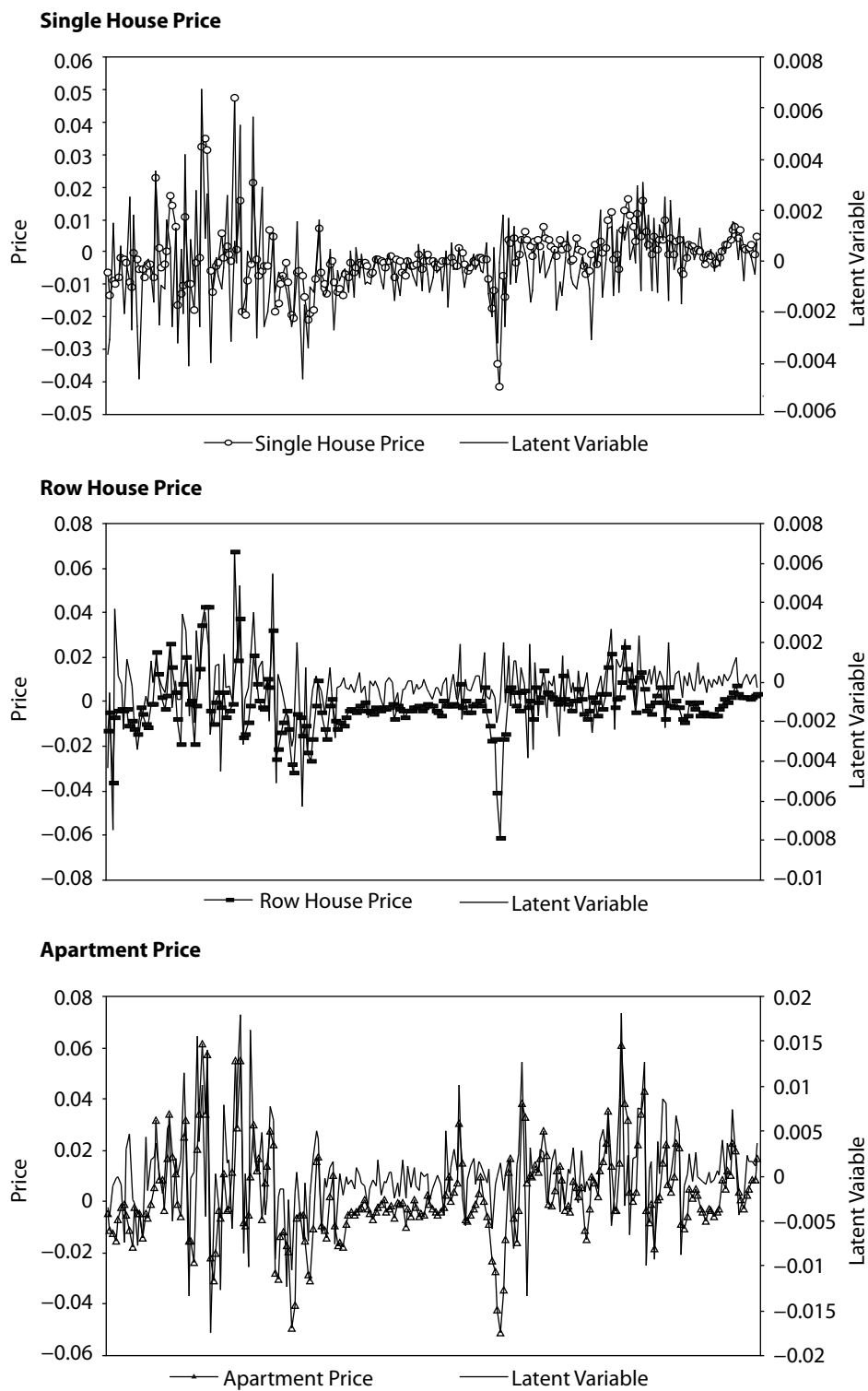
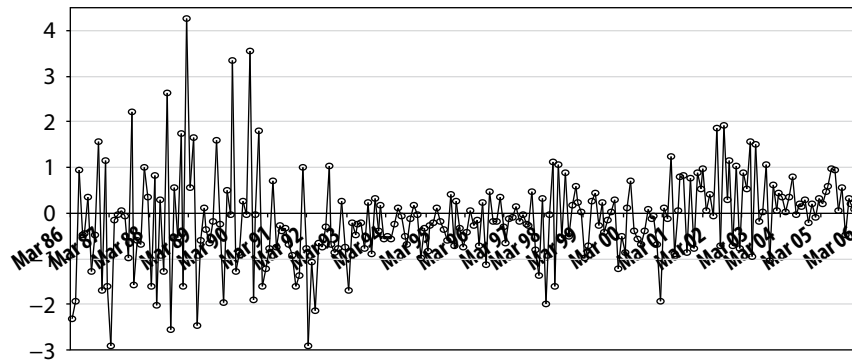
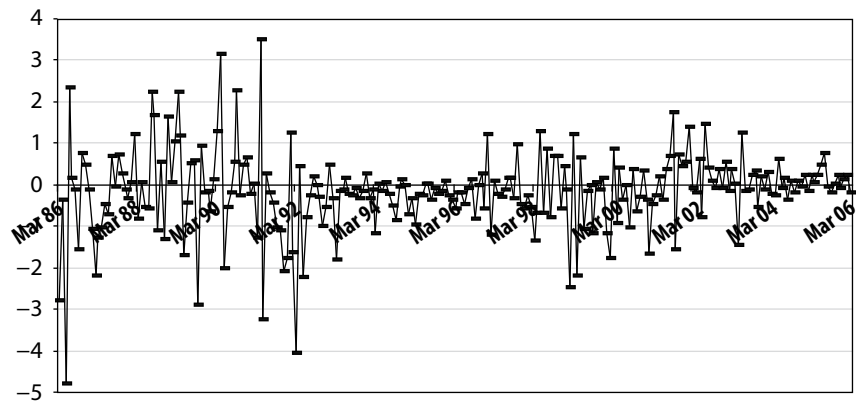
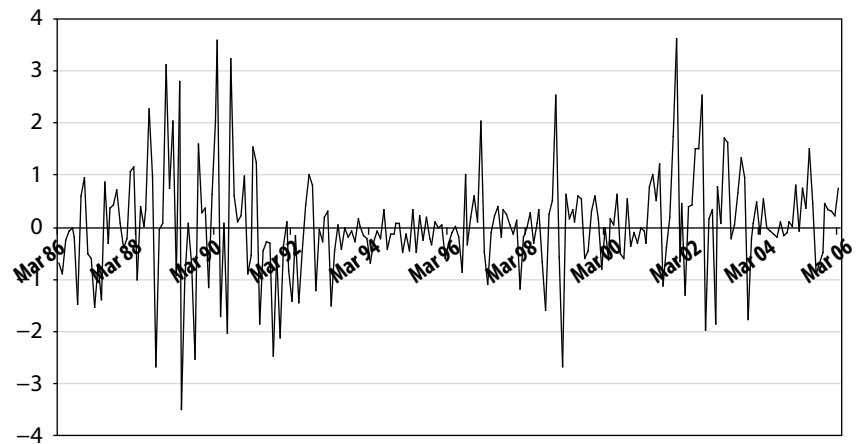
Figure 5: Price Growth Explained by the Latent Variable (Model II)

Figure 6: Standardized Residuals from Model II**Single House****Row House****Apartment**

VI. Conclusion

If the supply of housing is rigid, as is the case in Seoul, demand is likely to play a central role in the determination of market prices. Demand consists of both fundamental demand and rational speculative demand. In this study, we set out to gauge the relative importance of fundamentals versus rational bubble in the determination of housing prices in Seoul in the short run. Our preliminary analysis reveals that fundamental demand factors such as GDP, wage, or population have only limited influence on housing prices in the short run. A present value model based on rentals and private information is able to explain less than 55% of the growth in housing prices in Seoul. Even when a rational speculative bubble is included, the present value model is capable of explaining only 65–68% of the growth. That leaves room for investigating the existence of irrationality in the Korean market, an issue that is beyond the scope of the current study.

Our main empirical finding is that in Seoul the price of apartments is more responsive to changes in both fundamental and speculative demand than the price of row houses or single houses. This explains the divergence in price behavior between apartments and the other two housing types. But the deeper question is why apartment prices seem to be more sensitive. One largely conjectural answer has to do with the demographic characteristic of buyers. As discussed in Section V, there is little difference between the income levels of single house and apartment buyers. However, the average age of the household head of apartment buyers is about 5 years younger than that of single house buyers. Could it be that the younger generation is more watchful of market conditions and opportunities, and hence more speculative? Answering that question effectively would probably require a multi-disciplinary study that combines economic, psychological, and sociological perspectives.

Appendix: Phillips-Perron Unit Root Test

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau
Apartment, Price					
Zero Mean	0	0.6051	0.8320	2.24	0.9942
	1	0.5835	0.8268	1.71	0.9791
	2	0.5703	0.8236	1.51	0.9677
Single Mean	0	1.7090	0.9963	1.20	0.9981
	1	1.1138	0.9904	0.62	0.9900
	2	0.7505	0.9836	0.37	0.9816
Trend	0	0.4262	0.9977	0.27	0.9984
	1	-0.2807	0.9945	-0.14	0.9939
	2	-0.7077	0.9912	-0.33	0.9895
Apartment, Log Price					
Zero Mean	0	0.1149	0.7091	1.85	0.9847
	1	0.1138	0.7088	1.44	0.9630
	2	0.1130	0.7086	1.29	0.9501
Single Mean	0	1.1439	0.9909	0.79	0.9937
	1	0.5078	0.9771	0.27	0.9766
	2	0.1146	0.9624	0.05	0.9616
Trend	0	0.0236	0.9962	0.02	0.9963
	1	-0.7121	0.9911	-0.36	0.9884
	2	-1.1630	0.9859	-0.53	0.9815
Apartment, Differenced Log Price					
Zero Mean	0	-91.6865	<.0001	-7.48	<.0001
	1	-99.6442	<.0001	-7.73	<.0001
	2	-101.656	0.0001	-7.80	<.0001
Single Mean	0	-92.9819	0.0015	-7.54	<.0001
	1	-101.110	0.0001	-7.79	<.0001
	2	-103.113	0.0001	-7.85	<.0001
Trend	0	-94.5570	0.0006	-7.61	<.0001
	1	-102.917	0.0001	-7.87	<.0001
	2	-104.953	0.0001	-7.93	<.0001

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau
Apartment, Rent					
Zero Mean	0	0.6426	0.8409	1.90	0.9863
	1	0.6120	0.8337	1.46	0.9642
	2	0.5989	0.8305	1.33	0.9540
Single Mean	0	-1.8659	0.7935	-1.19	0.6786
	1	-2.5146	0.7149	-1.30	0.6312
	2	-2.7925	0.6805	-1.35	0.6089
Trend	0	-4.3428	0.8639	-1.54	0.8148
	1	-6.4658	0.7033	-1.85	0.6792
	2	-7.3872	0.6278	-1.97	0.6162
Apartment, Log Rent					
Zero Mean	0	0.1874	0.7266	2.11	0.9919
	1	0.1853	0.7261	1.68	0.9775
	2	0.1843	0.7258	1.56	0.9707
Single Mean	0	-3.1553	0.6360	-1.87	0.3446
	1	-3.9252	0.5453	-1.87	0.3437
	2	-4.2561	0.5086	-1.89	0.3344
Trend	0	-5.7688	0.7597	-1.93	0.6349
	1	-8.1876	0.5635	-2.21	0.4829
	2	-9.2424	0.4830	-2.32	0.4209
Apartment, Differenced Log Rent					
Zero Mean	0	-130.461	0.0001	-9.43	<.0001
	1	-136.338	0.0001	-9.57	<.0001
	2	-137.694	0.0001	-9.60	<.0001
Single Mean	0	-130.936	0.0001	-9.44	<.0001
	1	-136.882	0.0001	-9.58	<.0001
	2	-138.218	0.0001	-9.61	<.0001
Trend	0	-131.948	0.0001	-9.47	<.0001
	1	-138.045	0.0001	-9.61	<.0001
	2	-139.337	0.0001	-9.64	<.0001

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau
Row House, Price					
Zero Mean	0	-0.4018	0.5911	-1.88	0.0570
	1	-0.4122	0.5888	-1.60	0.1037
	2	-0.4193	0.5872	-1.48	0.1312
Single Mean	0	-1.1436	0.8719	-0.97	0.7653
	1	-1.4651	0.8387	-1.02	0.7441
	2	-1.6836	0.8145	-1.07	0.7282
Trend	0	-1.5032	0.9804	-0.76	0.9669
	1	-2.4007	0.9584	-1.00	0.9404
	2	-3.0115	0.9357	-1.14	0.9183
Row House, Log Price					
Zero Mean	0	-0.0792	0.6642	-1.97	0.0474
	1	-0.0797	0.6641	-1.61	0.1014
	2	-0.0799	0.6641	-1.46	0.1358
Single Mean	0	-1.0240	0.8833	-0.95	0.7695
	1	-1.3134	0.8548	-1.00	0.7545
	2	-1.5121	0.8336	-1.04	0.7401
Trend	0	-1.2367	0.9848	-0.66	0.9743
	1	-2.1201	0.9666	-0.92	0.9509
	2	-2.7270	0.9471	-1.07	0.9309
Row House, Differenced Log Price					
Zero Mean	0	-116.957	0.0001	-8.77	<.0001
	1	-116.028	0.0001	-8.74	<.0001
	2	-121.964	0.0001	-8.90	<.0001
Single Mean	0	-118.764	0.0001	-8.84	<.0001
	1	-118.095	0.0001	-8.82	<.0001
	2	-124.083	0.0001	-8.97	<.0001
Trend	0	-119.014	0.0001	-8.83	<.0001
	1	-118.391	0.0001	-8.82	<.0001
	2	-124.394	0.0001	-8.97	<.0001

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau
Row House, Rent					
Zero Mean	0	0.1868	0.7264	0.57	0.8388
	1	0.1641	0.7209	0.42	0.8032
	2	0.1533	0.7183	0.37	0.7898
Single Mean	0	-5.0012	0.4322	-2.02	0.2776
	1	-6.3012	0.3207	-2.13	0.2320
	2	-6.9210	0.2769	-2.19	0.2098
Trend	0	-4.6678	0.8421	-1.58	0.7991
	1	-6.5129	0.6995	-1.85	0.6798
	2	-7.3891	0.6276	-1.96	0.6198
Row House, Log Rent					
Zero Mean	0	0.0670	0.6978	0.88	0.8976
	1	0.0656	0.6974	0.71	0.8682
	2	0.0650	0.6973	0.66	0.8573
Single Mean	0	-5.2007	0.4133	-2.14	0.2294
	1	-6.5424	0.3030	-2.23	0.1958
	2	-7.1902	0.2597	-2.29	0.1775
Trend	0	-4.8146	0.8318	-1.66	0.7653
	1	-6.7062	0.6836	-1.92	0.6408
	2	-7.6157	0.6092	-2.04	0.5791
Row House, Differenced Log Rent					
Zero Mean	0	-112.982	0.0001	-8.58	<.0001
	1	-123.322	0.0001	-8.85	<.0001
	2	-122.824	0.0001	-8.84	<.0001
Single Mean	0	-113.046	0.0001	-8.56	<.0001
	1	-123.385	0.0001	-8.84	<.0001
	2	-122.872	0.0001	-8.82	<.0001
Trend	0	-113.809	0.0001	-8.57	<.0001
	1	-124.312	0.0001	-8.85	<.0001
	2	-123.798	0.0001	-8.84	<.0001

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau
Single House, Price					
Zero Mean	0	-0.5431	0.5602	-3.36	0.0009
	1	-0.5489	0.5589	-2.83	0.0048
	2	-0.5527	0.5581	-2.60	0.0095
Single Mean	0	-1.7578	0.8060	-2.30	0.1729
	1	-1.8857	0.7911	-2.06	0.2628
	2	-1.9700	0.7812	-1.96	0.3047
Trend	0	0.6430	0.9983	0.43	0.9991
	1	0.1744	0.9968	0.10	0.9971
	2	-0.1256	0.9954	-0.07	0.9952
Single House, Log Price					
Zero Mean	0	-0.0949	0.6607	-3.09	0.0021
	1	-0.0952	0.6606	-2.53	0.0115
	2	-0.0954	0.6606	-2.27	0.0226
Single Mean	0	-1.5230	0.8324	-2.21	0.2014
	1	-1.6404	0.8194	-1.95	0.3096
	2	-1.7241	0.8099	-1.84	0.3601
Trend	0	1.1439	0.9991	0.87	0.9999
	1	0.7316	0.9985	0.46	0.9992
	2	0.4459	0.9978	0.25	0.9983
Single House, Differenced Log Price					
Zero Mean	0	-114.208	0.0001	-8.63	<.0001
	1	-111.411	0.0001	-8.55	<.0001
	2	-118.524	0.0001	-8.74	<.0001
Single Mean	0	-118.463	0.0001	-8.81	<.0001
	1	-116.216	0.0001	-8.75	<.0001
	2	-123.526	0.0001	-8.94	<.0001
Trend	0	-123.437	0.0001	-9.05	<.0001
	1	-121.835	0.0001	-9.01	<.0001
	2	-129.272	0.0001	-9.20	<.0001

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau
Single House, Rent					
Zero Mean	0	-0.1207	0.6548	-0.39	0.5419
	1	-0.1437	0.6496	-0.38	0.5454
	2	-0.1532	0.6474	-0.38	0.5452
Single Mean	0	-2.6062	0.7036	-1.02	0.7446
	1	-4.1714	0.5178	-1.35	0.6092
	2	-4.8369	0.4483	-1.46	0.5516
Trend	0	-5.1927	0.8042	-1.82	0.6947
	1	-7.1476	0.6474	-2.06	0.5681
	2	-7.9698	0.5808	-2.15	0.5151
Single House, Log Rent					
Zero Mean	0	-0.0221	0.6772	-0.35	0.5572
	1	-0.0232	0.6770	-0.30	0.5778
	2	-0.0237	0.6769	-0.28	0.5838
Single Mean	0	-1.9705	0.7811	-0.85	0.8015
	1	-3.3791	0.6090	-1.18	0.6822
	2	-4.0602	0.5301	-1.32	0.6227
Trend	0	-4.3053	0.8663	-1.67	0.7634
	1	-6.0525	0.7369	-1.90	0.6535
	2	-6.8892	0.6686	-2.00	0.5980
Single House, Differenced Log Rent					
Zero Mean	0	-112.982	0.0001	-8.58	<.0001
	1	-123.322	0.0001	-8.85	<.0001
	2	-122.824	0.0001	-8.84	<.0001
Single Mean	0	-113.046	0.0001	-8.56	<.0001
	1	-123.385	0.0001	-8.84	<.0001
	2	-122.872	0.0001	-8.82	<.0001
Trend	0	-113.809	0.0001	-8.57	<.0001
	1	-124.312	0.0001	-8.85	<.0001
	2	-123.798	0.0001	-8.84	<.0001

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About the Paper

Donghyun Park and Qin Xiao adopt the asset-price approach to empirically explore the role of rational speculation in the doubling of Seoul apartment prices during 1998–2006. They find rational speculation to be a significant driver of prices. However, their results also suggest that slightly more than 30% of the price surge can be attributed to irrational speculation.

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