

Can Housing Prices be Justified by Economic Fundamentals? Evidence from Regional Housing Markets in Korea

Jan R. Kim and Sungjin Cho

In this study, we use a present-value approach to examine the dynamics of six regional housing markets in Korea. The large upswing in the price–rent ratio accompanied by intermittent ups and downs, which are typical features of the Korean housing market since the mid-1980s, is captured by a periodically collapsing bubble incorporated into an otherwise standard present-value model. The movements in the actual price–rent ratio are then decomposed into movements explained by the expectations of housing market fundamentals (*i.e.*, rent growth, risk-free interest rate, and excess returns from housing investment) and the speculative bubble. In all the six regional markets, most of the variations in the fundamental part of the price–rent ratio are explained by the expected risk premium of housing investment and the expected risk-free returns, whereas the expected rent growth account for relatively small fractions of the variations. The bubble has continuously accumulated since the early 2000s in all the six regions and has reached as high as 70% of house price by the end of 2017.

Keywords: Regional housing markets, Fundamentals, Bubble, Present-value model

JEL Classification: G12, C13, C32

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I. Introduction

The housing market in Korea has experienced three major episodes of boom since the mid-1980s. The first boom happened in 1988:Q1–1991:Q3, which marked the annual average of real house price increase by as high as 14.2%. After the economy bounced back from the Asian currency crisis, the second boom occurred. In 2001:Q4–2004:Q2, real house price increased by 12.3% per annum and most of the losses since the previous peak were recovered. The most recent boom was recorded in 2006:Q4–2007:Q4, which registered a 7.6% increase in real house price per annum. Such large swings in house prices triggered a debate on the appropriate responses of the central bank to asset price movements.¹

Another feature of the Korean housing market is that the patterns of price changes are inconsistent in different regions. For example, during the second episode of the bull market, the accumulated rate of nominal increase in house price in Seoul was 49.7%, which is nearly double the 28.5% increase in six other large cities. Even within the capital city of Seoul, a pronounced tendency of housing price decoupling is frequently observed between the recently developed Gangnam area and the traditional old city area of Gangbuk.

In this study, we examine whether house price movements in Korea reflect the existence of the housing bubble or are responses to changes in fundamentals. Compared with nearly perfect markets, such as the stock market, the housing market is typically regarded as a locally separated market given that properties are heterogeneous and immobile among locations. Therefore, we ask the following specific questions:

- (1) Are the movements in house price mostly responses to changes in market fundamentals or do they reflect a speculative bubble?
- (2) What is the driver of house price among its fundamental determinants?
- (3) How consistent are the answers to the two previous questions across different regions?

¹ For example, Kim and Cho (2010) examined whether the monetary authority should respond to asset prices to stabilize output and inflation.

To answer these questions, we need a baseline model to describe how the prices of housing units are determined. We maintain the view that housing units exhibit dual features as a durable good that provides housing service and as an asset; we use the present-value model proposed by Campbell and Shiller (1988a, 1988b). We tie the price of an asset to the expected value of the future payoff stream that accrues to the asset. The present-value model predicts that house price and rents should move in tandem. In terms of the low-frequency properties of data, house prices and rents should be of the same order of integration. If the two variables are nonstationary in level but stationary in initial differences, then they should be cointegrated such that their ratio (*i.e.*, the price–rent ratio) is stationary.²

However, the actual movements in the price–rent ratio frequently contradict the prediction of the present-value model. The plots in Figure 1 provide a clear illustration in terms of housing market data in Seoul since 1979:Q1. In the early part of the sample period, real rents in Panel (b) tended to move together with real house price, thereby yielding a stable price–rent ratio. However, since the end of the Asian currency crisis, real rents has steadily decreased by 2.5% per annum with its own troughs and peaks around the decreasing trend, whereas real house price has registered unprecedented increases over a decade. In summary, the price–rent ratio in Panel (c) exhibits the occurrences of boom–bust around the large upswing in the ratio itself, which contradicts the prediction of the present-value model.

The standard present-value model of Campbell and Shiller decomposes the changes in the price–rent ratio into changes in the expected paths of rent price growth rates, risk-free rates, and risk premiums for (or equivalently, excess returns from) housing investment. We suspect that a fourth “model consistent” factor, which affects the price–rent ratio, is the rational bubble component. In particular, we note that the intermittent buildup and collapse of the price–rent ratio cannot be adequately explained by the linear relations between house price and its drivers. To account for this feature, we extend the standard present-value model to incorporate a special class of rational bubbles, *i.e.*,

² A few papers have resorted to these features and applied the present-value model to the stock market, *e.g.*, Cochrane (1992) and Campbell and Ammer (1993), or the housing market, *e.g.*, Campbell *et al.* (2009) and Kishor and Morely (2015).

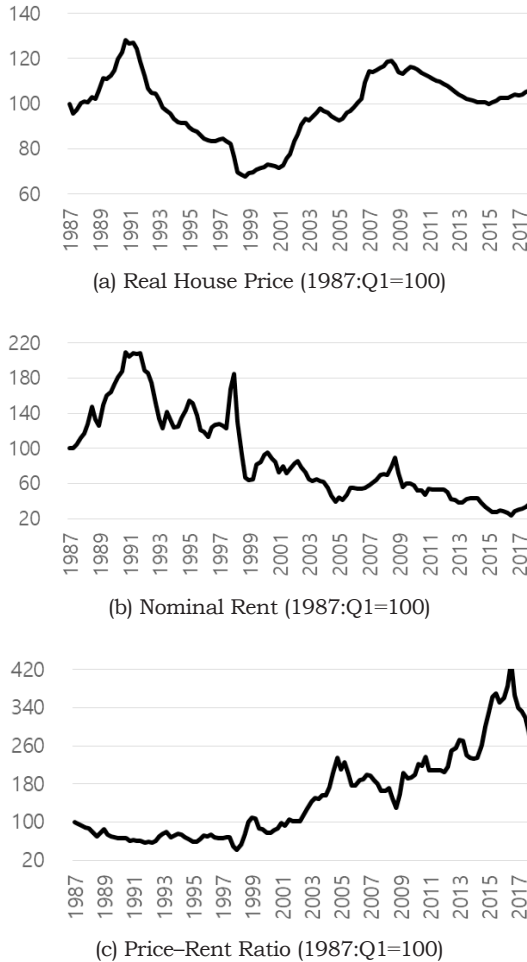


FIGURE 1
HOUSING MARKET TREND IN KOREA (SEOUL, 1987: Q1–2017:Q4)

bubbles that periodically gestate, bust, and reappear, as described in Balke and Wohar (2009). We then use the modified present-value model to decompose the movements in the price–rent ratios into those that can be attributed to the housing market fundamentals and the bubble to address the main questions posited earlier. On the basis of the results, we assess the differences and similarities among the behavior of house prices in the six largest cities of Korea in terms of the roles

played by fundamentals and the bubble. To the best of our knowledge, no previous study has yet examined the possibility of a periodically collapsing bubble in the regional housing markets in Korea.

Two main findings emerge from our study. First, when we focus on the fundamental part of the price–rent ratio, the main driver of the regional housing markets in Korea is the expectation of excess returns to housing investment and that of risk-free returns, not intrinsic rent payments. Second, the onset of a continued bubble buildup was detected in the early 2000s in all the regions, where the percentage of a speculative bubble in actual real house prices reached as high as 70% by the end of 2017. These findings are robust to the use of different interest rate data and post-1999 subsamples.

The remainder of this paper is organized as follows. Section II presents the workhorse model of the housing market and briefly describes the data used in the study. Section III provides and discusses the estimation results, which focus on the relative results of the tests. Section IV describes a sensitivity analysis of the results. Section V concludes the study.

II. Model, Data, and Key Estimates

A. Present-value Model with Collapsing Bubbles

We follow Campbell *et al.* (2009) and Balke and Wohar (2009) to construct a theoretical home pricing model for the housing market. We begin with the definition of the realized gross real return from holding a housing unit

$$H_{t+1} = (P_{t+1} + R_{t+1})/P_t, \quad (1)$$

where H_{t+1} denotes the real gross return on a home held from time t to $t + 1$, P_{t+1} is the real house price at the end of period $t + 1$, an R_{t+1} is the real rent payment received from time t to $t + 1$.

We apply the Campbell–Shiller approximation and obtain

$$pr_t = \mathcal{K} + \rho pr_{t+1} + \Delta r_{t+1} - h_{t+1}, \quad (2)$$

where $pr_t = \log(P_t/R_t)$, $r_{t+1} = \log(R_{t+1}/R_t)$, $h_{t+1} = \log(H_{t+1})$, $\rho = e^{\bar{p}r}/(1 + e^{\bar{p}r})$, $\bar{p}r$ is the average of the log of the price–rent ratio over the sample,

and \mathcal{K} is a linearization constant. Without any explosive behavior in pr_t , we obtain the standard present-value formula:

$$pr_t = \frac{\mathcal{K}}{1 - \rho} + E_t \left\{ \sum_{j=0}^{\infty} \rho^j (\Delta r_{t+j+1} - h_{t+j+1}) \right\}, \quad (3)$$

which implies that the log of the price–rent ratio is a weighted discounted sum of the expected future rent growth Δr_{t+j+1} and gross real return h_{t+j+1} for $j \geq 0$.

We implement two modifications to the preceding present-value formula. First, similar to that in Campbell and Ammer (1993) and Campbell *et al.* (2009), the log of gross real return, h_t , is broken down into the real interest rate, i_t (which corresponds to the risk-free rate of return), and the excess rate of return, π_t (which reflects the risk premium for investing in housing). Second, we allow the price–rent ratio to deviate from that predicted by Equation (3):

$$pr_t = \frac{\mathcal{K}}{1 - \rho} + E_t \left\{ \sum_{j=0}^{\infty} \rho^j (\Delta r_{t+j+1} - i_{t+j+1} - \pi_{t+j+1}) \right\} + b_t = pr_t^f + b_t, \quad (4)$$

where pr_t^f is the *fundamental* price–rent ratio determined by the expectations of the three housing market fundamentals (Δr , i , π), and b_t captures the deviations of the actual ratio from the fundamental level.

In accordance with van Binsbergen and Kojen (2010), we treat the one-period-ahead expectations of rent growth, $g_t = E_t[\Delta r_{t+1}]$, real interest rate, $\mu_t = E_t[i_{t+1}]$, and housing risk premium, $\lambda_t = E_t[\pi_{t+1}]$, as unobserved components that follow parsimonious autoregressive AR(2) processes³:

$$g_t - \gamma_0 = \gamma_1(g_{t-1} - \gamma_0) + \gamma_2(g_{t-2} - \gamma_0) + \epsilon_t^g, \quad (5)$$

$$\mu_t - \delta_0 = \delta_1(\mu_{t-1} - \delta_0) + \delta_2(\mu_{t-2} - \delta_0) + \epsilon_t^\mu, \quad (6)$$

$$\lambda_t - \theta_0 = \theta_1(\lambda_{t-1} - \theta_0) + \theta_2(\lambda_{t-2} - \theta_0) + \epsilon_t^\lambda, \quad (7)$$

where the innovations $\epsilon_t = (\epsilon_t^g, \epsilon_t^\mu, \epsilon_t^\lambda)$ can be interpreted as the effects

³ During the early stage of this study, we also tried the AR(1) specification, but the AR(2) specification fit the data better.

of news on the expectations. We assume that ε_t follows an independent and identically distributed (i.i.d.) Gaussian process with a general covariance matrix Σ_ε . The law of motion in Equations (5)–(7) can be recursively used in Equation (3) to pin down the fundamental price–rent ratio, such that

$$pr_t = pr_t^f + b_t \\ = \frac{\kappa}{1 - \rho} + \left[\frac{\gamma_0}{1 - \rho} + B_1 G_t \right] - \left[\frac{\delta_0}{1 - \rho} + B_2 M_t \right] - \left[\frac{\theta_0}{1 - \rho} + B_3 \Lambda_t \right] + b_t, \quad (8)$$

where $G_t = \begin{bmatrix} g_t - \gamma_0 \\ g_{t-1} - \gamma_0 \end{bmatrix}$, $M_t = \begin{bmatrix} \mu_t - \delta_0 \\ \mu_{t-1} - \delta_0 \end{bmatrix}$, and $\Lambda_t = \begin{bmatrix} \lambda_t - \theta_0 \\ \lambda_{t-1} - \theta_0 \end{bmatrix}$.

The factor loading coefficients (B_1 , B_2 , B_3) in the second line of Equation (8) measure the extent of contributions of the three expectation terms to the fundamental ratio.

In principle, the nonfundamental deviation b_t may reflect irrational behavior, such as fads (*e.g.*, Summers (1986) and Shiller and Perron (1985)), not a rational bubble as in this study. Gürkaynak (2008) argued that distinguishing between the bubble- and fundamentals-based explanations of asset price behavior is an inherently evasive task. However, at the risk of a possible misspecification, we opt to interpret b_t as representing a rational speculative bubble on two grounds. First, the availability of easy credits has been generally accepted as the main cause of speculation since the early 2000s and has encouraged “buying by borrowing.” Second, a few previous studies, *e.g.*, Kim and Min (2011), have found evidence that supports the presence of sporadic speculative bubbles in the Korean housing market in 1997–2003.

Motivated further by the continued divergence between house price and fundamental cash flow in the Korean housing market, particularly since early 2000, we follow Balke and Wohar (2009) and specify b_t as a periodically collapsing bubble that switches between non-exploding and exploding regimes. The realizations of the bubble regime are governed by a hidden state variable, S_t , which follows a Markov regime-switching process with the transition probabilities,

$$\text{Prob}[S_t = 1 | S_{t-1} = 1] = p, \text{Prob}[S_t = 0 | S_{t-1} = 0] = q, \quad (9)$$

which are time-invariant and independent of any other disturbances. In the regime with $S_t = 0$, b_t follows a stationary AR process:

$$b_t = \bar{b} + \psi b_{t-1} + \varepsilon_t^b, 0 < \psi < 1, \quad (10)$$

where b_t slowly dies out in the absence of the innovation ε_t^b in the bubble.⁴ This regime is dubbed as a non-exploding regime. If the regime switches from non-exploding to exploding (*i.e.*, $S_{t-1} = 0$ is followed by $S_t = 1$), then b_t evolves as

$$b_t = -\frac{q}{(1-q)} \bar{b} + \frac{1}{1-q} \left[\frac{1}{\rho} - q\psi \right] b_{t-1} + \varepsilon_t^b. \quad (11)$$

Finally, if the exploding regime continues (*i.e.*, $S_{t-1} = 1$ is followed by $S_t = 1$), then we obtain

$$b_t = -\frac{(1-p)}{p} \bar{b} + \frac{1}{p} \left[\frac{1}{\rho} - (1-p)\psi \right] b_{t-1} + \varepsilon_t^b. \quad (12)$$

We do not impose the non-negativity constraint on the bubble term b_t because the bubble is formed in the price-rent ratio and not in the price. Weil (1990) argued on theoretical grounds; an asset can be *undervalued* when the economy is in a bubble equilibrium.

The model is closed with the measurement equations that relate the observed data to their model counterparts. The actual price-rent ratio is related to the model components (G_t , M_t , Λ_t , b_t) via Equation (8), and the observations of the rent growth and real interest rate are equal to the sum of their respective one-step-ahead expectations and idiosyncratic innovations⁵:

$$\Delta r_t = \gamma_0 + g_{t-1} + u_t^r, \quad i_t = \delta_0 + \mu_{t-1} + u_t^i, \quad (13)$$

⁴ We specify ε_t^b as a Gaussian i.i.d. process that is independent of any other disturbances or innovations.

⁵ By using a data series on rent growth and real interest rate, we treat the contribution of housing risk premium as the residuals of the fundamental price-rent ratio left unexplained by the two former variables. However, as shown in Engsted *et al.* (2012), knowing which series is treated as residuals is irrelevant because the price-rent ratio series is used.

where the unexpected innovations, $u_t = (u_t^r, u_t^i)$, follow Gaussian i.i.d. distribution with a diagonal covariance matrix, $\Sigma_u = \text{diag}(\sigma_r^2, \sigma_i^2)$. We further assume that ε_t and u_t are mutually uncorrelated at any leads and lags.

The present-value model constructed earlier is cast into a state-space form with Markov switching and estimated via the approximate maximum likelihood method of Kim and Nelson (1999).⁶

B. Data

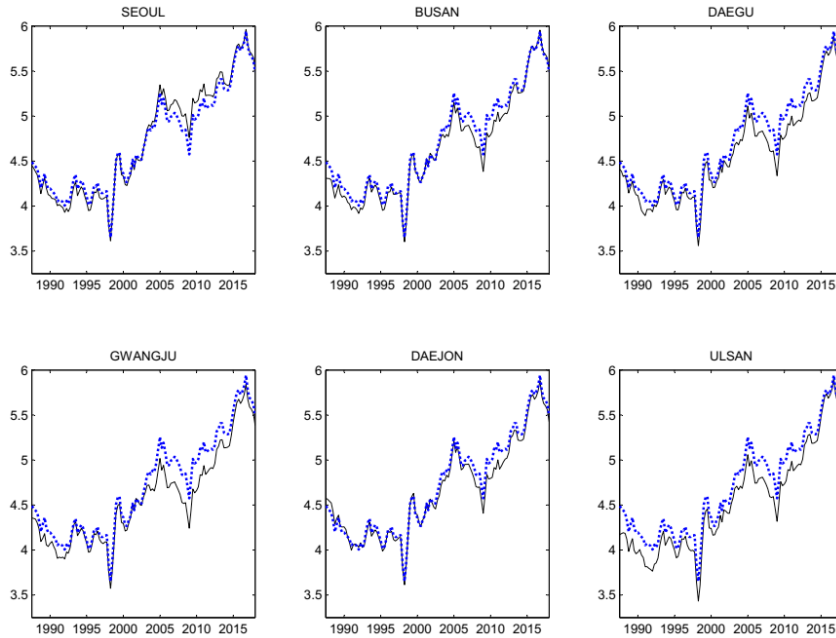
The raw data used in the present study are the nominal interest rates, core consumer price index (CPI), and nominal purchase and *chonsei* prices in the six largest cities in Korea in 1987:Q1 to 2017:Q4. The purchase and *chonsei* prices are taken from the *Kookmin Bank* database,⁷ from which the price–rent ratio is constructed. The nominal interest rate is the AA-rated corporate bond yields with a 3-year maturity, which are considered the representative market rates in Korea. The nominal interest rates and CPI series are obtained from the *Bank of Korea* database. The real interest rate is then constructed as the difference between nominal rates and the actually realized rate of year-on-year inflation for the core CPI. Thus, the constructed real interest rate is used as the data for risk-free return rates.⁸

Chonsei contracts do not involve explicit rent payments; thus, we should construct implicit quarterly rent payments. One problem is that the purchase and *chonsei* price series are only available as indexes.

⁶ The corresponding state-space model is summarized in the appendix. The Kalman filter is seeded with an arbitrarily large variance for the initial bubble term due to the possible explosiveness of b_t . Again, we arbitrarily assume that the initial value of the bubble is \bar{b} . Using 0 as the initial value of the bubble does not change the estimation results significantly.

⁷ A monthly survey is sent out by *Kookmin Bank* to real estate brokers to inquire about the prices of sample properties. The purchase and *chonsei* price indexes in a particular month may include the “asking” prices of sample properties that are not sold or rented that month. Price information on similar units is readily available to the public even on a daily basis. Those indexes are considered highly accurate.

⁸ The use of the AA-rated corporate bonds is dictated by the availability of interest rate data with sufficient length. Corporate bonds rates, including risk premiums, are likely to overstate risk-free returns. We deal with this issue in the sensitivity analysis of the results in Section IV.



Note: The dotted lines denote the price-rent ratio calculated at the national level.

FIGURE 2

LOG PRICE-RENT RATIOS AT THE REGIONAL LEVEL (1987:Q2-2017:Q4)

However, their ratios for apartments are available from 1999 onwards. Therefore, we rescale the *chonsei* price index to match the average purchase-*chonsei* price ratio in 2013 and then multiply the rescaled *chonsei* index with the nominal interest rate (divided by 4). The resulting implicit nominal rent index is then deflated into real terms by the core CPI, from which the real rent growth series is constructed.

The six regional log price-rent ratios (solid lines) and the nationwide average ratio (dotted lines) are plotted in Figure 2.⁹ The graphs show

⁹ Prior to the estimation of the model, we check the low-frequency properties of the constructed price and rent series. The ADF and Phillips-Perron tests run for the price-rent ratio fail to reject the null of a unit root at any practical significance level. The results of the Johansen test confirm the absence of any cointegrating relation between house price and rents. These results are supportive of augmenting the present-value model with a speculative bubble.

TABLE 1

SUMMARY OF DATA ON THE REAL GROWTH OF RENTS, REAL RETURN TO HOUSING, AND EXCESS RETURN

	Δr_t			h_t			π_t		
	Avg	SD	ρ	Avg	SD	ρ	Avg	SD	ρ
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
SEOUL	-3.157	41.937	0.329	4.326	9.184	0.585	-0.700	9.890	0.646
BUSAN	-4.002	41.368	0.345	4.207	8.562	0.736	-0.819	9.224	0.776
DAEGU	-3.816	41.618	0.318	3.982	9.721	0.592	-1.044	10.520	0.661
GWANGJU	-4.715	41.095	0.357	3.191	7.372	0.698	-1.835	8.489	0.775
DAEJON	-3.707	40.311	0.307	3.252	7.139	0.517	-1.775	8.284	0.643
ULSAN	-3.736	42.323	0.377	5.107	8.144	0.812	0.081	8.709	0.836
Nationwide	-3.236	41.138	0.334	3.991	7.488	0.615	-1.035	8.316	0.691

Note: All data series are annualized rates.

that the price–rent ratio in all the six cities is currently high compared with historical levels, where the upward trend for most regions started in the late 1990s. Despite the similar trend in the ratio throughout the sample period, the dynamics of the regional price–rent ratios are heterogeneous, particularly since the early 2000s. Seoul exhibits nearly the same pattern as the national level, whereas the other regions display a relatively subdued increase in the ratio during the same period. The presence of heterogeneous dynamic patterns highlights the importance of regional-level analysis because such analysis potentially enables us to detect regional housing bubbles that we would have missed within a national-level analysis due to the averaging nature of the aggregate ratio.

In Table 1, we list the sample mean (Avg.), standard deviation (SD), and autocorrelation coefficient (ρ) for the annualized real growth rate of rents (Columns 1–3), annualized real housing returns (4–6), and annualized excess returns (7–9) in our six housing markets over the entire sample. As shown in Columns 4 and 7, the real housing returns in the aggregate averaged 4.01% per year and the excess returns averaged approximately -1.02% over our entire sample. Across the six cities, the average real housing returns ranged from 3.2% (Gwangju) to 5.1% (Ulsan). Columns 5 and 8 show that the standard deviations of the real and excess housing returns vary from approximately 7% to 10% per year, depending on the market and whether the total or excess

TABLE 2
MAXIMUM LIKELIHOOD ESTIMATES OF PARAMETERS

	SEOUL	BUSAN	DAEGU	GWANGJU	DAEJON	ULSAN
γ_1	0.495 (0.056)	0.503 (0.056)	0.508 (0.041)	0.451 (0.062)	0.511 (0.047)	0.492 (0.054)
γ_2	-0.044 (0.037)	-0.051 (0.027)	-0.055 (0.017)	-0.038 (0.025)	-0.055 (0.020)	-0.044 (0.026)
δ_1	1.371 (0.066)	1.408 (0.066)	1.430 (0.041)	1.364 (0.067)	1.394 (0.065)	1.388 (0.067)
δ_2	-0.400 (0.062)	-0.436 (0.062)	-0.457 (0.038)	-0.398 (0.061)	-0.423 (0.061)	-0.417 (0.063)
θ_1	0.496 (0.045)	0.527 (0.045)	0.557 (0.048)	0.747 (0.087)	0.588 (0.060)	0.521 (0.051)
θ_2	0.424 (0.042)	0.395 (0.041)	0.366 (0.045)	0.176 (0.081)	0.335 (0.056)	0.399 (0.047)
q	0.942 (0.007)	0.940 (0.007)	0.938 (0.008)	0.914 (0.010)	0.933 (0.008)	0.939 (0.008)
p	0.994 (0.004)	0.995 (0.004)	0.995 (0.003)	0.987 (0.008)	0.994 (0.003)	0.993 (0.004)
\bar{b}	0.070 (0.009)	0.064 (0.009)	0.061 (0.010)	0.059 (0.009)	0.066 (0.009)	0.070 (0.009)
ψ	0.900 (0.005)	0.901 (0.005)	0.901 (0.004)	0.885 (0.007)	0.898 (0.005)	0.898 (0.005)

Note: Standard errors are in parentheses. All the parameters are sharply estimated at the 1% significance level.

return is considered. Excess returns tend to be more variable than total returns anywhere, and the returns of the first three larger cities tend to be more volatile than those of the remaining smaller cities. In general, the first-order autocorrelations of housing returns (Columns 6 and 9) range from 0.6 to 0.8, which are approximately two times larger than that of rent growth (Column 3).

C. Key Estimated Parameters

Table 2 presents the key estimates of the model parameters. The top panel shows that the expectations of the future real interest rate and excess returns change very slowly, as implied by the estimated long-run AR coefficients in Equations (5)–(7), *i.e.*, $\delta_1 + \delta_2$ and $\theta_1 + \theta_2$, which are

approximately 0.97 and 0.92, respectively. By contrast, the expectation of the future rent growth exhibits only a modest persistence degree with the long-run AR coefficient of approximately 0.45.

The estimated properties of the bubble components are reported in the bottom panel. The transition probabilities in Equation (9) for the two bubble regimes are sharply estimated. On average, the non-exploding regime is expected to last for $1/(1 - 0.934) = 15.2$ quarters. By contrast, the exploding regime is highly persistent, with an average duration of $1/(1 - 0.992) = 125$ quarters. The estimated AR coefficient and transition probabilities of the bubble term in Equations (10)–(12) demonstrate the qualitatively different behavior of the bubble across the two regimes. In the non-exploding regime, the bubble process is stationary, with ψ approximately 0.9 on average, although it exhibits a considerable degree of inertia. By contrast, the bubble in the exploding regime is clearly self-reinforcing. Seoul is selected as an example. When the current bubble regime is explosive following a non-exploding regime in the previous period, the AR coefficient

$$\frac{1}{1-q} \left[\frac{1}{\rho} - q\psi \right]$$

is as high as 2.78, which exhibits a sudden expansion of the bubble in its gestation stage. If the bubble continues in the exploding regime, then the AR coefficient

$$\frac{1}{p} \left[\frac{1}{\rho} - (1-p)\psi \right] = 1.01$$

implies that the bubble is less explosive and close to a random walk.

Table 3 shows the results of the augmented Dickey–Fuller (ADF) test for the stationarity of the estimated b_t series. Cunado *et al.* (2005) suggested that the estimated nonfundamental term should be nonstationary if it will be interpreted as a bubble.¹⁰ Table 3 clearly shows that the null of a unit root cannot be rejected for the level of the estimated bubble series at any practical significance level, whereas their first differences are stationary. We interpret these results to support our

¹⁰ We thank an anonymous referee for pointing out this issue.

TABLE 3
ADF TEST FOR THE ESTIMATED BUBBLE SERIES

	SEOUL	BUSAN	DAEGU	GWANGJU	DAEJON	ULSAN
b_t	0.9644	0.9936	0.9938	0.9967	0.9996	0.9916
Δb_t	0.0060	0.0006	0.0001	0.0001	0.0001	0.0003

Note: The numbers reported are the p-values for the null of the unit root.

specification, *i.e.*, b_t is a speculative bubble term.

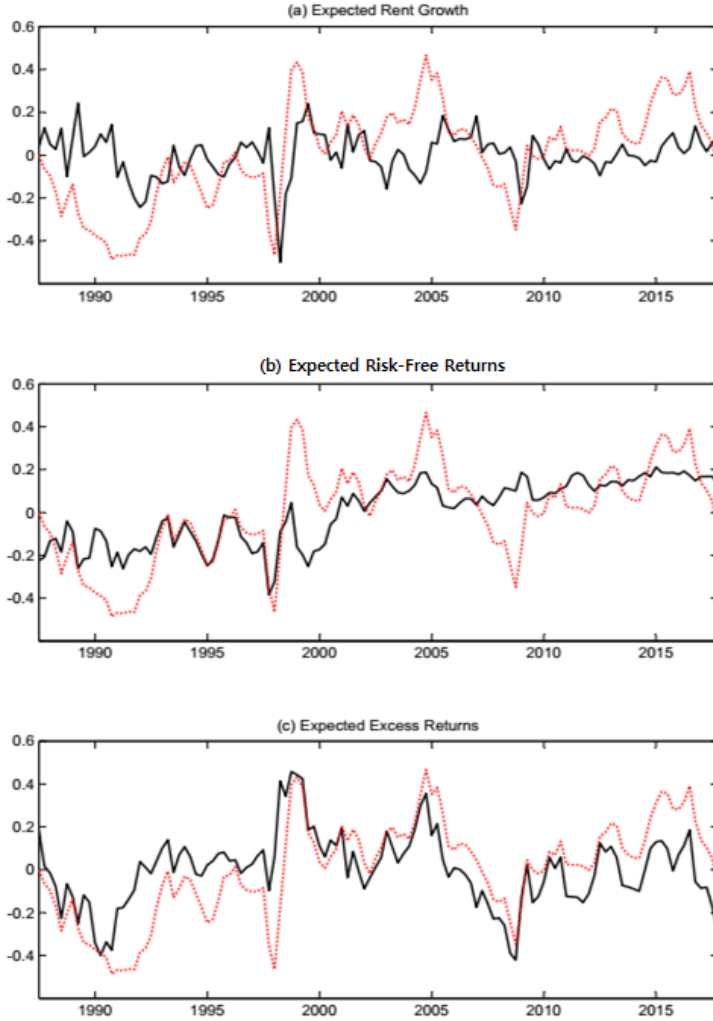
III. What Drives Regional Housing Markets in Korea?

We are ready to address the main research questions. We first explain what determines the movements in the fundamental part of the price–rent ratio and examine the relative importance of the bubble and fundamental part. To save space, we report only the results of Seoul and Ulsan in this paper. These cities are the most isolated in terms of geographic and socioeconomic aspects. The results of the other cities are provided in the appendix.

A. Movements in the Fundamental Price–rent Ratio

Figures 3 and 4 show the loadings of the expected market fundamentals (in solid lines) onto the fundamental price–rent ratio (in dotted lines) for the two cities. Each series is plotted in mean deviations for easy comparison. In both cities, even a casual inspection shows that the expected excess returns in the bottom panel have made the largest contribution to the fundamental ratio, which moves closely with the latter throughout the sample period. By contrast, the contributions of the other two expectations of housing market fundamentals are relatively small, if not negligible. The simple correlation coefficients with the fundamental ratio present a similar picture. In Seoul, for example, the correlation between the expected rent growth and the fundamental ratio reaches as low as 0.201. However, those for the expected risk-free returns and excess returns are 0.654 and 0.640, respectively. We also observe that the expected risk-free returns capture the gradual increase in the fundamental ratio over the entire sample period. This finding supports that the continued decline in the interest rate plays a role in triggering the bullish runs in the 2000s.

After estimating the model parameters, we can decompose the

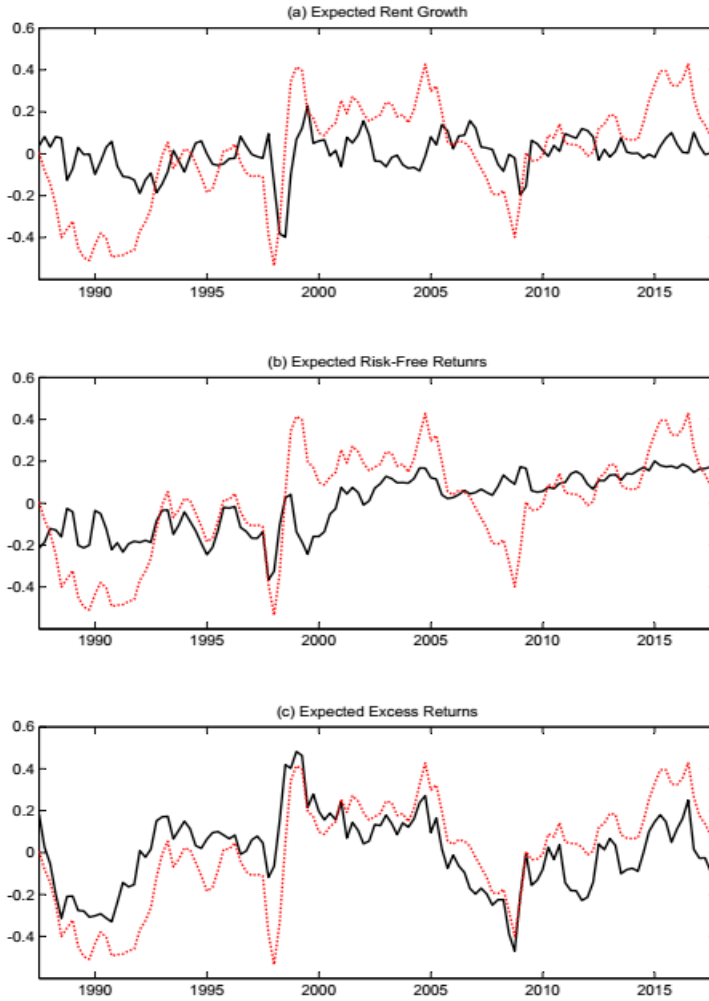


Note: The dotted lines denote the fundamental part of the price-rent ratio.

FIGURE 3
CONTRIBUTIONS OF EXPECTED MARKET FUNDAMENTALS (SEOUL)

unconditional variance of pr_t^f as follows:

$$\begin{aligned} \text{var}(pr_t^f) = & B_1 \text{var}(G_t) B_1' + B_2 \text{var}(M_t) B_2' + B_3 \text{var}(\Lambda_t) B_3' \\ & - 2B_1 \text{cov}(G_t, M_t) B_2' - 2B_1 \text{cov}(G_t, \Lambda_t) B_3' + 2B_2 \text{cov}(M_t, \Lambda_t) B_3', \end{aligned} \quad (10)$$



Note: The dotted lines denote the fundamental part of the price-rent ratio.

FIGURE 4
CONTRIBUTIONS OF EXPECTED MARKET FUNDAMENTALS (ULSAN)

which shows that the uncertainty of the estimated coefficients is abstracted away, and the variance of pr_t^f depends on the variance-covariance structure among the three fundamental market expectations. The preceding variance decomposition constitutes another means to assess the relative importance of the individual expectation terms for

TABLE 4

VARIANCE DECOMPOSITION FOR THE FUNDAMENTAL PRICE-RENT RATIO (SEOUL)

	Measured by	Estimate	% of $\text{var}(pr_t^f)$
$\text{var}(pr_t^f)$		0.1460	100%
$\text{var}(G_t)$	$B_1 \text{var}(G_t) B_1'$	0.0264	18.1%
$\text{var}(M_t)$	$B_2 \text{var}(M_t) B_2'$	0.0292	20.0%
$\text{var}(\Lambda_t)$	$B_3 \text{var}(\Lambda_t) B_3'$	0.0963	66.0%
$\text{cov}(G_t, M_t)$	$-2B_1 \text{cov}(G_t, M_t) B_2'$	-0.0212	-14.5%
$\text{cov}(G_t, \Lambda_t)$	$-2B_1 \text{cov}(G_t, \Lambda_t) B_3'$	-0.0437	-30.0%
$\text{cov}(M_t, \Lambda_t)$	$2B_2 \text{cov}(M_t, \Lambda_t) B_3'$	0.0590	40.4%

TABLE 5

VARIANCE DECOMPOSITION FOR THE FUNDAMENTAL PRICE-RENT RATIO (ULSAN)

	Measured by	Estimate	% of $\text{var}(pr_t^f)$
$\text{var}(pr_t^f)$		0.172	100%
$\text{var}(G_t)$	$B_1 \text{var}(G_t) B_1'$	0.035	20.3%
$\text{var}(M_t)$	$B_2 \text{var}(M_t) B_2'$	0.041	24.0%
$\text{var}(\Lambda_t)$	$B_3 \text{var}(\Lambda_t) B_3'$	0.112	65.1%
$\text{cov}(G_t, M_t)$	$-2B_1 \text{cov}(G_t, M_t) B_2'$	-0.030	-17.4%
$\text{cov}(G_t, \Lambda_t)$	$-2B_1 \text{cov}(G_t, \Lambda_t) B_3'$	-0.058	-33.7%
$\text{cov}(M_t, \Lambda_t)$	$2B_2 \text{cov}(M_t, \Lambda_t) B_3'$	0.072	41.7%

driving the fundamental price-rent ratio.

The variance decomposition results are reported in Table 4. The innovations $\varepsilon_t = (\varepsilon_t^g, \varepsilon_t^m, \varepsilon_t^\lambda)$ in the expectations are correlated, and thus, selecting the portions of variance that are attributable to individual expectation terms may not appear straightforward. Meanwhile, the variations due to the piecewise correlation structure in the bottom panel are cancelled out. Consequently, we concentrate on the individual variance terms in the top panel. The expected risk premium is the dominant factor that drives the housing market, which explains approximately 65% of the total variance in the fundamental ratio for both cities. By contrast, the shares of variations in the expected rent growth and real interest rate are only approximately 20% across the two cities.

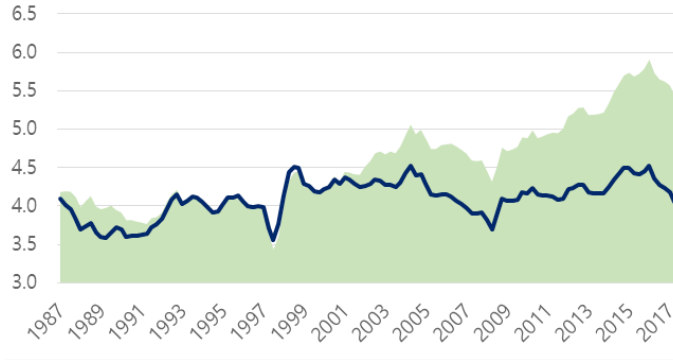
The message conveyed by Figures 3 and 4 and Tables 4 and 5 is clear. In the absence of a bubble, the fundamental price-rent ratio in

the Korean housing market is mainly driven by the expected future excess returns, whereas the expectations of the intrinsic cash flow and real interest rate are of secondary importance. This result is reminiscent of that of Campbell *et al.* (2009). However, their results are obtained from the US using a standard present-value model without a bubble component. Similar results are also found in stock market studies. Campbell and Ammer (1993) estimated that 70% of the variations in the US stock returns is attributable to the news about future excess returns, whereas only 15% of the return variance is explained by the news about future dividends. Bernanke and Kuttner (2005) also found that an important channel in which stock prices increase is the expected equity premium or the perceived riskiness of stocks, which is approximately thrice as volatile as the expected increase of future dividends.

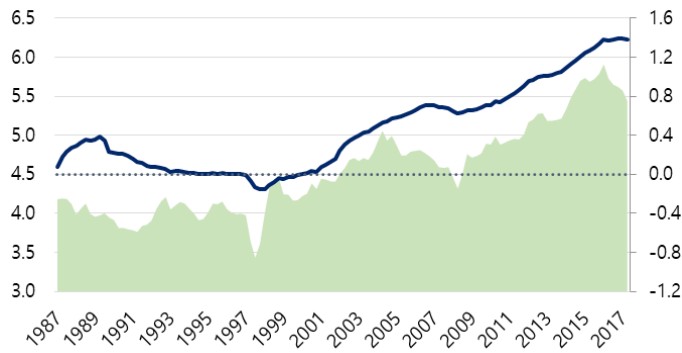
B. Relative Importance: Bubble versus Fundamentals

We now turn to the relative importance of the fundamental and bubble parts in the entire price–rent ratio. The first panels of Figures 5 and 6 plot the estimated fundamental ratio along with the actual ratio for Seoul and Ulsan, respectively. The two ratio series tend to move around a common average until before the 2000s, although the difference between the two series implies a modest degree of overvaluation (in 1987–1991). Since 2001, however, the actual ratio has continued to increase, whereas the fundamental ratio has remained relatively stable around its post-2000 average. Accordingly, the estimated bubble in Panel (b) has also built up since then. We have previously observed that the expected risk premium is the most dominant driver of the price–rent ratio among the expectations of housing market fundamentals. Comparatively, the bubble part has claimed a considerably larger share of the movements in the price–rent ratio since the early 2000s. Consequently, the percentage of a speculative bubble in the actual real house price is as large as 70% in both cities, as shown in the bottom panels of Figures 5 and 6.

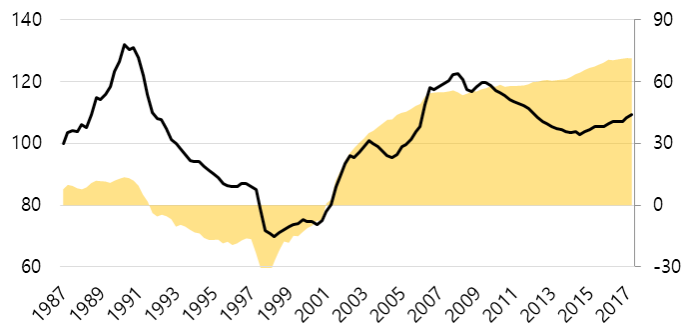
The movements of the estimated bubble are consistent with many previous studies on the Korean housing market. Kim and Min (2011) used the composite indexes of house price and rents for apartments and other types of dwellings in Korea. They detected a speculative bubble in house prices, which reached a local peak in 1991 and started



(a) Actual vs. Fundamental Ratio



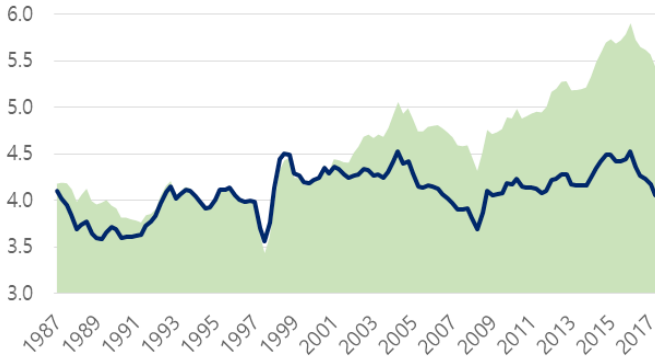
(b) Actual Ratio vs. Bubble (Right Axis)



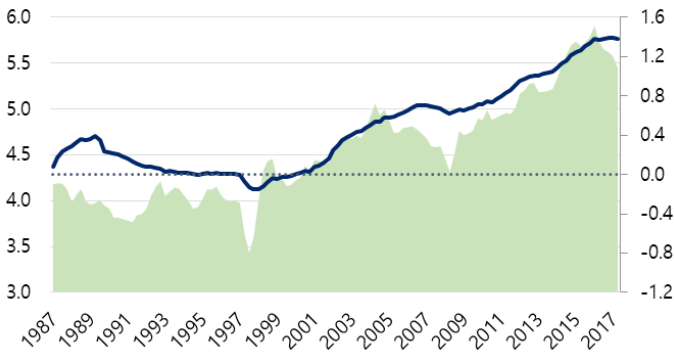
(c) Actual Real House Price vs. % of Bubble (Right Axis)

Note: Real house price is indexed with 1987:Q3=100.

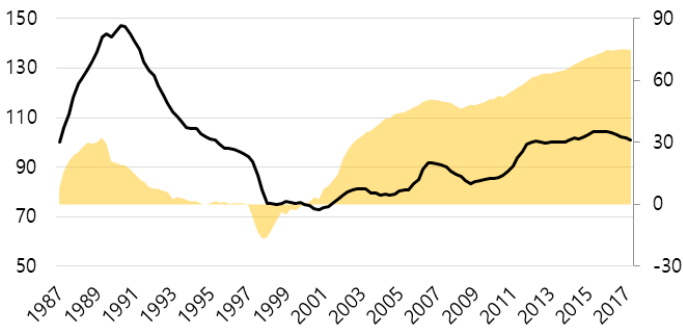
FIGURE 5
FUNDAMENTAL AND BUBBLE COMPONENTS (SEOUL)



(a) Actual vs. Fundamental Ratio



(b) Actual Ratio vs. Bubble (Right Axis)



(c) Actual Real House Price vs. % of Bubble (Right Axis)

Note: Real house price is indexed with 1987:Q3=100.

FIGURE 6
FUNDAMENTAL AND BUBBLE COMPONENTS (ULSAN)

to build up again from the end of the Asian currency crisis until 2003. The study of apartment price in Seoul by Xiao and Park (2010) is also comparable to our study, in that the fit of the present value model for apartment prices in Seoul is significantly improved if augmented with a rational bubble. Finally, Hwang *et al.* (2006) used the standard present-value model without a bubble and found no evidence of a bubble in Seoul apartment price in 1986–2006. Nonetheless, we believe that our results are not too contradictory to theirs because our estimates of a bubble are small on average over their sample period.

IV. Sensitivity Analysis

A. Nominal Interest Rate

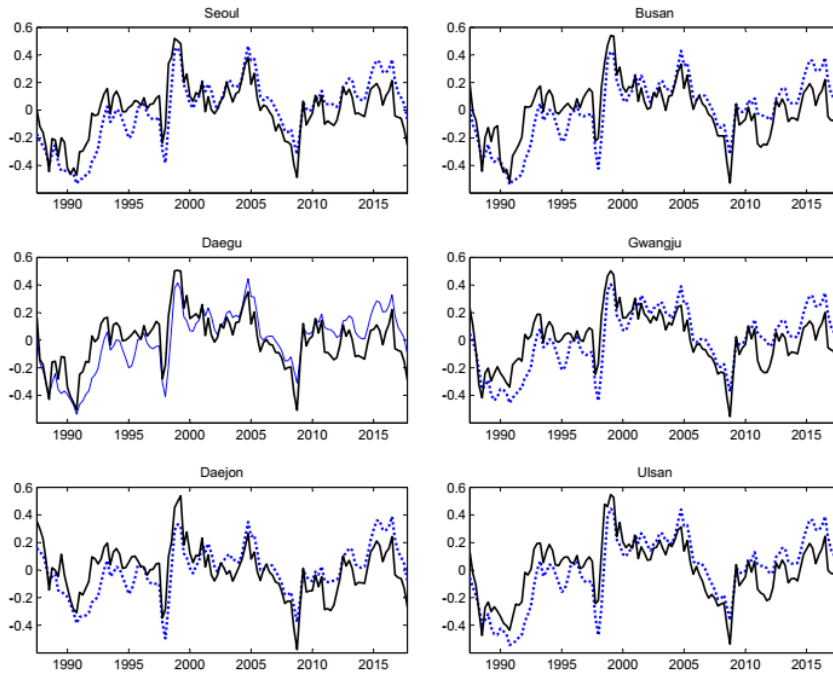
As mentioned earlier, the use of AA-rated corporate bonds is dictated by data availability. For the first robustness check, we use another nominal interest rate series with a comparable length. The rates for national housing bonds with a 5-year maturity are available from 1987:Q1 and are less subject to the risk of default than corporate bonds.¹¹

Figures 7 and 8 show the robustness of the two main results presented in Section IV. As shown in Figure 7, the expected excess returns move nearly in tandem with the fundamental price–rent ratio in all the six regions. The evidence shown in Figure 8 confirms that the movements in all the regional housing prices since the early 2000s have been mainly driven by bubble buildup, most prominently in Seoul and Ulsan.

B. Sample Period

Many economists, *e.g.*, Kim and Cho (2010), have argued that the Korean housing market went through structural changes at around 2000, particularly in mortgage lending and its consequences for the housing price dynamics. For the second robustness check, we examine whether our main findings are preserved in the subsample period since

¹¹ Over the period of 2000:Q4–2017:Q4, when the rates of the 10-year government bonds are available, the housing and government bond rates are nearly indistinguishable and exhibit less pronounced variations than the AA rates, particularly during the period of the global financial crisis in 2007–2008.



Note: The dotted lines denote the fundamental part of the price-rent ratio.

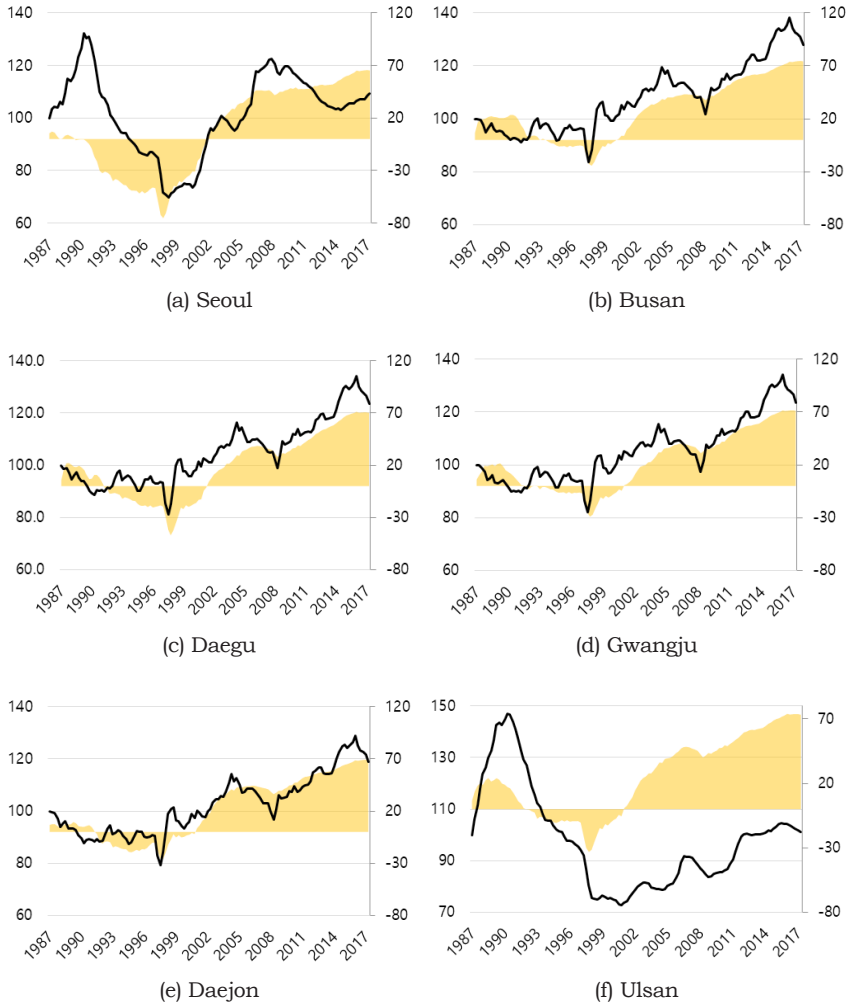
FIGURE 7

CONTRIBUTIONS OF EXPECTED EXCESS RETURNS (USING NATIONAL HOUSING BONDS RATES)

2000. The results are summarized in Figures 9 and 10.

Figure 9 plots the expected excess returns along with the fundamental price-rent ratio. The close movements of the two series are even more pronounced than that in the whole sample estimates. Figure 10 plots the actual real house price and the estimated percentage of a speculative bubble in each region.

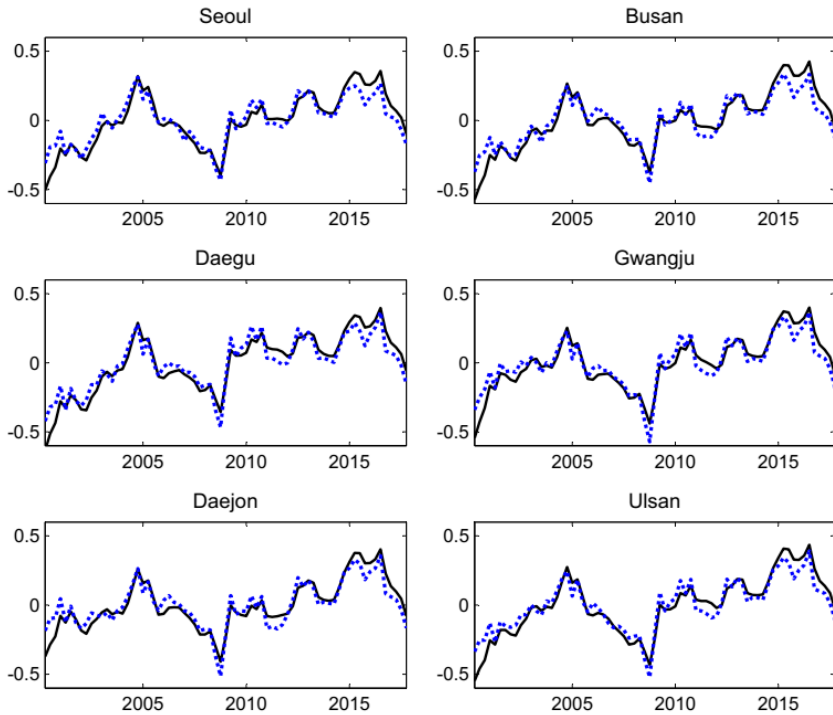
Compared with the whole sample estimates from the previous section, the results in Figure 10 for the post-1999 subsample are not less unequivocal about the time of the bubble onset. For example, the real house prices in Seoul, Daejeon, and Ulsan gestated speculative bubbles as early as in 2002, whereas the onset of a serious bubble in the other cities was determined as approximately 10 years later. The results in Figure 10 still confirm that the nationwide house price increases in the past decade are mainly driven by a speculative bubble and not by any



Note: The solid lines denote actual real house price, and the shades against the right axes denote the percentages of the bubble.

FIGURE 8

PERCENTAGE OF BUBBLE IN REAL HOUSE PRICE (USING NATIONAL HOUSING BONDS RATES)



Note: The dotted lines denote the fundamental part of the price-rent ratio.

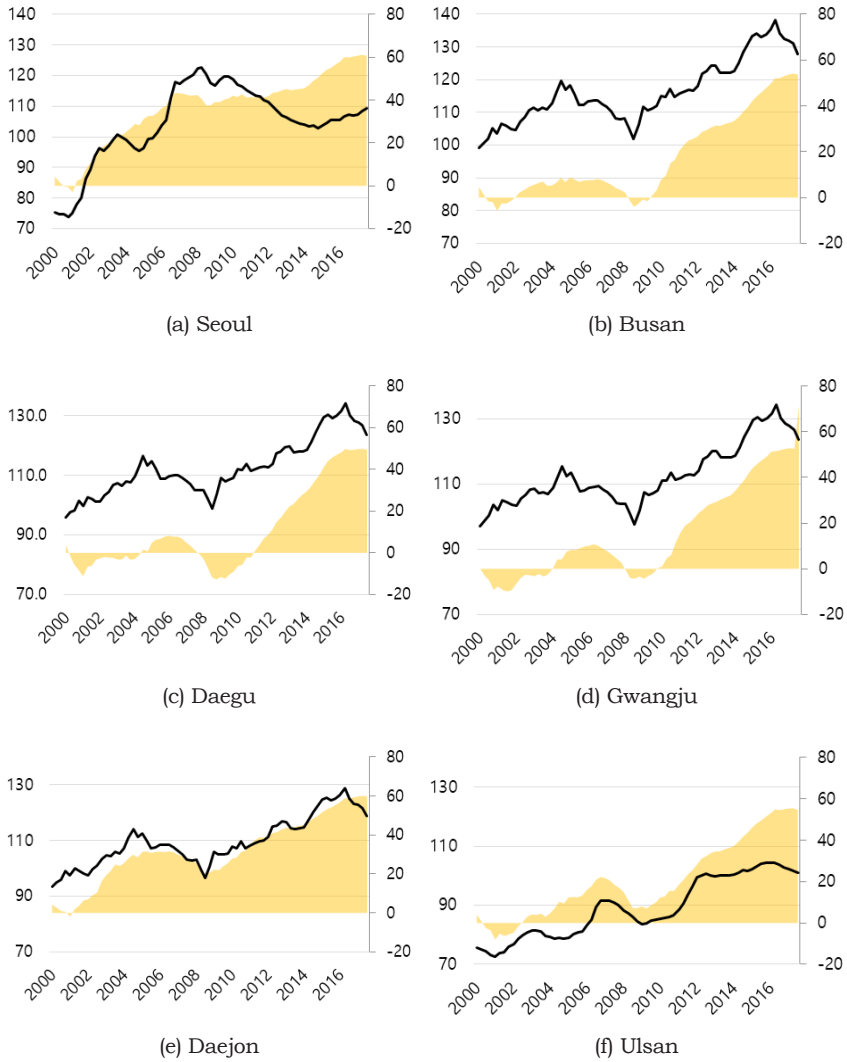
FIGURE 9

CONTRIBUTIONS OF EXPECTED EXCESS RETURNS (2000:Q2–2017:Q4 SUBSAMPLE)

of the housing market fundamentals.

V. Conclusion

In this study, we adopt the Campbell–Shiller present-value model to examine the variation sources in the Korean housing market in 1987–2014. In contrast to the prediction of the standard present-value formula, the price-rent ratio in Korea since the early 2000s exhibits a sustained increase along with a large swing around the rising trend. Therefore, we modify the Campbell–Shiller model and allow the price-rent ratio to be driven by a periodically collapsing rational bubble in addition to the expectations of future housing market fundamentals, such as rent growth, real interest rate, and risk premium for (or excess



Note: The solid lines denote actual real house price, and the shades against the right axes denote the percentages of the bubble.

FIGURE 10
 PERCENTAGE OF BUBBLE IN REAL HOUSE PRICE (2000:Q2–2017:Q4 SUBSAMPLE)

returns from) housing investment. The model is estimated using a body of data that are consistent with the postulates of the present-value approach. Then, we apply the estimated model to decompose the price-rent ratio into the fundamental part explained by the expectations and the bubble part.

Our first finding suggests that the price-rent ratio is mainly driven by the expected excess returns from housing investment in the absence of bubbles, and the roles of the expected rent growth and real interest rate are of secondary importance. This finding is corroborated by the variance decomposition results. On average, the variation in the expected excess returns to housing investment accounts for approximately 65% of that in the fundamental price-rent ratio across the six regional housing markets, whereas the expected rent growth and real interest rate individually explain approximately 25% of the variation in the fundamental ratio. Our second finding suggests that the speculative bubble term that represents the deviation of the price-rent ratio from its present-value model is important in all the six regional housing markets. In particular, the Korean housing market in 2001–2014 was significantly affected by the accumulation of the bubble, such that the bubble accounted for approximately 70% of house price toward the end of 2017. These findings are robust to the use of different interest rate series and the post-1999 subsample characterized by a bullish run in the housing market.

Appendix

A. State-space Form of the Estimated Model

In this appendix, we summarize casting the model into the state-space form through regime switching. We first apply the law of iterated expectation to represent the fundamental part of the price-rent ratio in terms of expectations:

$$pr_t^f = \frac{K}{1-\rho} + \frac{\gamma_0 - \delta_0 - \theta_0}{1-\rho} + B_1 \begin{bmatrix} g_t \\ g_{t-1} \end{bmatrix} - B_2 \begin{bmatrix} \mu_t \\ \mu_{t-1} \end{bmatrix} - B_3 \begin{bmatrix} \lambda_t \\ \lambda_{t-1} \end{bmatrix}, \quad (15)$$

where

$$B_1 = \rho[1 \ 0] \left(I - \rho \begin{bmatrix} \gamma_1 & \gamma_2 \\ 1 & 0 \end{bmatrix} \right)^{-1}, \quad B_2 = \rho[1 \ 0] \left(I - \rho \begin{bmatrix} \delta_1 & \delta_2 \\ 1 & 0 \end{bmatrix} \right)^{-1},$$

and

$$B_3 = \rho[1 \ 0] \left(I - \rho \begin{bmatrix} \delta_1 & \delta_2 \\ 1 & 0 \end{bmatrix} \right)^{-1}.$$

The transition equations of the model are cast into the following form:

$$\begin{bmatrix} g_t \\ g_{t-1} \\ \mu_t \\ \mu_{t-1} \\ \lambda_t \\ \lambda_{t-1} \\ u_t^r \\ u_t^i \\ u_t^\pi \\ \varepsilon_t^g \\ \varepsilon_t^\mu \\ \varepsilon_t^\lambda \\ b_t \end{bmatrix} = \begin{bmatrix} 0_{2 \times 1} \\ 0_{2 \times 1} \\ 0_{2 \times 1} \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ \bar{b}(S_t) \end{bmatrix} + \begin{bmatrix} \begin{bmatrix} \gamma_1 & \gamma_2 \\ 1 & 0 \end{bmatrix} & 0_{2 \times 2} & 0_{2 \times 2} & 0_{2 \times 7} \\ 0_{2 \times 2} & \begin{bmatrix} \delta_1 & \delta_2 \\ 1 & 0 \end{bmatrix} & 0_{2 \times 2} & 0_{2 \times 7} \\ 0_{2 \times 2} & 0_{2 \times 2} & \begin{bmatrix} \delta_1 & \delta_2 \\ 1 & 0 \end{bmatrix} & 0_{2 \times 7} \\ & 0_{1 \times 13} & & \\ & 0_{1 \times 13} & & \\ & 0_{1 \times 13} & & \\ & 0_{1 \times 13} & & \\ & 0_{1 \times 13} & & \\ 0_{1 \times 12} & & & F_b(S_t) \end{bmatrix} \begin{bmatrix} g_{t-1} \\ g_{t-2} \\ \mu_{t-1} \\ \mu_{t-2} \\ \lambda_{t-1} \\ \lambda_{t-2} \\ u_{t-1}^r \\ u_{t-1}^i \\ u_{t-1}^\pi \\ \varepsilon_{t-1}^g \\ \varepsilon_{t-1}^\mu \\ \varepsilon_{t-1}^\lambda \\ b_{t-1} \end{bmatrix} + \begin{bmatrix} C_G \\ C_M \\ C_\Lambda \\ I_6 \ 0_{6 \times 1} \\ 0_{1 \times 6} \ 1 \end{bmatrix} \begin{bmatrix} u_t^r \\ u_t^i \\ u_t^\pi \\ \varepsilon_t^g \\ \varepsilon_t^\mu \\ \varepsilon_t^\lambda \\ \varepsilon_t^b \end{bmatrix}, \quad (16)$$

$$(X_t = A(S_{t-1}) + F(S_{t-1})X_{t-1} + C\eta_t),$$

where

$$C_G = \begin{bmatrix} 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ & & & 0_{1 \times 7} & & & \end{bmatrix}, \quad C_M = \begin{bmatrix} 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ & & & & 0_{1 \times 7} & & \end{bmatrix}, \quad C_\Lambda = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ & & & & & 0_{1 \times 7} & \end{bmatrix},$$

$$\bar{b}(S_t) = \bar{b}(1 - S_t) - \frac{q}{1 - q} \bar{b}S_t(1 - S_{t-1}) - \frac{1 - p}{p} \bar{b}S_tS_{t-1}, \text{ and}$$

$$F_b(S_t) = \psi(1 - S_t) + \frac{1}{1 - q} \left(\frac{1}{\rho} - q\psi \right) S_t(1 - S_{t-1}) + \frac{1}{p} \left(\frac{1}{\rho} - (1 - p)\psi \right) S_tS_{t-1}.$$

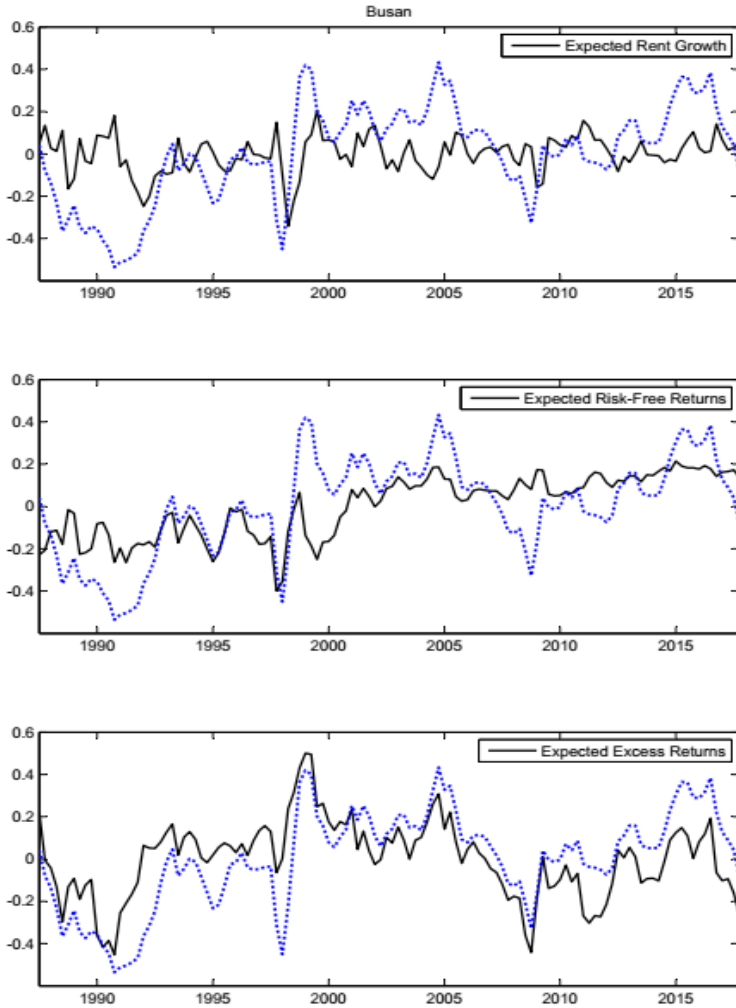
Using $pr_t = pr_t^f + b_t$, we write the observation equations as

$$\begin{bmatrix} \Delta r_t \\ i_t \\ \pi_t \\ pr_t \end{bmatrix} = \begin{bmatrix} \gamma_0 \\ \delta_0 \\ \theta_0 \\ \frac{K}{1-\rho} + \frac{\gamma_0 - \delta_0 - \theta_0}{1-\rho} \end{bmatrix} + \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ B_1 & B_2 & B_3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \end{bmatrix} \cdot \begin{bmatrix} g_t \\ g_{t-1} \\ \mu_t \\ \mu_{t-1} \\ \lambda_t \\ \lambda_{t-1} \\ u_t^r \\ u_t^i \\ u_t^\pi \\ \varepsilon_t^g \\ \varepsilon_t^\mu \\ \varepsilon_t^\lambda \\ b_t \end{bmatrix} \quad (17)$$

B. Results of the Other Cities

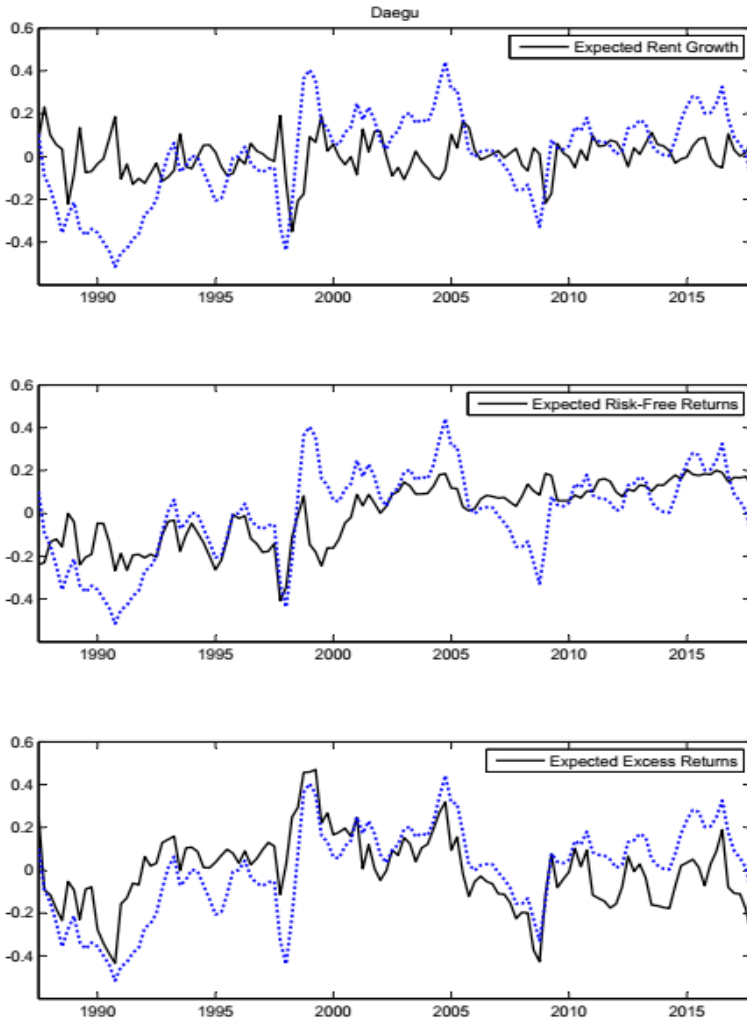
APPENDIX TABLE 1
 VARIANCE DECOMPOSITION FOR THE FUNDAMENTAL PRICE-RENT RATIO

	% of var(pr_t^f)			
	Busan	Daegu	Gwangju	Daejon
var(G_t)	19.1%	19.4%	22.0%	20.1%
var(M_t)	24.7%	23.3%	23.5%	24.0%
var(Λ_t)	63.6%	66.6%	69.6%	66.9%
cov(G_t, M_t)	-17.0%	-16.6%	-18.0%	-17.4%
cov(G_t, Λ_t)	-31.9%	-33.0%	-36.7%	-34.3%
cov(M_t, Λ_t)	41.5%	40.3%	39.6%	40.8%



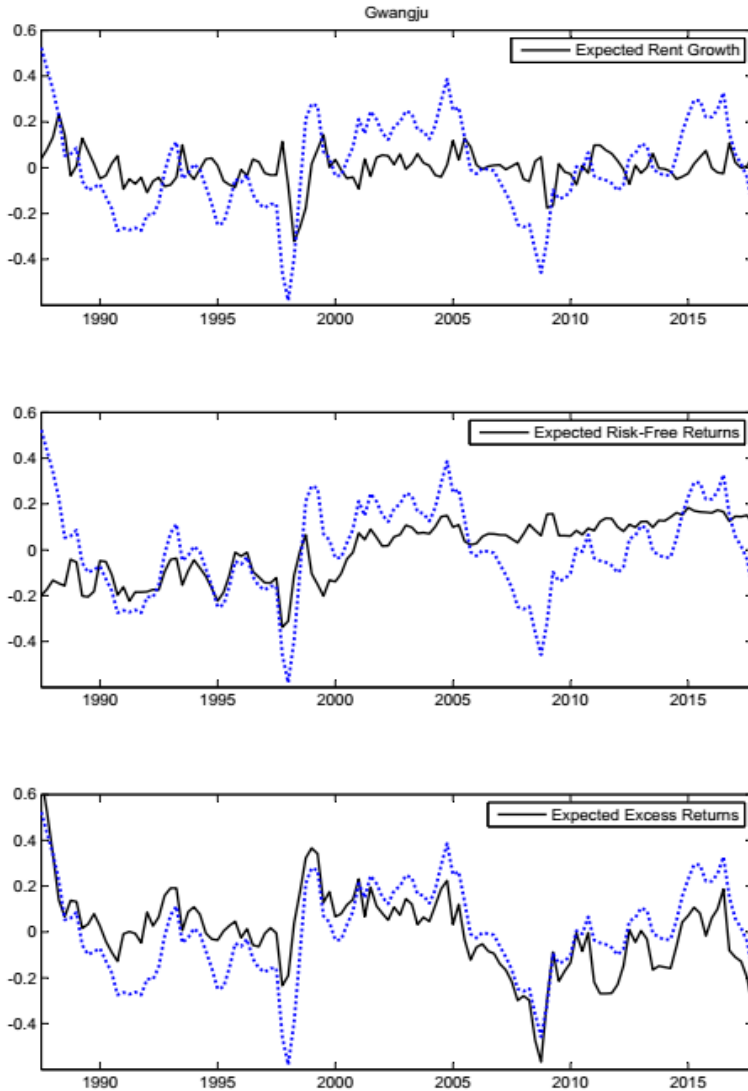
Note: The dotted line denotes the estimated fundamental part of the ratio.

APPENDIX FIGURE 1
CONTRIBUTIONS OF EXPECTED MARKET FUNDAMENTALS



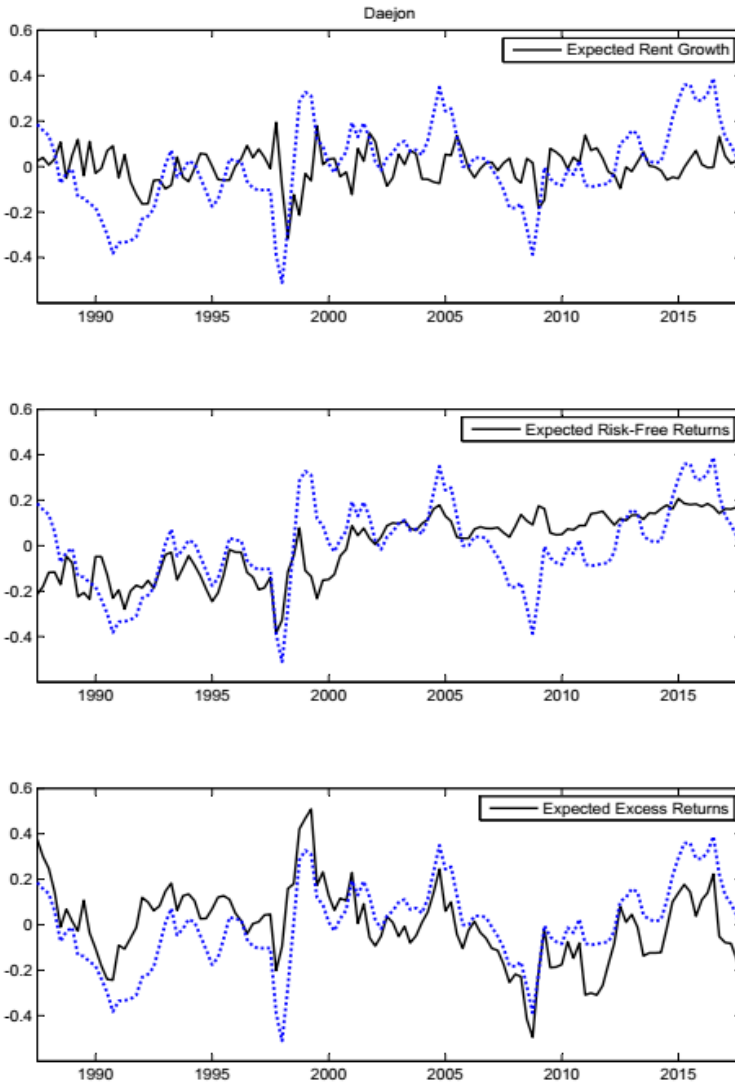
Note: The dotted line denotes the estimated fundamental part of the ratio.

APPENDIX FIGURE 1
(CONTINUED)



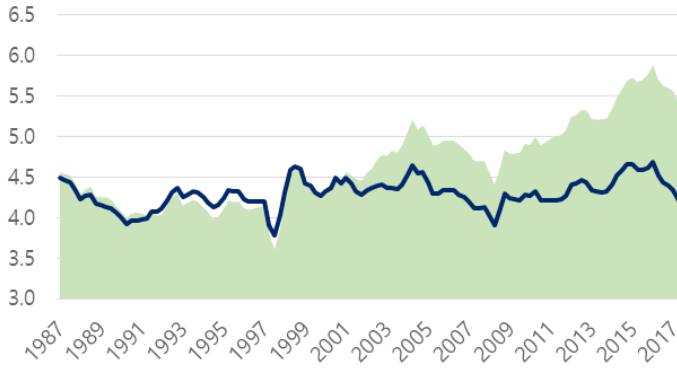
Note: The dotted line denotes the estimated fundamental part of the ratio.

APPENDIX FIGURE 1
(CONTINUED)

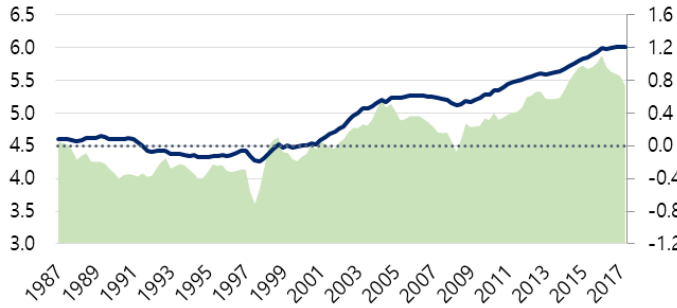


Note: The dotted line denotes the estimated fundamental part of the ratio.

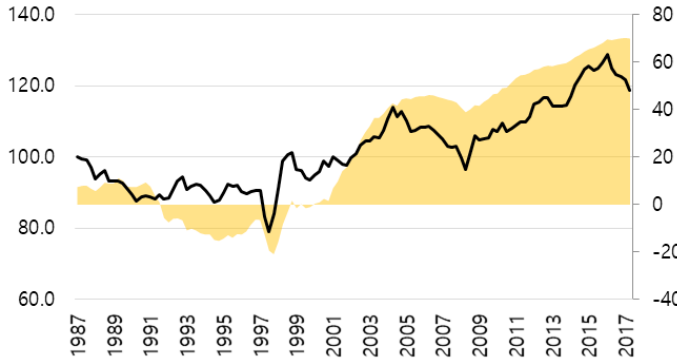
APPENDIX FIGURE 1
(CONTINUED)



(a) Actual vs. Fundamental Ratio



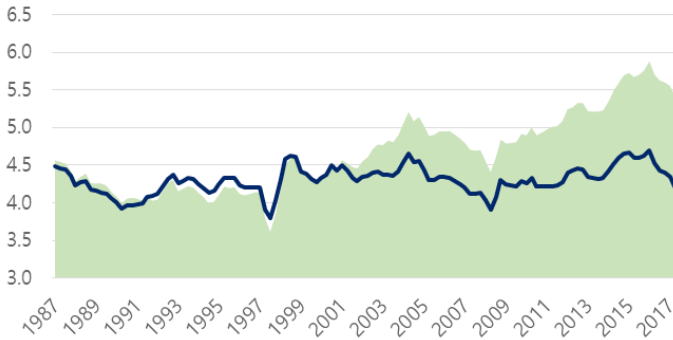
(b) Actual Ratio vs. Bubble (Right Axis)



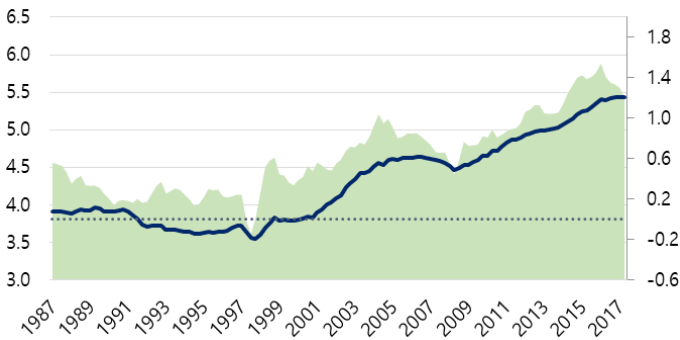
(c) Actual Real House Price vs. % of Bubble (Right Axis)

Note: Real house price is indexed with 1987:Q3=100.

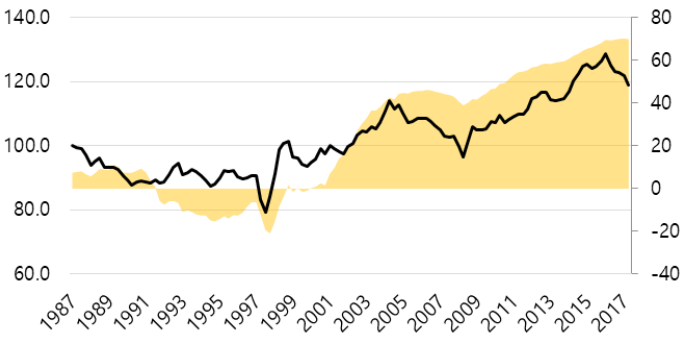
APPENDIX FIGURE 2
 FUNDAMENTAL AND BUBBLE COMPONENTS (BUSAN)



(a) Actual vs. Fundamental Ratio



(b) Actual Ratio vs. Bubble (Right Axis)

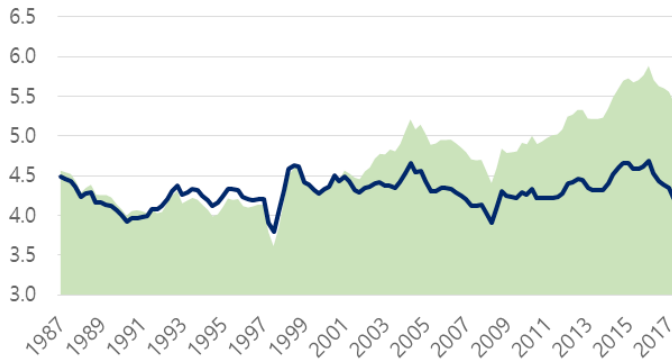


(c) Actual Real House Price vs. % of Bubble (Right Axis)

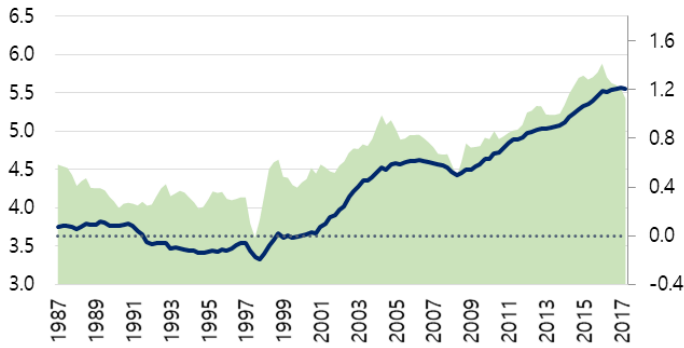
Note: Real house price is indexed with 1987:Q3=100.

APPENDIX FIGURE 3

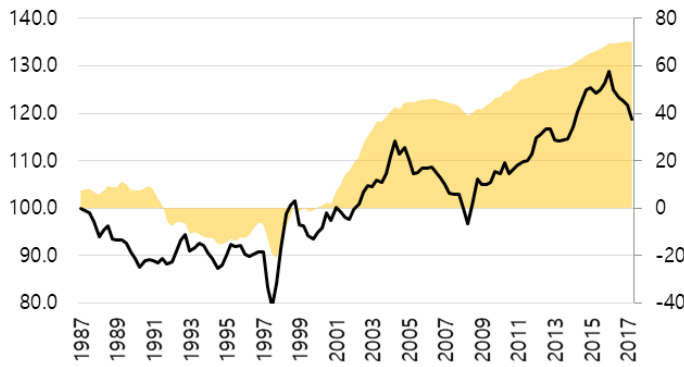
FUNDAMENTAL AND BUBBLE COMPONENTS (DAEGU)



(a) Actual (shaded) vs. Fundamental Ratio (solid)



(b) Actual Ratio vs. Bubble (Right Axis)

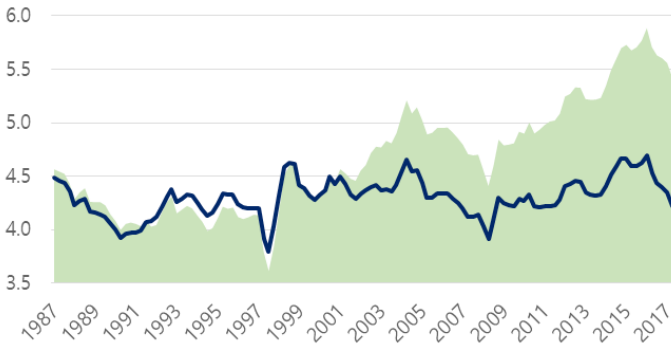


(c) Actual Real House Price vs. % of Bubble (Right Axis)

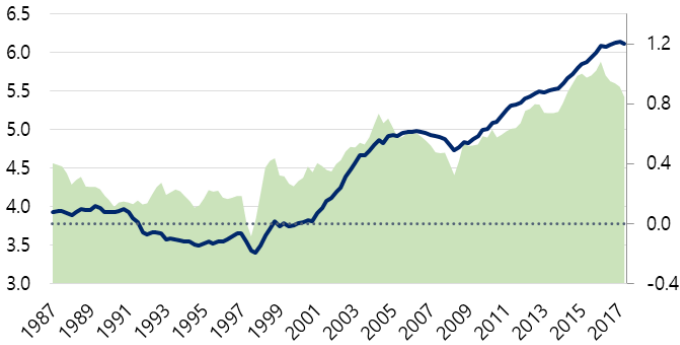
Note: Real house price is indexed with 1987:Q3=100.

APPENDIX FIGURE 4

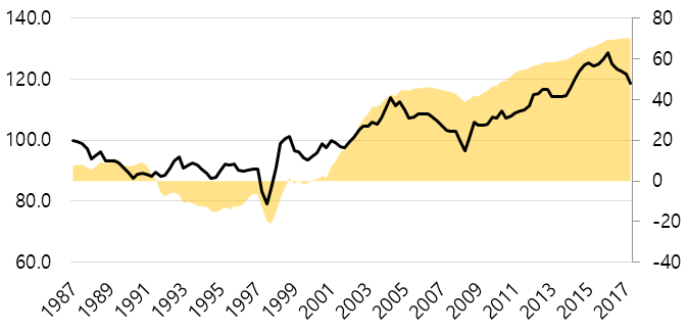
FUNDAMENTAL AND BUBBLE COMPONENTS (GWANGJU)



(a) Actual vs. Fundamental Ratio



(b) Actual Ratio vs. Bubble (Right Axis)



(c) Actual Real House Price vs. % of Bubble (Right Axis)

Note: Real house price is indexed with 1987:Q3=100.

APPENDIX FIGURE 5

FUNDAMENTAL AND BUBBLE COMPONENTS (DAEJON)

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