Graduate Thesis

Fundamental value of Korean housing price
韓国の不動産価格のファンダメンタルバリュー

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Abstract

This paper applies the present-value model to housing market prices in South Korea, covering 1987 to 2020 data. The housing market in Korea had experienced a lack of supply during the 1960s and a dramatic increase under the supply-oriented policy by the government since 1980. Then, the price-rent ratio index in South Korea exhibits three peaks in 2005, 2016, and 2020, mainly caused by three different peaks in real buying price and continuous decreasing trend of real rent price. To analyze components of housing price, this paper considers housing fundamentals and bubble. First, to estimate housing fundamentals, the model of the present-value model is used to decompose the price-rent ratio into three expectations of housing market fundamentals; real rent growth, risk-free return, and risk premium. By using the vector-auto regression approach, this paper estimates housing fundamentals and concludes that most variances of the price-rent ratio are explained by the expected risk-free returns. Second, considering the irrational expectation as a bubble which is a deviation of a price from the fundamental value, this paper introduces a periodically collapsing bubble and figures out that the exploding regime is more persistent with a longer predicted duration than the non-exploding regimes.

Keywords: Housing price, Present-value model, Fundamental value

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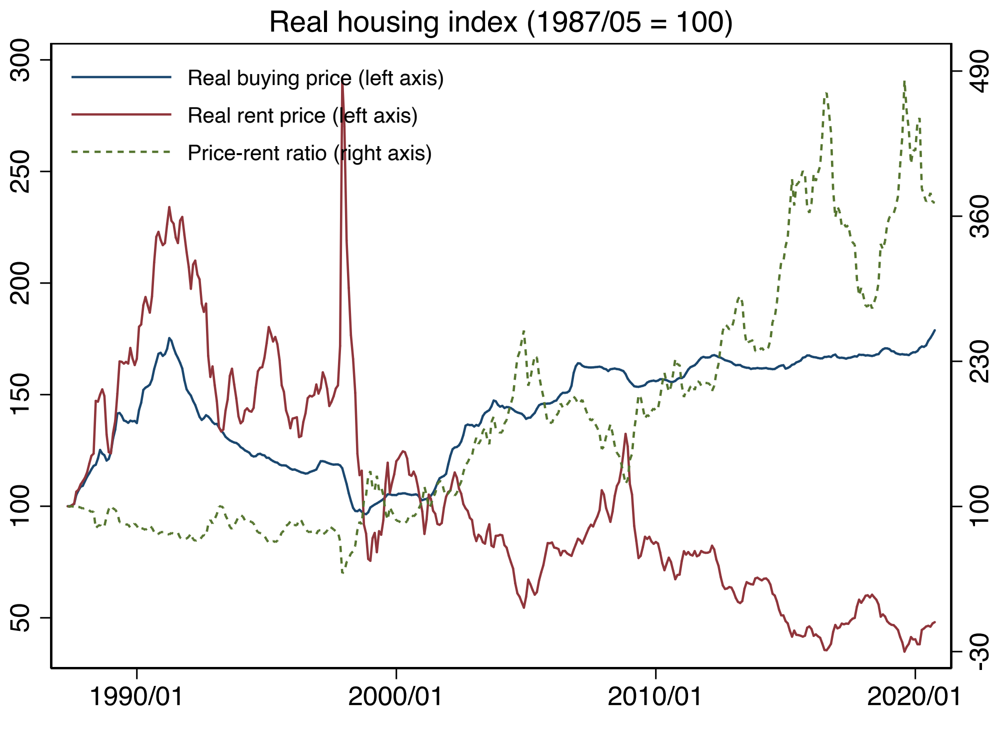
Contents

1 Introduction

Over the previous decades, we can observe a boom and bust in housing prices in South Korea. There are three different major periods of the housing market boom. From April 1988 to June 1991, the average year on year change in buying price is 15.1%. In Figure 1, we can observe the increase in real buying price until 1991. Then, there has been a decreasing trend of real buying price because of supply surge in the housing market until 1998. As the economy recovered from the Asian currency crisis, the second boom occurred. From 2001 to 2004, the real buying price increased by 8.3% and recovered the previous peak of the boom. The recent boom from 2006 to 2007 recorded a 6.6% increase in the real buying price. Since then, the real buying price has maintained stable condition but the continuing decreasing trend of real rent price leads to the boom of price-rent ratio nowadays. The price-rent ratio exhibits three peaks in 2005, 2016, and 2020, mainly caused by the recent boom from 2006 to 2007 and a continuous decreasing trend of real rent price.

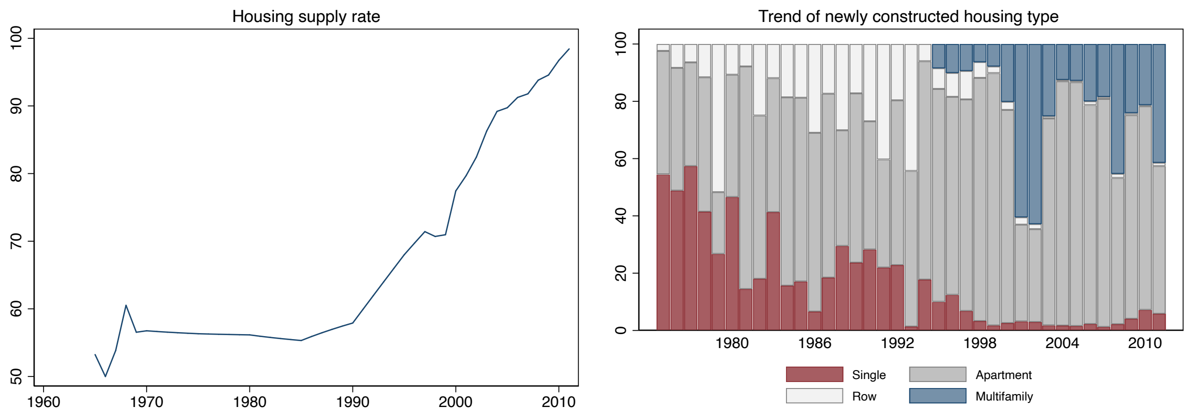
Figure 1: Real buying price, real rent price and Price-rent ratio in South Korea



Buying and rent prices are the two main indexes in housing to evaluate the housing market and understand the fundamental value and bubble. The relationship between two indexes, price- rent ratio is a significant factor to monitor the overvaluation or bubble in the housing market. Under the rational expectation hypothesis, fundamental value is determined by long-term rational expectation and if there is a price not in the range of equilibrium, we assume that there is a price bubble. However, a bubble itself that is a deviation from fundamental value is difficult to observe because the fundamental value is unobservable. One possible measure is the price-rent ratio which helps to construct determinants of fundamental value and is equal to the present discounted value of expected housing flow or returns. With this background, this paper will mainly focus on decomposing the price-rent ratio into the fundamental value and bubble in South Korea. To figure out if the price-rent ratio responds to changes in fundamentals or bubble term, we will use the present-value model to understand how the changes in fundamentals are decided. Also, to understand the contribution of determinants in fundamentals, we assume that the price-rent ratio can be split into the sum of expected rent growth, risk-free return, and risk premium paid to the house. These determinants are defined by Campbell and Shiller who lead lots of literature to follow their determinant choosing.

According to Xiao and Park (2010), the divergent behavior of price index is striking by the type of housing and the only apartment shows a high increase in a price index. Since South Korea is in a housing market with supply rigidity which is mainly decided by the government and especially concentrated in Seoul, the capital city, then the price volatility of housing is largely a result of demand volatility. There is a historical background of supply rigidity. In the late 60s-80s, the government had control over the supply of land and houses, and the power to implement a supply-oriented housing policy to overcome the lack of supply in housing under the high economic growth and rapid population growth. To keep the demand within the supply, the government imposed taxes but after the 1980s, it is inevitable to solve the housing shortage problem. The major dwellings to keep the demand in housing was apartments, which showed average annual growth of houses 50,000 units to double in the next ten years[1] only in Seoul. When we compare to the Newyork City constructed 10,000 units each year, Seoul keeps new construction of 50,000-100,000 units since 1980. As a result, the form such as floor or materials becomes more homogenous compared to other countries' houses. Then, the apartment became the major type of housing to contain increasing demand in housing during the high economic growth and shows a high increase in price index still now. Following analysis in section 3 will mainly focus on the apartment type which has been a significant indicator to analyze bubble in the context of Korea. Figure 2 shows a continuous increase in housing supply, which reaches around 100% in 2010 and exhibits increasing trend of apartment among newly constructed houses in Seoul.

Figure 2: Housing supply rate and newly constructed housing



[1]http://data.si.re.kr/node/343

2 Literature Review

Related to the factors which can contribute to the fundamental value of the price-rent ratio, Kim and Lim (2016) figure out that expected excess returns are the largest part of the contribution. Campbell et al. (2009) use variance decomposition of rent-price ratio in the United States by applying the dynamic Gordon growth model to 23 metropolitan markets and considering different time periods. They conclude that housing risk premium exhibits significant variance in housing fundamentals. Basic model or data construction is inspired by these two pieces of literature. Both pieces of literature are significant to analyze which factor contributes more on the fundamental value.

When it comes to bubble term, we can categorize it into rational term and irrational term. Kim and Lim (2016) specify irrational bubble term as a periodically collapsing which is following Markov regime-switching process and decompose the price-rent ratio into bubble and fundamentals. Kim and Cho (2018) also adopt an identical Markov regime-switching process and apply the model to 6 different regional data. The authors conclude that the expected excess return to housing investment accounts for 65% in the fundamental price-rent ratio and suggests that the bubble accounted for 70% of the house price. Chung and Kim (2004) suggest three different methods to analyze bubble and find out that the percentage share of speculative demand in housing inflation is very high by regressing housing price to income and bond yield. Speculative demand is captured by the lagged value of the housing price in the regression equation, which is decided by expectation at the lagged period. When it comes to the rational bubble term, Xiao and Park (2010) mainly focus on demand itself and argue that apartments are preferred as vehicles of speculation since the price of apartments is more responsive to change in demand rather than row houses or single houses. They assume the bubble term at the current period in a price-rent ratio is exponential and relies on rational expectation at the previous period.

Mainly there are two methods to analyze components of fundamental value on price-rent ratio, VAR approach, and unobserved components model. When it comes to the discussion on the model method to analyze fundamentals over the range of housing, Kim and Chung (2018). focus on the method to analyze the model. They examine whether the predictions of the present-value model are consistent across the two approaches, VAR model and the unobserved components model. For the United Kingdom, two approaches show similar results but not for the United States. The strategies to analyze price-rent ratio can be different in the context of the housing situation. Kim and Lim (2014) also tried the similar analysis on the Irish housing market and concluded that the share of excess return is relatively high.

To understand VAR approach and Campbell-Shiller decomposition, Campbell (1991) explains the VAR approach in the context of stock returns. This literature defines vector with k elements, following a first-order VAR and mathematically explains written form of discounted sum of revisions in forecast returns. Campbell and Shiller (1988) introduce a log-linear approximation to the present value identity. Realized log gross turn on the portfolio can be approximated by the variable with log of sum of price and dividend. By following the mathematical method introduced by these two literatures, this paper will approximate present-value model in gross return housing into log of buying price and rent price.

3 Model

3.1 Decompose fundamental value into components

From the present-value model, we denote

$$H_{t+1} = \frac{P_{t+1} + R_{t+1}}{P_t} \tag{1}$$

gross real return on housing where P_{t+1} is the real house price at the end of period t and $t+1$ and R_{t+1} is the real rent payment during period t. We can rewrite equation (1) as

$$P_t = \sum_{k=1}^{\infty} \frac{R_{t+k}}{H_{t,t+k}}$$

where $H_{t,t+k} = H_{t+1} \times ... \times H_{t+k}$. The first order Taylor expansion gives the following expression of housing price

$$pr_t = \kappa + \rho p_{t+1} + \Delta r_{t+1} - h_{t+1} \tag{2}$$

where $pr_t = log(P_t/R_t)$ is the log of price-rent ratio, $\Delta r_t = log(R_t/R_{t-1})$ is the log of real rent growth, $h_{t+1} = log(H_{t+1})$ is the log of gross real return on housing, and $p_t = log(P_t)$ is the log of real buying price index . Discount factor ρ is $e^{\overline{pr}}/(1+e^{\overline{pr}})$, where $\overline{pr}$ is the sample average of the log of price-rent ratio, and κ denotes a linearization constant. Then, it is possible to break down the real return from housing h_t into real interest rate i_t and risk premium π_t

$$h_t = i_t + \pi_t \tag{3}$$

where i_t corresponds to the risk-free rate of return and π_t is the excess return from investing in house. Iterating equation (2) forward and using equation (3) by applying Campbell-Shiller present-value formula, it follows that

$$\begin{aligned}
p_t &= \frac{\kappa}{1-\rho} + (1-\rho)\sum_{k=0}^{\infty} \rho^k r_{t+k+1} - \sum_{k=0}^{\infty} \rho^k h_{t+k+1} \\
p_t - r_t &= \frac{\kappa}{1-\rho} + E_t\{\sum_{j=0}^{\infty} \rho^j (\Delta r_{t+j+1} - h_{t+j+1})\} \\
pr_t &= \frac{\kappa}{1-\rho} + E_t\{\sum_{j=0}^{\infty} \rho^j (\Delta r_{t+j+1} - i_{t+j+1} - \pi_{t+j+1})\}
\end{aligned}$$

where $\Delta r_t = log(R_t/R_{t-1})$ is the real rent growth, i_t is the real risk-free rate of return , and π_t is excess return from housing investment. This formula implies that the fundamental value of the price-rent ratio is discomposed into real rent growth, risk-free rate of return, and risk premium. From here, this paper assumes the observable fundamental value of actual price-rent ratio as

$$pr_t^f = \frac{\kappa}{1-\rho} + E_t\{\sum_{j=0}^{\infty} \rho^j (\Delta r_{t+j+1} - i_{t+j+1} - \pi_{t+j+1})\}. \tag{4}$$

To estimate the expectations of total fundamentals of housing market, it is necessary to apply expectations on each factors which consist of price-rent ratio. Expected present value of each factors can be expressed as

$$\begin{aligned}\mathcal{R}_t &= E_t \sum_{j=0}^{\infty} \rho^j \Delta r_{t+j+1} \\ \mathcal{I}_t &= E_t \sum_{j=0}^{\infty} \rho^j i_{t+j+1} \\ \Pi_t &= E_t \sum_{j=0}^{\infty} \rho^j \pi_{t+j+1}.\end{aligned}$$

Then, equation (4) can be rewritten as

$$pr_t^f = \frac{\kappa}{1-\rho} + \mathcal{R}_t - \mathcal{I}_t - \Pi_t.$$

As following the VAR approach introduced by Campbell et al.(2009), define the component factor

$$Z_t = (i_t, \pi_t, \Delta r_t, x_t^{'})^{'}$$

where $x_t^{'}$ is the vector of variables for influencing the housing market fundamentals $(i_t, \pi_t, \Delta r_t)$ such as real GDP growth rate or population growth rate. Then, assume multivariate time series X_t follows p-order VAR

$$X_t = a_1 X_{t-1} + a_2 X_{t-2} + ... + a_p X_{t-p} + \epsilon_t \tag{5}$$

and then, we can rewrite equation (5) with AR(p) model into the form of AR(1) model

$$\begin{bmatrix} X_t \\ X_{t-1} \\ \vdots \\ X_{t-p+1} \end{bmatrix} = \begin{bmatrix} a_1 & a_2 & \dots & a_{p-1} & a_p \\ I & 0 & \dots & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ I & 0 & ... & I & 0 \end{bmatrix} \begin{bmatrix} X_{t-1} \\ X_{t-2} \\ \vdots \\ X_{t-p} \end{bmatrix} + \begin{bmatrix} \epsilon_t \\ 0 \\ \vdots \\ 0 \end{bmatrix}.$$

AR(1) model can be rewritten as companion form

$$Z_t = \Gamma Z_{t-1} + \varepsilon_t$$

where $Z_t = \begin{bmatrix} X_t \\ X_{t-1} \\ \vdots \\ X_{t-p+1} \end{bmatrix}$, $\Gamma = \begin{bmatrix} X_{t-1} \\ X_{t-2} \\ \dots \\ X_{t-p} \end{bmatrix}$, and $\varepsilon_t = \begin{bmatrix} \epsilon_t \\ 0 \\ \dots \\ 0 \end{bmatrix}$. Then, given an coefficient estimation of Γ, $\widehat{\Gamma}$ estimates of present values $\mathcal{R}_t, \mathcal{I}_t, \Pi_t$ are the first three elements of

$$\widehat{\Gamma}(I - \rho\widehat{\Gamma})^{-1} Z_t$$

where I is the identity matrix and ρ is discount factor. Finally, estimated fundamental value of price-rent ratio is represented as

$$\widehat{pr_t}^f = \frac{\kappa}{1-\rho} + \widehat{\mathcal{R}}_t - \widehat{\mathcal{I}}_t - \widehat{\Pi}_t. \tag{6}$$

where

$$\begin{aligned} \widehat{\mathcal{R}}_t &= \sum_{j=0}^{\infty} \rho^j e_1' \Gamma^{j+1} Z_t \\ \widehat{\mathcal{I}}_t &= \sum_{j=0}^{\infty} \rho^j e_2' \Gamma^{j+1} Z_t \\ \widehat{\Pi}_t &= \sum_{j=0}^{\infty} \rho^j e_3' \Gamma^{j+1} Z_t \end{aligned}$$

and e_i is vector whose i th element is 1 and whose other elements are all 0. Estimated fundamental value $\widehat{pr_t}^f$ still can be deviated from the real price-rent ratio pr_t with forecast discrepancy b_t. Denote the actual price-rent ratio

$$pr_t = \widehat{pr_t}^f + b_t$$

which consists of estimated fundamental value based on expected factors, and forecast discrepancy. Forecast discrepancy implies that VAR model does not produce expectations which are perfectly aligned with the observable data in equation (4). Then, by treating the forecast discrepancy as bubble term, we can discuss the bubble term in price-rent ratio.

3.2 Bubble

Considering the irrational expectation as bubble which is a deviation of a price from the fundamental value, we can modify the present-value formula into

$$pr_t = \frac{\kappa}{1-\rho} + E_t\{\sum_{j=0}^{\infty} \rho^j (\Delta r_{t+j+1} - i_{t+j+1} - \pi_{t+j+1})\} + b_t = \widehat{pr_t}^f + b_t \tag{7}$$

where pr_t^f is the fundamental price-rent ratio by rational expectations under three different factors from section 3.1, and b_t captures the deviations from fundamental value. There are two patterns of assuming bubble term in price-rent ratio. One is the rational bubble and the other is irrational bubble. Assume there is a rational bubble

$$E_t b_{t+1} = \frac{1}{\rho} b_t$$

which implies that hat transversality condition of (1) may fail to hold. If the transversality condition, $lim_{j\to\infty}\rho^j(pr_{t+j}) = 0$ holds, the log of price-rent ratio does not explode. The other case from Kim and Lim (2016) dealt with irrational bubble, governed by a hidden state variable S_t, which follows a Markov regime-switching process with the transition probabilities p and q

under

$$Prob[S_t = 1|S_{t-1} = 1] = p, Prob[S_t = 0|S_{t-1} = 0] = q.$$

Let the exploding regime probability p as state 1 and non-exploding regime probability q as state 2. If the regime keeps non-exploding, then

$$b_t = \bar{b} + \psi b_{t-1} + \epsilon_t^b.$$

If the regime changes from non-exploding to exploding, then bubble term follows

$$b_t = -\frac{q}{1-q}\bar{b} + \frac{1}{1-q}(\frac{1}{\rho} - q\psi)b_{t-1} + \epsilon_t^b.$$

And if regime keeps exploding one, then bubble term follows

$$b_t = -\frac{1-p}{p}\bar{b} + \frac{1}{p}(\frac{1}{\rho} - (1-p)\psi)b_{t-1} + \epsilon_t^b.$$

Regarding the forecast discrepancy in Section 3.1 as bubble term, this paper will estimate the probability of each regime and figure out how long each regime continues.

4 Data and information

4.1 Data

This paper basically follows the data Kim and Lim (2016) examined and extends the range of analysis. The raw data used in the present paper are the monthly series of nominal housing purchase and *chonsei* (rent) prices of apartments, nominal interest rates, and core CPI, covering 1987/05 - 2020/10. To use enough data for making first-difference or year-on-year data, raw data begins from 1986/01. Different from Kim and Lim (2016), this paper directly uses monthly latest data instead of quarterly data and adds macro variables to conduct the VAR approach. Housing purchase and *chonsei* prices are compiled by the Kookmin Bank database and are downloadable in public. Nominal interest and CPI series are downloaded from the Bank of Korea database[2]. The nominal interest rate is the AA- rate corporate bonds yields with a 3-year maturity, considered as a representative market rate in Korea. Especially for *chonsei* contracts which do not directly involve a monthly rent payments, it is possible to derive monthly rent index by rescaling *chonsei* price index to match the purchase-to-*chonsei* price ratio (price-rent ratio) and then multiplying the index with nominal interest rate. KOSIS (Korean Statistical Information Service)[3] provides well-organized time series data of housing index and price by type and location. Therefore, there is a possibility to adapt this analysis by a different type of housing and location. The risk premium is decided by the log of the gross real return h_t and the sum of risk-free rate i_t from equation (3). Also, macro variables data using to apply VAR approach are available from the World Bank and FRED.

[2] https://onland.kbstar.com/quics?page=okbland
[3] https://kosis.kr/index/index.do

4.2 The unique system of rent payment

There exists a rental housing payment system called *chonsei* which makes people live in a house by paying a large lump-sum amount of deposit which is usually about 50% to 60% of the market value of the property instead of paying monthly rent payment, but it can be as high as 80%. It is also called *Jeonse*. From the background of housing-shortage during the 60s-70s, there was an insufficient supply of housing and then the government had implemented supply-oriented construction since the 1970s. Therefore, instead of buying a house which requires a high amount of payment, there is a demand for tenants who can live the house affordable within their budget. Also, there is a demand for affordable buyers who are willing to buy a house and give it to tenants as a form of *chonsei*. Then, those affordable buyers can expect capital gain after the lease contract ends. This system has a mechanism to prevent a sharp drop in the value of housing by keeping the quality of the residential property as much as a large lump-sum amount. There is a rule that tenants who use this system can not change or innovate the house without permission from owners. Basically, this system considered a rental system in Korea.

4.3 Analysis

Firstly, this paper examines the ADF(Augmented Dickey-Fuller) test and Philips-Perron test to examine if the series of the price-rent ratio is stationary. As a result, the price-rent ratio fails to reject the null hypothesis that unit root exists in a time series data. Lags are chosen as 2 by following the result of AIC statistics. Using the price-rent ratio covering 1987/05 - 2020/10, the results of two tests are Table 1. These results are supportive of the fact that the price-rent ratio series have unit root and non-stationary. From this result, it is possible to say that there is a bubble in the present-value model. Also, the stationarity of other variables is estimated as well. Under the null hypothesis, that time series have a unit root, real rent growth, real interest rate, and risk premium can reject the null hypothesis.

Table 1: Stationarity Test

Variable	Test	Statistics	p value
$log(pr_t)$	ADF test	-0.7400	0.8361
	Phillips-Perron test	-1.5500	0.8485
Y_t	ADF test	-3.2420	0.0177
Δr_t	ADF test	-10.0400	0.000
i_t	ADF test	-3.6730	0.0242
Π_t	ADF test	-3.6390	0.0267

Table 2 shows how each component of the fundamental values on the price-rent ratio are shaped to consist of price-rent ratio. I list sample mean, standard deviation over the entire 1987/05 - 2020/10 sample.

Table 2: Descriptive Statistics

	Δr_t	i_t	π_t	pr_t
mean	-0.0018	7.8215	-7.2480	5.0165
sd	0.0577	5.1085	4.8830	0.5873
skewness	1.6418	0.6228	-0.6510	0.2076
count	402	402	402	402

5 Results

For each market, forecast equations for real interest rate, real rent growth, and risk premium are following first-order VAR. The employed macro variables to VAR are chosen by Campbell et al. (2009) and Kim and Lim (2016). Only three components of housing fundamental value can be applied to the VAR approach, however, assuming GDP growth rate and annual population growth can affect $(\Delta r_t, i_t, \pi_t)$, this paper allows the VAR approach to include macro variables as well. Following equations are VAR approach formula

$$\begin{aligned}
\Delta r_t &= \gamma_0 + \gamma_{\Delta_r} \Delta r_{t-1} + \gamma_i i_{t-1} + \gamma_\pi \pi_{t-1} + \gamma_Y Y_{t-2} + \gamma_N N_{t-2} + u_t^r \\
i_t &= \delta_0 + \delta_{\Delta_r} \Delta r_{t-1} + \delta_i i_{t-1} + \delta_\pi \pi_{t-1} + \delta_Y Y_{t-2} + \delta_N N_{t-2} + u_t^i \\
\pi_t &= \theta_0 + \theta_{\Delta_r} \Delta r_{t-1} + \theta_i i_{t-1} + \theta_\pi \pi_{t-1} + \theta_Y Y_{t-2} + \theta_N N_{t-2} + u_t^\pi
\end{aligned}$$

which employ two auxiliary variables. Y_t denotes real GDP growth rate and N_t denotes annual population growth. As a result, we can estimate three components $(\Delta r_t, i_t, \pi_t)$ of the fundamental value. By using estimated components, it is possible to calculate expected sum of each component and discount factor ρ. Finally, estimated expectations of each component $(\widehat{\mathcal{R}}_t, \widehat{\mathcal{I}}_t, \widehat{\Pi}_t)$ determine the estimated housing fundamental value.

Table 3: Forecast Estimation

	Δr_t	i_t	π_t
Δr_{t-1}	0.2900 ***	1.6630 *	-1.5630 *
	(5.92)	(2.47)	(-2.40)
i_{t-1}	-0.0588	0.8420	0.1190
	(-1.47)	(1.54)	(0.22)
π_{t-1}	-0.0569	-0.1150	1.0780
	(-1.38)	(-0.20)	(1.96)
Y_{t-2}	0.0026**	0.0278*	-0.0266*
	(2.99)	(2.36)	(-2.33)
N_{t-2}	4.5930 *	0.4420	-0.4160
	(2.25)	(1.57)	(-1.53)
Constant	0.0016	-0.0604	0.0622
	(0.16)	(-0.45)	(0.47)
Observations	400	400	400

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

From the forecast equation, it is possible to how estimated expectation components on estimated price-rent ratio contributes to the fundamental value . Figure 3 shows that high volatility in real rent growth ($\widehat{\mathcal{R}}_t$) but which is small change compared to other two components. In figure 3, real GDP growth used in the VAR approach is graphed as well. Real GDP growth in 1997 and 2008 shows a sharp decrease, caused by the economic crisis. Figure 4 illustrates expected market fundamentals $\widehat{pr_t}^f$ (solid line) onto the fundament price-rent ratio pr_t (dotted lines). Also, the discrepancy, which is the residuals of the estimated fundamental value, shows an increasing trend. From now, discrepancy will be called bubble term b_t since the discrepancy term is the gap between expected fundamental value and original price-rent ratio. Bubble term shows decreasing trend until 1996 and exhibits a high and sudden decrease in 1997. Until the mid-2000s, it follows an increasing trend and shows another sudden decrease in 2008 and 2019. The first and second sudden decreases can be related to macroeconomic shock. As a common trend, bubble term has an increasing trend since 2000 and a dramatic decrease in some several time periods. Then, bubble term accounts for 20% of actual price-rent ratio nowadays and more than 20% of expected market fundamentals.

Figure 3: Variables used in the VAR approach

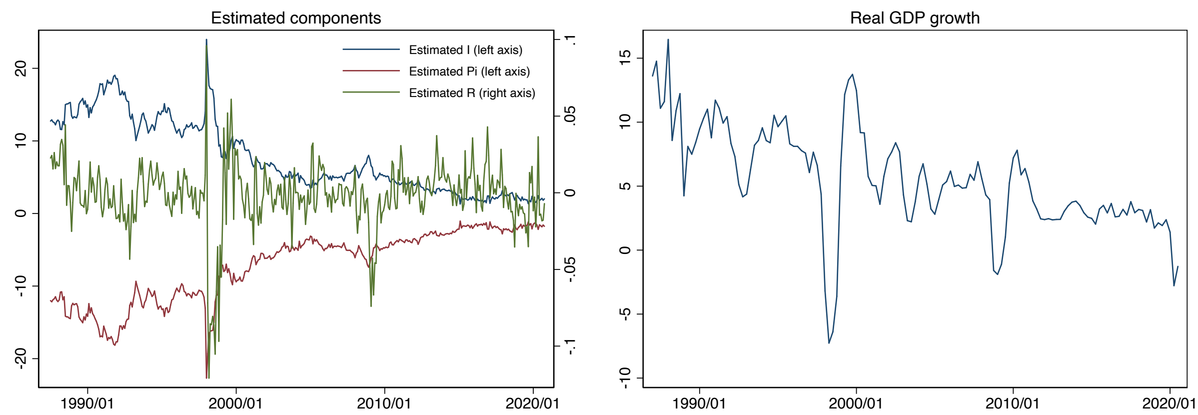
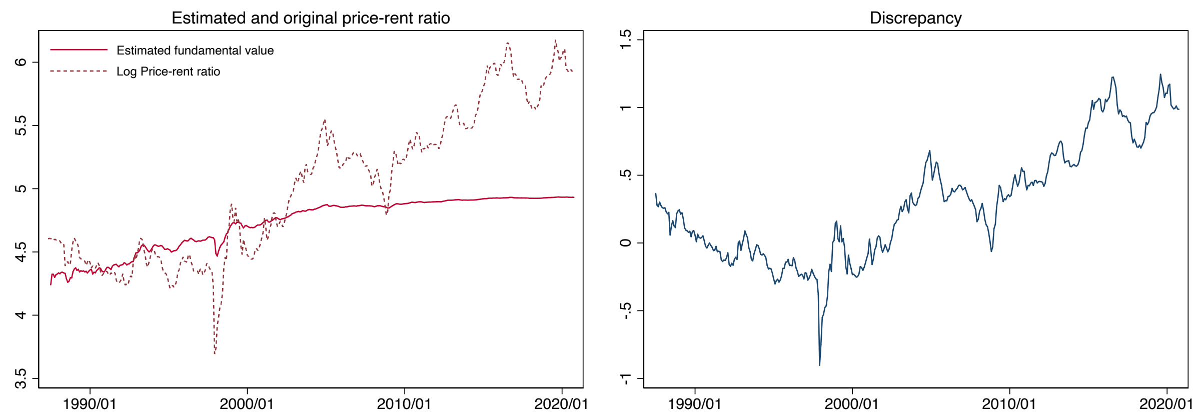


Figure 4: Estimated fundamental value



Using equation (6), variance of price-rent ratio will decompose into

$$var(\widehat{pr_t}^f) = var(\widehat{\mathcal{R}}_t) + var(\widehat{\mathcal{I}}_t) + var(\widehat{\Pi}_t) - 2cov(\widehat{\mathcal{R}}_t, \widehat{\mathcal{I}}_t) - 2cov(\widehat{\mathcal{R}}_t, \widehat{\Pi}_t) + 2cov(\widehat{\mathcal{I}}_t, \widehat{\Pi}_t).$$

Table 4 shows the decomposition of variance in each component by extending the national data to regional. All the raw data include rent or buying rice data of 7 representative cities in South Korea. As a common trend, a variance of risk-free interest rate share is the highest among the three components of fundamental value.

Table 4: Decompsition of Variance

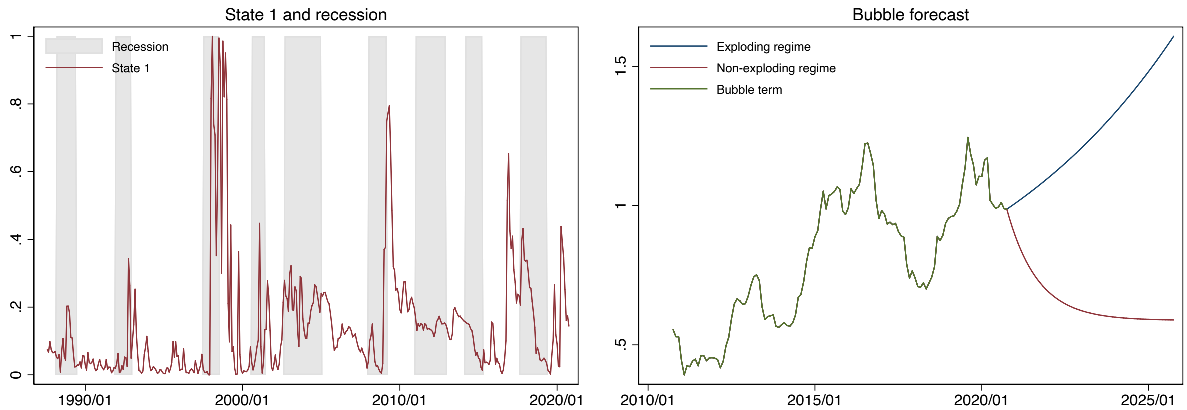
	Variance		Variance Shares			Covariance Shares		
	pr	$\hat{pr}^f$	$\widehat{\mathcal{I}}_t$	$\widehat{\mathcal{R}}_t$	$\widehat{\Pi}_t$	$(\widehat{\mathcal{R}}_t, \widehat{\mathcal{I}}_t)$	$(\widehat{\mathcal{R}}_t, \widehat{\Pi}_t)$	$(\widehat{\mathcal{I}}_t, \widehat{\Pi}_t)$
South Korea	0.3449	0.0434	15.0396	0.0001	13.4849	0.0021	-0.0019	-14.2404
Seoul	0.4343	0.0494	15.7878	0.0001	14.0963	0.0008	-0.0007	-14.9172
Busan	0.3718	0.0384	16.9323	0.0001	15.3922	-0.0024	0.0025	-16.1431
Daegu	0.3414	0.0410	15.8439	0.0001	14.2969	-0.0033	0.0032	-15.0500
Incheon	0.3223	0.0452	13.9491	0.0001	12.4224	0.0040	-0.0037	-13.1629
Gwangju	0.3258	0.0424	15.6090	0.0001	14.0488	-0.0343	0.0033	-14.8078
Daejeon	0.2902	0.0447	12.3443	0.0000	10.9186	0.0023	-0.0022	-11.6090
Ulsan	0.4027	0.0425	16.2126	0.0001	14.6123	0.0003	-0.0002	-15.3912

Table 5 shows the Markov-switching model results. The non-exploding regime is expected to last for $1/(1-q) = 6.95$ months and the exploding regime will last for $1/(1-p) = 43.2$ months. An exploding regime is more persistent than a non-exploding regime. This implies that it is much persistent to change the regime once the log of the price-rent ratio moves to a bubble exploding regime. Figure 5 shows the exploding regime and recession shades together. Except for two peaks of state, the probability of being in an exploding regime is aligned with the recession data from FRED. When the bubble term keeps following the non-exploding regime, we can figure out that bubble term b_t decreases at a similar bubble level in 2015. When the current bubble regime changes from non-exploding to exploding regime, AR coefficient of bubble term will be $\frac{1}{1-q}(\frac{1}{\rho} - q\psi) = 1.079$ and in the case of continuing exploding regime, AR coefficient of bubble term $\frac{1}{p}(\frac{1}{\rho} - (1-p)\psi) = 0.791$. This implies that the bubble is less explosive when it keeps being in an exploding regime, but once the bubble term changed from a non-exploding to an exploding regime, then it exhibits a sudden explosive bubble. If there is an invention to provoke bubble term to change its regime, the explosion of a bubble can be a sudden explosion.

Table 5: Bubble components

Bubble component	Estimate	Standard error
ρ	0.9934	0.0000
p	0.9768	0.0211
q	0.8561	0.1120
$\bar{b}$	0.0031	0.0034
ψ	0.9946	0.0066
$SD(\epsilon_t^b)$	0.0010	0.0560

Figure 5: Bubble term by Markov-switching model



6 Discussion

6.1 Fundamental Value

There are two prospective to analyze asset pricing. One is that asset price is determined by fundamentals and the other is that asset price is diverged from fundamentals by the existence of a bubble. It is possible to mention that not all factors of asset price can be explained by the fundamental value. In South Korea, there is a possibility that housing price is mainly contributed by bubble, not by the fundamentals nowadays. Figure 5 shows the increasing discrepancy from 2010. However, it is still important to understand fundamental values. Before analyzing how much bubble exists on price, the fundamental value of the price-rent ratio is a significant index that determines the price.

6.2 Tax and depreciation rate

There is less consideration of the tax system in the present-value model. In South Korea, there is a discussion that housing buyers tend to purchase housing not for residence, but for gaining asset capital gain or for another purpose. In 2018, the current government decided to impose up to 3.2% of the heavy gross real estate tax for those who own two or more houses in a controlled area. Also, the tax policy is related to the monetary policy as well. Jang et al. (2020)

) suggest that regulation policy has effectively restrained the booming trend of housing prices in South Korea. However, there is still controversy whether the tax system directly influences the real return on house. Campbell et al. (2009) does not consider depreciation expenses because it does not affect any of their main results but literature also allows that depreciation expenses can shift the average level of returns. Also, literature does not account for tax as well.

7 Conclusion

From the present value model, the gross real return on housing can be expressed with real house price and real rent payment. Then, by using Campbell-Shiller approximation, the log of price-rent ratio is approximated into a log of real rent growth and a log of gross return on housing, which is possible to break down into real risk-free return and excess return. The movements in the actual price-rent ratio are decomposed into expectations of housing fundamentals such as real rent growth, risk-free interest rate, and risk premium. However, there is a deviation between housing fundamental value and actual price-rent ratio. Assuming such a deviation as a bubble, actual price-rent ratio consists of housing fundamentals and bubble. To estimate expectations of housing fundamentals, this paper used the VAR approach with three components and two macro variables. Derived housing fundamentals account for a high amount of actual price-rent ratio in the 1990s but after 2010, bubble term shows an increasing trend.

After doing the VAR approach, this paper focuses on the bubble term and predicts how the bubble term changes. Under the assumption that bubble term follows a Markov switching model with two states, exploding and non-exploding state, this paper calculates the possibility of being each regime. As a result, the exploding regime is persistent with a predicted duration of 43 months compared to the non-exploding regime that lasts 7 months. Then, the AR coefficient of bubble term when it changes from non-exploding to exploding regime is higher than the case of being in the exploding regime. This implies that the bubble is less explosive when it keeps being in an exploding regime, but once the bubble term changed from a non-exploding to an exploding regime, then it exhibits a sudden explosive bubble. Also, this paper predicts how bubble term changes under two regimes. If the non-exploding regime continues, the level of the bubble will decrease to the level of 2014-2015. However, if the exploding regime continues, the bubble term will be 1.5 times higher than the bubble term in 2010.

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