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Housing Price Convergence in Korea: Do Purchase Price and Jeonse Price Have in Common?*

Young Se Kim**

Using panels of housing purchase price and jeonse price, I investigate house price convergence in Korea. This study is to analyze mainly two important issues. First, I test whether the house prices are converging over time. For any type of the house prices, purchase price and jeonse price, I find there is little evidence of overall house price convergence. Next, I employ a clustering algorithm to examine the existence of a convergence club where the cross-sectional variation within a subgroup decreases over time. The results support that there is strong evidence of multiple convergence clubs. Despite the fact that national house purchase price and jeonse price share similar time-series properties, the club convergence results suggest that there exist differences in cross-sectional properties between purchase price and jeonse price.

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** School of Economics, Sungkyunkwan University.

1. INTRODUCTION

This paper studies housing price convergence in panels of house purchase price and jeonse price in Korea. Ample empirical studies continue to explain regional differences and convergence of housing prices elsewhere, such as the United Kingdom (Ashworth and Parker, 1997; Meen and Andrew, 1998; Holmes, 2007) and the United States (Gallin, 2006; Clark and Coggin, 2009; Kim and Rous, 2010), among others. Nevertheless, these long-term housing price dynamics have not been extensively studied in Korea, despite its importance to policymakers and financial institutions. As a consequence, how regional house prices behave in relation to each other over time in Korea's housing market is not well established.

The importance of understanding housing price movement can be highlighted by the observation that during the late 1990s and the early 2000s, the abnormal fall and surge in housing prices experienced in Korea did not follow a consistent pattern across cities in Korea. Meanwhile, researchers have suspected that the purchase price and the jeonse price have much in common in terms of their dynamic behavior. Recently, Korea's housing market experiences soaring the jeonse prices nationally whereas the purchase prices remain stable. This motivate us to study potential differences in their cross-sectional properties in the context of housing price convergence. In addition, there is a rapidly growing literature studies the importance of the relationship between housing prices and key macroeconomic variables.[1)]

Before proceeding further, it is essential to introduce the fundamental economic theory behind housing prices. At its most basic, housing prices are believed to derive from the process of spatial equilibrium.[2)] For an inter-city analysis, the primary model originally outlined by Rosen (1979) and Roback (1982) suggests that despite differing amenities across cities, the

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[1)] For an excellent survey of the interactive nexus between and among housing markets and the macroeconomy, see Leung (2004).

[2)] The spatial equilibrium is a central tenet of urban economics. To say a spatial equilibrium exists across cities is to say that equilibrium conditions for households, employers and homebuilders are all met (Glaeser, Gyourko, and Saks, 2006).

fundamentals, such as population, wages, and housing prices, will adjust so that the marginal residents of all cities receive the same utility. Were this not true, migration towards cities providing more utility causes the housing market fundamentals to adjust until migration would no longer pay off. Because theoretically it is utility that converges rather than wages, housing prices, or city amenities, there is little theoretical support for the idea that housing prices must converge. However, despite this paucity of theoretical support, there are some important reasons to discover empirically whether housing prices are indeed converging and, if so, to understand the nature and extent of that convergence.

At its most simplistic, overall convergence suggests that housing prices *i* cities are all converging to the common price in the long run. In a country as heterogeneous as Korea, such a finding is not expected. However, it would not be surprising to find club convergence, where groups of cities which share similar economic fundamentals also experience housing price convergence among the members of each convergence club.[3] Next, the ripple effect (Meen, 1999) implies that changes in house prices in one location may spread out more broadly over period of time. As a consequence, relative regional house price differentials would be expected to shrink over time.[4] Note that such an effect may be able to explain why housing prices in major satellite cities near Southern Seoul have been approaching to that of Southern Seoul.

In the present paper, I examine empirically whether house prices of major cities in Korea share a common component using panels of housing purchase price and jeonse price. In addition to overall convergence, the possibility of a convergence club that a subset of cities that have in common exhibits house

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[3] Researchers routinely document that demographic and economic variables appear to converge over time. For example, there is ample evidence on income convergence. Since income is one of the primary determinants of housing demand, it would be plausible to expect that income convergence might also imply housing price convergence.

[4] A considerable amount of empirical work on regional house prices in the U.K. has been published, including MacDonald and Taylor (1993), Alexander and Barrow (1994), and Cook (2003), among others, suggests that the ripple effect appears to exist — differences between studies stem mainly from econometric methodology and potential segmentation (Drake, 1995; Ashworth and Parker, 1997).

price convergence within its members is also explored. To summarize the main findings, according to the log *t* convergence test developed by Phillips and Sul (2007), I find that house prices for all cities considered do not converge to a common trend. Next, the applications of clustering procedure to the house price panels suggest that the house prices can be divided into multiple subgroups in which common stochastic trends are very distinctive across convergence clubs and hence the house purchase price and jeonse price both can be better characterized by a multiple-component model.

The remainder of this paper consists of four sections. The following section demonstrates that housing purchase price and housing jeonse price display almost identical systematic pattern over the long periods of time. In addition, those prices look quite similar even in the short run as they exhibit the same cyclical behavior. Section 3 describes the data and presents log *t* convergence test results for the panels of house prices in. In section 4, the possibility of house price convergence club is scrutinized and I discuss the implications of empirical findings. Section 5 concludes with a discussion of future research directions.

2. STYLIZED FACTS OF HOUSE PRICES IN KOREA

In this section, a couple of stylized facts regarding dynamic behavior of house prices in Korea are established. As a starting point, I study long-term and short-term aspects of national prices of house purchase and house jeonse. Panel A in figure 1 shows the national house purchase price (solid line) and the jeonse price (dotted line) measured by housing purchase price composite index and housing jeonse price composite index, respectively, over January 1986 to February 2011.[5)]

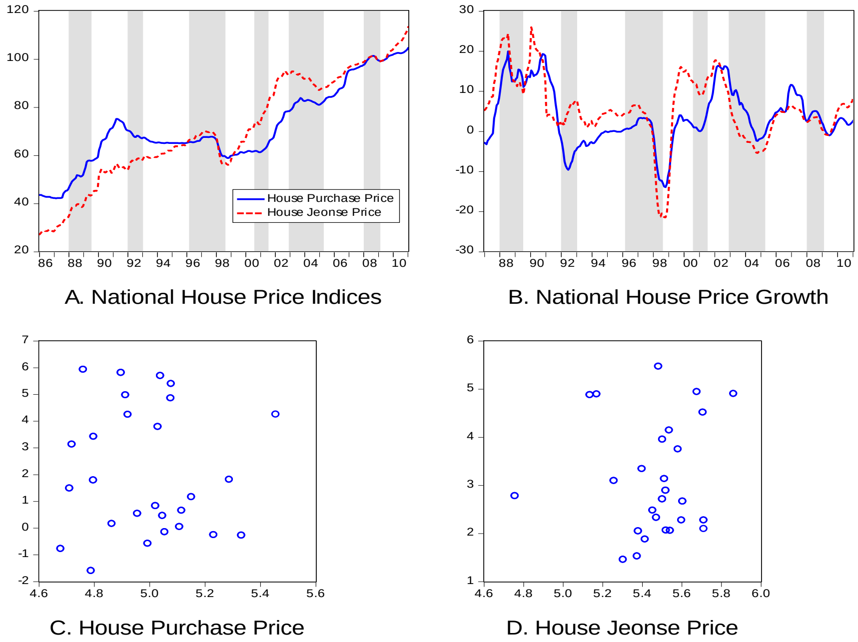
Two features of this figure are noteworthy. First, house prices have been

[5)] The house price indices are published by Kookmin Bank. See section 3.2 for a detailed discussion on the housing price indices of Korea and other data-related issues, such as base initialization problem.

substantially and persistently growing over time. House purchase price today is about 90% higher than it was in 1986. The house jeonse price has grown more rapidly during the sample period as its growth rate is about 150%. Second, although house prices rise in most times, the growth of house prices is not steady as there exist repeated periods during which house prices fall, the most striking instance being the late 1990s. That is, the annual growth in house prices averages about 3.6% for the purchase price and 5.6% for the jeonse price, but there are substantial short-term fluctuations around their averages. In Panel B, I plot percentage change of housing prices from 12 months earlier, and this cyclical patterns of house prices become much clearer. Both types of house prices are found to be highly procyclical since the shaded areas in panels A and B represent periods of recession. In addition, in recent years, 12-month changes in house prices, especially for jeonse price, have been about 3%, indicating that house prices have been fairly stable since the mid 2000s. Finally, the correlation between housing purchase price and jeonse is considerably high as the correlation coefficient is 0.909 during the sample period. In sum, in Korea, the purchase price and the jeonse price display the same systematic pattern over time and they look quite similar even in the short run because they exhibit almost identical cyclical behavior. Therefore, I conclude that house purchase price and house jeonse price in Korea have much in common in terms of their time-series properties.

I now turn to study the cross-sectional properties of housing prices in Korea. One of the most appealing aspects in panel studies for housing market is to investigate whether house prices are converging to their steady states. As the simplest case, one can assume that there exists a single common stochastic trend and examine if all individual house prices tend to converge to the common trend. Specifically, it is of interest to see whether cities with relatively low initial house prices experience faster housing price growth rates. This type of convergence, overall or ultimate convergence, can be tested by regressing the growth rate of house prices over the sample period on the initial housing prices. A negative value of the slope coefficient

Figure 1 Stylized Facts of House Prices



in the regression model would be evidence of convergence. Panels C and D in figure 1 illustrate the relationship between initial log house prices and average growth rate of house prices for some selected periods. The scatter plots suggest that the overall housing price convergence does not hold in Korea. That is, neither the purchase price nor jeonse price displays a strong negative relationship between initial housing price level and the subsequent growth rate.[6] From the visual inspection, I suspect that both types of housing prices in Korea generally are diverging, which is another common feature that the purchase and jeonse prices share.

There also exits a time-series notion of convergence, stochastic

[6] If individual cities have different determinants of steady-state housing prices, there is no reason why the long-run price levels should be the same. A subset of house prices that have similar amenities, wages and new home construction costs may see housing prices converge to their own steady states. I will look into the possibility of house price clustering later.

convergence. A number of empirical studies on house price convergence, such as MacDonald and Taylor (1993), Meen (2002), Cook (2003), Cook (2005), Holmes (2007), and Clark and Coggin (2009), have focused on this stochastic convergence to examine whether there exists a stable long-run relationship of housing prices between regions or between regions and housing prices nationally. A serious shortcoming of conventional convergence tests based on cointegration method is that, in the presence of heterogeneous transition, this type of convergence tests may or may not manifest whether convergence applies.[7] The house prices in Korea display substantial heterogeneous transitional dynamics, which I will show in section 4. Hence a new test of house price convergence that allows for cross-section heterogeneity is inevitable.

3. TESTING HOUSE PRICE CONVERGENCE IN KOREA

In this section, I begin by introducing factor models stressing the importance of individual heterogeneity. Next, house prices will be modeled as a simple nonlinear factor model that involves a time-varying idiosyncratic component and a common factor, and log *t* convergence test by Phillips and Sul (2007) is employed. Third, house price panel data sets and some data-related issues will be briefly discussed. Finally, empirical results of overall house prices in Korea will be presented.

3.1. Modeling Disaggregate House Prices and Log *t* Convergence Test

Much progress in dynamic panel regression theories together with a rapidly growing number of empirical panel data studies have addressed the importance of individual heterogeneity in panel models. In order to incorporate heterogeneous individuals into econometric modeling, factor models by Stock and Watson (2002) and Bai (2003), among others, have

[7] See Phillips and Sul (2007) for an extensive discussion on this issue.

been widely used in the literature. For example, one may consider the following equation for observed house prices in the cross section of individual cities,

$$p_{it} = p_t^c + p_{it}^o \text{ for } i = 1, \cdots, N \text{ and } t = 1, \cdots, N, \tag{1}$$

where p_{it} is log house price in the ith city at period t, p_t^c is a common component across all cities, and p_{it}^o is an idiosyncratic house price term for city i. As an important feature of equation (1), in this model, house prices are assumed to have a single common stochastic trend. Hence long-term movements in the cross section of house prices are governed by this common stochastic trend. However, the specification of a single stochastic trend in house prices is not attractive as it precludes any long-term house price divergence. Therefore, when there is a finite set of common stochastic trends underlying disaggregate house prices, the dynamics of house prices are better explained by a multi-component model, in which house prices from different subgroups have distinct persistent components. To illustrate, consider the case where a subset of house prices share a persistent component p_t^{c1}, whereas the remainder share a different persistent component p_t^{c2}. That is,

$$p_{it} = p_t^{c1} + p_{it}^o \text{ for } i \in S_1 \text{ and } p_{it} = p_t^{c2} + p_{it}^o \text{ for } i \in S_2.$$

Note that p_t^{c1} and p_t^{c2} are slow-moving and persistent components and p_{it}^o is volatile and transient, and the house prices of the two groups will diverge insomuch as $(p_t^{c1} - p_t^{c2})$ is non-zero on average. As a starting point, I consider a simple nonlinear factor model involving common and idiosyncratic components. To illustrate this, time-varying factor representation is utilized. That is,

$$p_{it} = b_{it}\lambda_t, \tag{2}$$

where λ_t is a common house price factor such as common trend component. b_{it} measures the relative share in λ_t of city *i* at time *t*. According to Phillips and Sul (2007), b_{it} in this model can be further decomposed into time-invariant mean and time-varying idiosyncratic error term as I discussed above. In order to capture heterogeneous individuals and their dynamic properties as well as a random component, bit is now assumed to take semiparametric form. That is, $b_{it} = b_i + \zeta_{it}[\sigma_i / L(t)t^{\alpha_i}]$, where ζ_{it} is i.i.d.(0, 1) across *i* but may be weakly dependent over *t*, σ_i is idiosyncratic scale parameter, and $L(t)$ is a slowly varying function, for instance $L(t)$ = log *t*. Since α measures the rate at which cross sectional variation that decays to zero over time, overall house price convergence is mainly governed by the size of α. For example, when $\alpha_i = 0$ for all *i* and $b_i = 1$, all individual house prices are converging to a common factor λ_t. On the other hand, when $\alpha_i < 0$ for some *i*, then the house prices will be are diverging over time.

For this study of house price convergence, the concept of relative convergence by Phillips and Sul (2007) is used. The relative convergence refers to the idea that, the cross-sectional dispersion of individual prices tends to decline over time.[8] That is, the relative convergence is defined as

$$\lim_{t\to\infty} \frac{\log P_{it}}{\log P_{jt}} = 1, \tag{3}$$

for all *i* and *j*. It is worth mentioning that relative convergence is a more general convergence concept since absolute convergence is interpreted as a special case. For example, relative convergence implies absolute convergence if b_{it} converges faster than the divergence rate of λ_t. On the

[8] One might attempt to consider a panel unit root test. However, given this factor model framework, an examination of house price convergence using panel unit root tests has no advantages over standard time-series unit root tests in the presence of common component having a unit root. This is because the nonstationary feature in the house prices are generated by the same univariate time series. In addition, under relative convergence, the common component diverges at the same rate regardless of the assumption concerning trend stationarity or stochastic nonstationarity in the common component.

other hand, when b_{it} converges slower than the divergence rate of λ_t, relative convergence holds, but not absolute convergence.

The composite null hypothesis of house price convergence can be written as

$$H_0 : b_i = b \text{ and } a_i \geq 0, \tag{4}$$

against the alternative hypothesis of

$$\begin{aligned} & H_A : \{b_i = b \text{ for all } i \text{ with } a_i < 0\} \\ \text{or} \quad & \{b_i \neq b \text{ for some } i \text{ with } a_i \geq 0\}. \end{aligned} \tag{5}$$

Let's define relative transition coefficient that measures the transition element for city i relative to the cross-section arithmetic mean. That is,

$$h_{it} = \frac{p_{it}}{N^{-1}\sum_{i=1}^{N} p_{it}} = \frac{b_{it}}{N^{-1}\sum_{i=1}^{N} b_{it}}. \tag{6}$$

When there is a limiting transition behavior across cities, $h_{it} = h_t$ across *i*. In particular, when there is ultimate house price convergence, $h_{it} \to h_t$ for all *i*, as $t \to \infty$.[9] Using this relative transition coefficient, Phillips and Sul (2007) utilize quadratic distance measure of

$$H_t = N^{-1}\sum_{i=1}^{N}(h_{it} - 1)^2. \tag{7}$$

Thus under the convergence, $H_t \to 0$ as $t \to \infty$ while the distance remain positive as $t \to \infty$ when house prices are diverging over time.

Under the null hypothesis, the transition distance measure H_t has the limiting form of $H_t \sim A[L(t)^2 t^{2\alpha_i}]^{-1}$ for some constant A > 0 as $t \to \infty$.

[9] Notice that, depending on its common transition behavior, house prices display overall convergence or club convergence.

Following Phillips and Sul (2007), I set $L(t) = \log\ t$ and thus the empirical log *t* regression model takes the form

$$\log\frac{H_1}{H_t} - 2\log(\log\ t) = a + \gamma\log t + \varepsilon_t,\quad \text{for}\quad t = rT,\ rT+1,\ \cdots,\ T, \qquad (8)$$

where *r* indicates that only $(1-r)$ fraction of sample should be used for the regression analysis.[10] Consequently, the null and alternative hypothesis can be transformed into

$$H_0:\ \gamma \geq 0 \text{ and } H_A:\ \gamma < 0. \qquad (9)$$

Before proceeding, let me briefly discuss some important features if the log *t* regression model. First, given the fact that $\gamma = 2\alpha$ under the null, a one-sided *t*-test of $\alpha \geq 0$ is used for the log *t* convergence test because, the point estimate of converges to zero regardless of the true value of α under the alternative hypothesis, but the corresponding *t*-statistic diverges to negative infinity. Second, the term $-2\log(\log\ t)$ plays like a penalty function. Without having this term in the regression model, under the alternative, the least squares estimator of becomes biased upward which impedes the test results in a finite sample. Lastly, heteroskedasticity and autocorrelation consistent (HAC) estimator for the covariance of must be used to compute t-statistic since this model allows that the regression errors can be serially correlated.

3.2. House Price Data

The most popular house price indices in Korea for empirical studies are house purchase composite index and house Jeonse composite index, a broad measure of the movement of house prices, and they are available from

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[10] Phillips and Sul (2007) recommend that the value of *r* can be chosen from the interval $r \in (0.2,\ 0.3)$.

Kookmin Bank (KB). Note that, undoubtedly, this house price index is not free from any potential problems in terms of the purpose and statistical methodology. A number of issues related on housing price index in Korea, see Lee (2007) and Suh (2009), among others.[11] Nonetheless, I employ this house price data set as it has been widely accepted for many studies on long-term systematic house price dynamics in Korea.

For house price panels, monthly house purchase price index and house Jeonse price index spanning from 1986:M1 through 2011:M2 are utilized. Although the KB report some higher-level classification of regions, not all house prices start from 1986. Since one need a sufficiently long time-series sample period to undertake house price convergence tests, I consider a major city panel consisting of two regions of Seoul, “Northern Seoul” and “Southern Seoul,” and 25 other major cities (N = 26).[12]

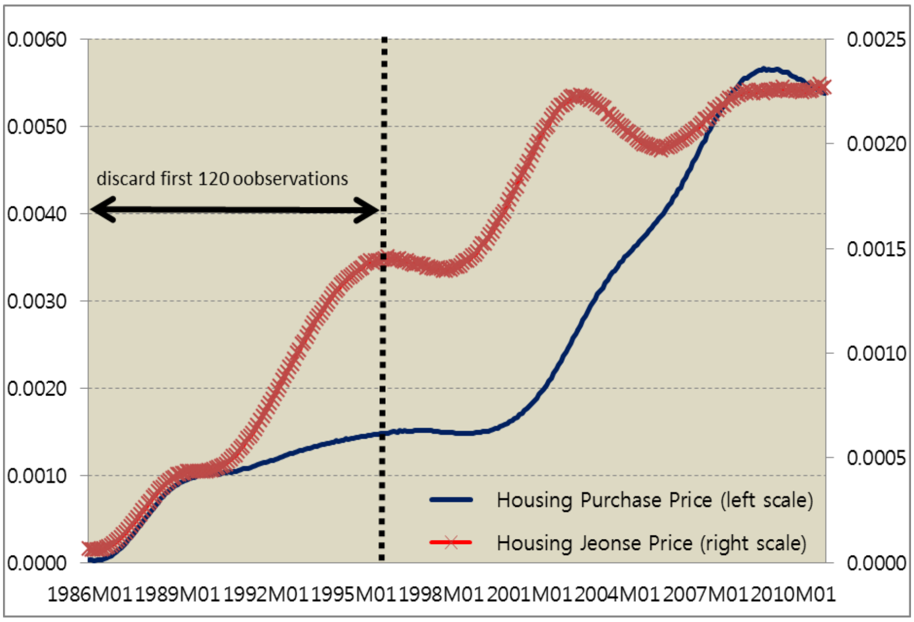
There are some important data-related issues before we test house price convergence in Korea. First of all, the house price data used in this study are indices, not actual prices. Therefore, the convergence result relies on the choice of the base year. As an example, if the last observation is set as the base year, then all house prices appear to converge to a single point.[13] The base periods of house price indices are 2008:M12. In order to avoid the initial effect associated with this base year, I set the first observation as the base period as $p_{it} = p_{it} - p_{i1}$ for $t = 1, 2, \cdots, T$ and discard some fraction of

[11] In the United States, there exist two popular house prices indices, House Price Index (HPI) from the U.S. Federal Housing Finance Agency (FHFA) and S&P/The Case-Shiller (CS) home price index. The HPI is a weighted repeat sales index by using all single-family houses whose mortgages have been purchased or securitized by Freddie Mac or Fannie Mae since 1975. The CS home price index is also a widely used house price measure in the literature and the sample begins with 1987 for 14 major metropolitan areas. For a detailed discussion of these house price indices, see Drieman and Pennington-Cross (2004), for example.

[12] 25 other major cities are Busan, Daegu, Incheon, Gwangju, Daejeon, Ulsan, Suwon, Seongnam, Anyang, Bucheon, Gwangmyeong, Ansan, Chuncheon, Wonju, Cheongju, Chungju, Cheonan, Jeonju, Iksan-si, Mokpo, Suncheon, Pohang, Gumi, Masan, and Changwon.

[13] Ray and Ray (2009) study stability of U.S. housing prices using S&P/Case-Shiller (CS) home price index for 14 major cities. Since the original CS data use 2000:M1 as the base year, all house price indices are 100. However, Ray and Ray mistakenly interpret this as evidence of house price convergence.

Figure 2 Cross-sectional Variance of House Prices (H_t) and Base-year Initialization Effect



Note: This figure plots quadratic distance measure of relative transition curves, $H_t = N^{-1}\sum_{i=1}^{N}(h_{it}-1)^2$, where $h_{it} = p_{it} / (N^{-1}\sum_{i=1}^{N} p_{it})$ and p_{it} is the Hodrick-Prescott trend of log house price index for city i at time t, using panels of Korea's house purchase price (left scale) and house jeonse price (right scale) from 1986:M1 through 2011:M2.

sample from the beginning to overcome initial effects as suggested by Phillips and Sul (2007). For example, figure 2 presents the quadratic distance measure of (7) for purchase price and jeonse price panels. The Ht diverge from the beginning of the sample, but the base year initialization effect seems to disappear around late 1995. Consequently, I discard the first 40% of the sample from 302 time-series observations in the panels and work with 182 time-series observations spanning from 1996:M1 to 2011:M2. Next, I take Hodrick and Prescott (1997) trend of house prices from the original house price data since the elimination of the cyclical components of the data improves the finite sample power and size of the test as suggested by Phillips and Sul (2007).

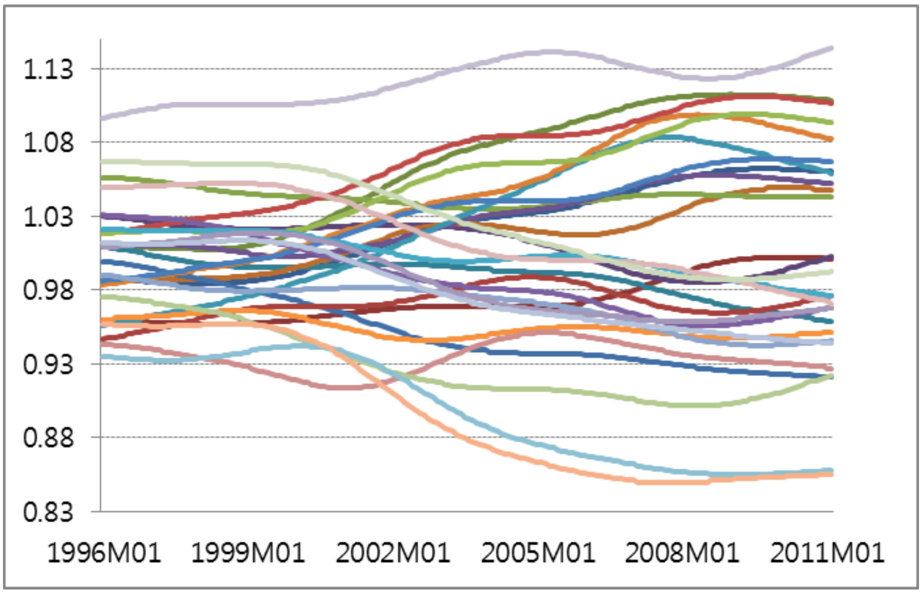
3.3. Empirical Results

Before applying a formal econometric technique to house price convergence, it is useful to illustrate the behavior of relative transition curves displaying transitional and convergence behavior over time in relation to the common factor. For example, figure 3 presents relative transition curves, h_{it}, for 26 major cities.[14] First, as is apparent in figure 3, a variety of different transitional patterns are found across major cities in Korea. This clearly suggests cross-sectional and time-series heterogeneity in Korea's house price data, which supports the use of relative convergence in this study because conventional convergence tests based on homogeneity may inappropriately imply the convergence holds. More importantly, $h_{it}s$ do not show a remarkable reduction in dispersion of the transition curves over the sample period. Note that in the case of ultimate convergence, $h_{it} \rightarrow 1$, for all *i*, as $t \rightarrow \infty$. Form this visual inspection, I conclude that house prices in Korea exhibit substantial heterogeneity in their transitions and there is little evidence of relative house price convergence as the cross-sectional variances of house prices, purchase prices and jeonse prices, tend to increase over time.

Next, I apply a more formal econometric tool, the log *t* test, for house purchase price (Panel I) and for house jeonse price (Panel II). The convergence test results for $r \in (0.15, 0.35)$ are resented in table 1. Despite the fact that *t*-statistics for slope coefficients of the log *t* regression, which are computed using an automated HAC procedure, are found to be quite sensitive to the choice of *r* value, the slope coefficient estimates are consistently negative $(\hat{r} < 0)$ and the corresponding *t*-ratios for slope coefficients in log *t* regression are so large as to readily reject the null hypothesis (9) even at the 1% level. As a result, I surmise that, for any type of house prices, there is no sign of house price convergence among 26 major cities in Korea, which confirms earlier findings from the relative transitions

[14] A similar pattern is also found in house jeonse panel. I did not report hit for the jeonse prices to conserve on space (available from the author upon request).

Figure 3 Relative Transition Curves (hit)



Note: This figure plots relative transition curves, hit, using a panel of house purchase price composite indices for 26 major cities in Korea from 1996:M1 through 2011:M12.

Table 1 Log-*t* Regression Results: House Price Panels in Korea

First Observation in Log *t* Regression							
	1998:M3 (r=0.15)	1998:M8 (r=0.18)	1998:M12 (r=0.20)	1999:M9 (r=0.25)	2000:M6 (r=0.30)	2000:M10 (r=0.32)	2001:M3 (r=0.35)
Panel I: House Purchase Price							
$\hat{\gamma}$	–1.41	–1.45	–1.49	–1.53	–1.53	–1.51	–1.48
t-ratio	–34.32	–77.61	–298.92	–36.39	–29.32	–33.17	–42.95
Panel II: House Jeonse Price							
$\hat{\gamma}$	–0.71	–0.68	–0.66	–0.6	-0.54	–0.51	–0.49
t-ratio	–73.21	–39.18	–29.19	–27.75	–38.85	–43.49	–98.46

curves. Thus, there is no significant difference in long-run behavior between purchase prices and jeonse prices in the context of house price convergence as found in the previous section.

4. HOUSE PRICE CONVERGENCE CLUB CLASSIFICATIONS

The fact that there is no statistical evidence that house prices are converging nationally does not necessarily imply members in a subgroup of major cities do not share a common factor. In this section, I explore the possibility that house prices are converging to their own steady states within subgroups in Korea by employing clustering algorithm based on Phillips and Sul (2007) that includes the stepwise application of log t regression tests as the regression has a discriminatory power against club convergence alternatives.[15] By analyzing subgroup-convergent behavior, one may locate the sources of divergence in the entire panel. It is also clearly of interest to examine the characteristics in each convergence clubs and divergence subgroups.[16] As I discussed in the previous section, the dynamic behavior of individual house price is subject to the time-varying factor loadings bit in (2). There exists a possibility that a subgroup of house prices, S_k for $k = 1, \cdots, K$, where K is the number of convergence clubs, may demonstrate convergence to a common factor depending on the dynamic behavior of b_{it}. That is, the alternative hypothesis of (5) includes overall divergence as well as a set of club convergence.

4.1. House Purchase Price

Table 2 reports club convergence results from applying the clustering

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15) This test is explicitly designed for panel data sets with a large cross section of trending time-series, thereby circumventing the curse of dimensionality problem that afflicts traditional methods in the large cross section framework.

16) However, this analysis is well beyond the scope of the current paper. For the further details about the clustering algorithm, see Phillips and Sul (2007).

Table 2 Convergence Club Classification: House Purchase Price

Club	$\hat{\gamma}$	*t*-ratio	Member Cities
Club 1 [8]	0.419	18.396	Southern Seoul, Suwon, Seongnam, Anyang, Bucheon, Gwangmyeong, Ansan, Changwon
Club 2 [3]	0.443	32.117	Northern Seoul, Incheon, Ulsan
Club 3 [14]	0.413	91.822	Busan, Daegu, Gwangju, Daejeon, Chuncheon, Wonju, Cheongju, Chungju, Cheonan, Jeonju Iksan-si, Pohang, Gumi, Masan
Club 4 [2]	0.741	0.47	Mokpo, Suncheon

Note: Entries in square brackets represent the number of states in a convergence club.

algorithm to the house purchase price panel of 27 major cities in Korea. I found 4 convergence clubs and none of house purchase prices appears to diverge from a common house purchase price. The fitted log *t* regression slope coefficients are all significantly positive and hence this suggests strong empirical support for the presence of club convergence.[17] Club 1 consists of a group of 8 cities that are Southern Seoul and all satellite cities located near Southern Seoul, except for Changwon.[18] Clubs 2 is a relatively small group of 3 major areas, Northern Seoul, Incheon, and Ulsan. Club 3 encompasses most metropolitan areas and their satellite cities. Finally, the members of club 4 are two major cities in Jeollanam-do, which is a province

[17] Phillips and Sul (2007) point out that their clustering mechanism is to be excessively conservative for convergence club determination. To overcome this issue, Phillips and Sul (2009) suggest utilizing a series of club merging tests to examine whether any of the initial subgroups can be merged to form a larger size of convergence club. Following their recommendation, I carry out the club merging tests by considering adjacent subgroups in the initial classification. I found none of initial convergence clubs merges to any convergence club since all slope coefficients are significantly negative at 1% level. The same result is obtained for house jeonse price.

[18] There appears to be a weak form of ripple effect in southern areas of Seoul. It might come to a surprise that the purchase price of Changwon tends to share a common trend with the purchase prices of other member cities in club 1. However, in every respect, Changwon is known to be one of the most rapidly growing cities. Per capita income and population have been growing hastily, which result in substantial increase in housing demand, whereas regulations on land and construction have been relatively strictly enforced.

in the southwest of Korea, Mokpo and Suncheon. It is worth pointing out that the clustering results are not based entirely on geographic neighboring since member cities in a convergence club are not all contiguous, while there appears a weak form of ripple effect among member cities within a convergence club, especially for clubs 1 and 4.[19)]

Some important features of the house purchase price panel come forth from this clustering analysis. Most of all, multiple common house purchase prices measured as arithmetic mean of log purchase price indices exhibit distinctive patterns across convergence clubs as is apparent in figure 4. Therefore, when there is a finite set of common stochastic trends underlying disaggregate house prices, the dynamics of house prices are better characterized by a multi-component model, in which house prices from different clubs have distinct persistent components.[20)] Notice that member cities in both club 2 and 3 tend to share a common stochastic trend until the early 2000s and the house purchase prices for club 2 begin to be driven by a different common factor. Next, relative transition curves $h_{it}^{k} = p_{it}^{k} / (N_{k}^{-1} \sum_{i=1}^{N^k} p_{it}^{k})$ for each convergence club S_k for $k = 1, \cdots, 4$, where N_k be the number of member cities in subgroup k are calculated. For example, figure 5 plots transition paths for member cities in club 3 and there is a marked reduction in dispersion of cross sectional variance as the transition paths tend to converge to unity over the sample period, which is not recognizable for the case of entire cross-sectional sample as in figure 3. Lastly, there are some evident heterogeneous transitional dynamics of house purchase prices.[21)] In figure 5, the relative transition paths for member cities in club 3 tend to narrow toward unity over time but transitional manners are very different across individual cities. For instance, Masan and Daejeon have substantially different initializations but their relative transition curves

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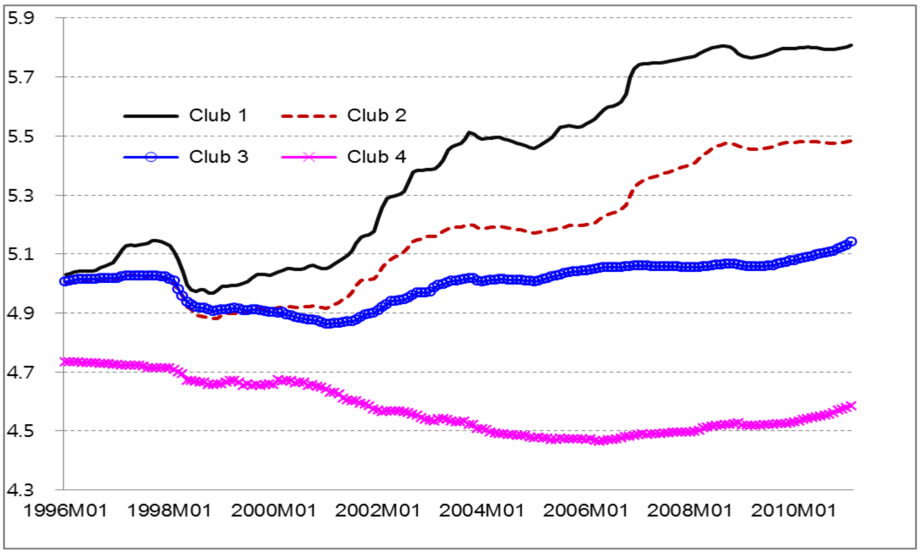
19) This finding is in line with Pollakowski and Ray (1997) who show that the spatial house price relationship in contiguous regions is not necessarily stronger than that in noncontiguous regions.

20) A considerable shortcoming of traditional measures of house price changes is that they are not robust in the presence of multiple components because the measures become systematically biased over longer time interval.

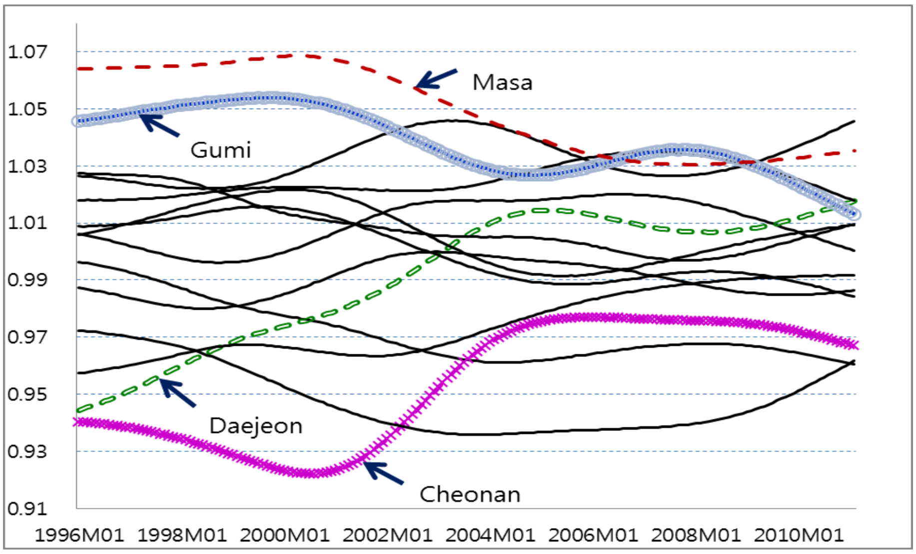
21) For various forms of transitional divergence and convergence, see Phillips and Sul (2009).

Figure 4 Common House Purchase Prices



Note: This figure plots arithmetic mean of log house purchase price indices for each convergence club.

Figure 5 Transition Paths (hit) for Member Cities in Club 3



tend to converge to unity. The dynamic path for Masan involves transition from a high initial state whereas path for Daejeon involves transition from a low initial state. In addition, some cities such as Gumi and Cheonan that have similar initial state with other club members, but their relative transition involves an initial phase of divergence from the club, followed by a catch-up period and later convergence.

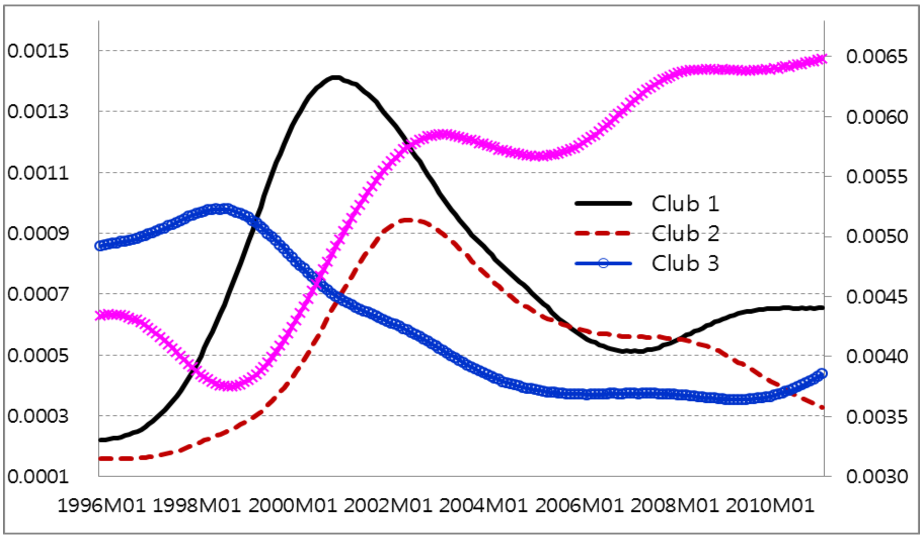
4.2. House Jeonse Price

I also study the existence of city-level housing jeonse price convergence clubs in Korea. The clustering procedure is also utilized for the jeonse price panel and, after a series of club-merging tests, I found 3 convergence clubs and one subgroup consisting of diverging cities. Table 3 lists the estimated club membership. For all convergence clubs, clubs 1, 2, and 3, I was not able to reject the null hypothesis of house jeonse price convergence as $\hat{\gamma}$ for each club is significantly positive. This convergence behavior is also evident by inspecting cross-sectional variance of jeonse prices, which is illustrated in figure 6. Although a cross-sectional variance of relative transition curves h_{it}^{k} for each convergence club S_k for $k = 1, \cdots, 3,$

$$H_t^k = N_k^{-1} \sum_{i=1}^{N} (h_{it}^k - 1)^2, \tag{10}$$

exhibits a transient surge around financial crisis in the late 1990s, in general, each quadratic distance measure tends to decline over time. On the other hand, for a set of diverging cities labeled Group 4, log t convergence test rejects the null of convergence among the cities even at 0.1% significance level. This is indubitably noticeable in the data. The cross-sectional variance of relative transition curves for Group 4 shown in figure 6 is ever increasing for almost entire sample period. All other dynamic properties of house purchase prices are also observed in the panel of house jeonse prices. That is, while there are apparent heterogeneous transitional dynamics of house jeonse prices in each convergence club, the dispersion of cross sectional

Figure 6　Cross-sectional Variance of Log House Jeonse Prices



Note: This figure plots cross-sectional variance of log house jeonse prices for each convergence club (left scale) and a group of diverging cities labeled Group 4 (right scale).

variances for each convergent club decreases over time, which implies that prices within a club converge toward a common house jeonse price in the long run.

The overall convergence tests and clustering analysis for house prices in Korea suggest that purchase prices and jeonse prices have much in common over the sample period, in so far as one can draw conclusions that neither of those house prices display overall convergence and the house prices both can be better characterized by a multiple-component model. Notwithstanding their common features, one can readily find differences in cross sectional properties that may have enormously important implications on public policies about housing markets in Korea. First, as I discussed earlier, there exist a considerable number of cities that exhibit divergent house jeonse price from any of present common stochastic trends. Thus, any government policy aimed to control jeonse prices must be implemented differently depending on their convergence manners. Second, according to the club

Table 3 Convergence Club Classification: House Jeonse Prices

Club	$\hat{\gamma}$	*t*-ratio	Member Cities
Club 1 [5]	0.459	16.003	Incheon, Suwon, Anyang, Bucheon, Cheonan
Club 2 [5]	0.244	1.892	Southern Seoul, Ulsan, Gwangmyeong, Wonju, Jeonju
Club 3 [12]	0.179	2.147	Northern Seoul, Busan, Gwangju, Daejeon, Seongnam, Chuncheon, Cheongju, Chungju, Iksan-si, Gumi, Masan, Changwon
Club 4 [5]	–0.644	–50.94*	Daegu, Ansan, Mokpo, Suncheon, Pohang

Note: Entries in square brackets represent the number of states in a convergence club. * denotes tatistical significance at 1% level under the null hypothesis of convergence.

convergence results, when the government ought to invoke regulations on housing market environment, it must make a distinction between house purchase market and house jeonse market. As is apparent in table 3, member cities in a convergence club for the jeonse prices are not quite consistent with those for the purchase prices. The first convergence club consists of cities located near Seoul that have experienced a large population inflows. Club 2 includes 5 somewhat heterogeneous cities in terms of their geographical locations. Clubs 3 is a relatively large group of 12 major cities other than Southern Seoul.[22) It is worthy of mentioning that two major cities in Jeollanam-do included in the house price panel, Mokpo and Suncheon, are entered in both relatively low purchase price and jeonse price groups.

4.3. Discussion

So far, I showed that the clustering mechanism successfully discovers multiple common components for each type of house prices in Korea,

22) Note that it is very interesting that whereas Changwon is found to be one of club members with relatively high house purchase price, its jeonse price appears to converge to cities with relatively low jeonse prices.

purchase price and jeonse price. A naive strategy detecting forces that drive the club convergence is to study whether some often considered house price determinants have discriminatory power in grouping individual house prices in terms of their convergent behavior. A number of theoretical and empirical studies have put forth various factors that determine house prices. While people disagree about how best to explain the long-run behavior of house prices, an accepted conclusion is house prices are determined to a large extent by economic fundamentals. Even though careful scrutiny of club determinants is well beyond the scope of the current paper mainly due to the availability of data, in this subsection, I briefly discuss how to proceed to uncover major factors driving multiple convergence clubs for future research.

In most cases, housing price dynamics are modeled in terms of factors shifting demand and supply in housing market. First, for the demand shifting factors, household income, financial wealth, market interest rate on housing loans, population, geographic location or neighborhood, education, and other socioeconomic factors are typically taken (Gabriel and Rosenthal, 1989; Haurin and Brasington, 1996; Downes and Zabel, 2002; Meen, 2002; Gallin, 2006; Kiel and Zabel, 2008; Mikhed and Zemcik, 2009).[23)] Next, notable supply shifters are construction costs including labor costs and raw materials and housing or land regulations impeding new housing construction (Malpezzi, 1996, 1999; Lum, 2002; Saks, 2008).[24)] In order to examine whether differences in demand and supply factors across individual cities can be attributed to overall house price divergence or possible club convergence, one first constructs a set of subgroups based on the shifting factors. Then, the log-*t* convergence test for each of the arbitrarily constructed subgroups

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[23)] Of these demand factors, household income is probably the most extensively used in empirical studies.

[24)] As discussed by Glaeser, Gyourko, and Saks (2006), housing supply is the primary determinant of urban growth through its effect on labor supply. In areas with an elastic supply house prices need not rise significantly to create a large expansion in new housing. On the other hand, in cities with inelastic housing supply because of natural or regulatory constraints, housing prices will have to rise much more to facilitate the construction of new housing. Thus, any positive labor demand shocks result in a higher demand for and price of housing and the magnitude of the change is largely determined by the elasticity of housing supply.

can be applied to find a convergence club.[25)]

Alternatively, for further research, one may analyze a more complex interaction between potentially important determinants of house prices and club membership by utilizing a multinomial logit model predicting how city characteristics consistent with a spatial equilibrium model impinge on the likelihood that any given city would be found to be a member of each convergence club.[26)]

5. CONCLUSION

In this study, I have documented that major cities in Korea do not share a common stochastic trend overall, but there exist subgroups of the cities that appear to be converging to their own common housing prices whereas the theoretical model explaining housing price differences across cities does not predict housing price convergence clusters. That convergence clubs for housing purchase price do not align with those for housing jeonse price is also noteworthy. Although the overall convergence tests and clustering analysis for house prices in Korea suggest that purchase prices and jeonse prices have much in common over the sample period, there exist significant differences in cross-sectional properties. This suggests that when the government ought to invoke regulations on housing market environment, it must make a distinction between house purchase market and house jeonse market. In addition, any government policy aimed to control jeonse prices must be implemented differently depending on their convergence manners.

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25) Using panels of U.S. states and metropolitan areas, Kim and Rous (2010) examined the general characteristics of differing convergence clubs by employing some traditionally considered shift determinants, such as income and construction costs. However, in spite their importance in determining housing prices, they found that heterogeneous common house prices are not entirely attributed to differences in demand and supply shifting factors as the log-*t* test results show that there is no single subgroup that displays convergent behavior.

26) Kim and Rous (2010) employed this approach and their estimates of multinomial logit model suggest that housing supply regulation together with climate are major sources of diverging house prices in the United States.

The empirical results of this paper suggest productive extensions in a number of directions. First, researchers understandably often analyze housing markets at the regional level. However, the use of traditional economic regions based mainly on geographical location may not be appropriate. If groupings are to be made, defining housing markets by convergence club membership may result in more efficient results. Next, the general characteristics of convergent and divergent subgroups as well as possible factors driving the convergence clubs should prove useful. For instance, Glaeser, Gyourko, and Saks (2006) who show that housing supply is a primary determinant of urban growth through its effect on labor supply. Thus it would be interesting to examine the extent to which the housing supply elasticity in individual cities along with differential changes in labor demand and supply can explain housing price club membership.

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