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The dynamic effect of population ageing on house prices: evidence from Korea

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ABSTRACT
This study empirically analyses how population ageing affects house price using sample data of six metropolitan cities and seven provinces of Korea over the time period from 1990 to 2014. Panel regression results show that economic and demographic factors such as real GRDP per capita and the dependency ratio affect real house prices significantly. However, total population is not statistically significant. House price in regional market is inversely correlated with the dependency ratio, but positively correlated with GRDP per capita in each region. From these results, it can be estimated that the house price will decline by 3–12% in 2020, and more than 20% in 2030. The headwinds are the largest for provinces where ageing is very fast such as Jeonnam and Gyeongbuk – less urbanized and industrialized regions compared to other regions in Korea.

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Introduction

Future house price is inevitably a great concern for existing home owners and potential home buyers as well as investors. According to the life cycle hypothesis of Ando and Modigliani (1963), people buy houses during their working age and sell them in their old age. Therefore, if the relative proportion of old age compared to working age increases, then house prices may come under pressure. According to the United Nations (2015), the number of people aged 60 and above is expected to more than double by 2050 and more than triple by 2100. In Korea, the Korea Statistical Office (2015) predicts that the ratio of people aged 65 and above to the total population will be 13.5% by 2016 and is expected to increase rapidly thereafter to 24.3 and 37.4% by 2030 and 2050, respectively. Meanwhile, the total population of Korea will increase slightly over the next 15 years from 51 million in 2015 to 52 million in 2030, but will subsequently decrease to 50 million in 2045.

The time taken to shift to the aged society is said to be 73 years in the US and 24 years in Japan. However, it is said to be 18 years in Korea, whose ageing speed is faster than any other developed countries.[1] Moreover, as its baby boomer generations born between1955 and 1963 have already reached or are almost approaching their old age, the ageing rate of Korea will significantly rise in the near future.

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In countries like Korea where real estate accounts for a huge chunk of household assets, the future price meltdown as argued may result in a bigger spillover effect.[2]

The effects of ageing on the housing market have been an important research field since the paper of Mankiw and Weil (1989). In his study of 22 OECD countries, Takats (2012) estimated that the Korean housing market is gradually approaching a housing price meltdown. Our research is basically in line with his study. But unlike his study, we venture to use regional data rather than national to get more precise empirical results of the effects of demography on house price since housing markets are, by nature, not national but local. We also extend the analysis period to 2014.

Our major contributions to the existing literature can be as follows:

First, we estimate long-run relationships among our main variables using the regional panel error correction model. Second, by multiplying coefficients of dependency variables in each region with differences of dependency ratios between two points of time, we estimate both historic and projected ageing impact for each region in Korea.

The remainder of this paper is organized as follows:

The second section reviews previous literature. The third one on the other hand introduces a theoretical model to derive key house price drivers and then describes data-set. The fourth presents the empirical results and discusses estimates of future house prices on a regional basis while the final section concludes.

Literature review

Whether population ageing puts downward or upward pressure on house price has become a frequent topic for debates and researches. But the results appear to vary depending on the methodologies and the periods of various studies. Research on the relationship between ageing and house prices was first conducted by Mankiw and Weil (1989), which argues that US housing demand would peak in the 1980s due to the baby boomer generation. They predict that house prices will subsequently decline by 47% in real terms by 2007 when the baby boomers start to retire. Ermisch (1996) finds that a change in the age distribution of the population has important effects on aggregate housing demand in UK over the period from 1988 to 1989. Levin, Montagnoli, and Wright (2009) examine the impact of demographic change on the housing market. Their analysis suggests that population decline and population ageing all together put downward pressure on house prices. Likewise, Guest and Swift (2010) find that the ageing of the population may cause average real house prices to be between 3 and 27% lower than they otherwise would be over the period from 2008 to 2050 in Australia. Meanwhile, Saita, Shimizu, and Watanabe (2013) confirm that population ageing may cause average real housing price to decrease by 2.4% per year during the period from 2012 to 2040 in Japan. Hiller and Lerbs (2016) also derive a similar result using data of 87 German cities over the period from 1995 to 2014. They find that real urban house price appreciation tends to be substantially lower in cities that age more rapidly and that population ageing has heterogeneous effects across housing segments: sale price growth of condominiums and single-family homes is negatively related to stronger growth of the old-age dependency ratio, while a positive association is found for ageing and real rent growth.

Arestis and Gonzalez-Martinez (2017) find that while ageing has a significant negative impact on house prices in Ireland, Spain, Australia and Japan, it is not significant in 13 other OECD countries like the USA and UK. Takats (2012) empirically tests the relationship between demographic changes and house prices using panel data of 22 OECD countries, showing a statistically significant correlation between the two. His analysis finds that in the next 40 years, ageing will decrease house prices on the average by around 80 basis points per annum compared to neutral demographics. He argues that the headwinds are the largest for Korea where ageing speed is very fast, estimating that Korean house prices will decrease by 2.5% per annum. From this result, he adds that the Korean housing market comes close to an asset price meltdown as already estimated by Mankiw and Weil (1989).

However, other researchers suggest that demographic changes and house prices do not have a statistically significant correlation. Eichholtz and Lindenthal (2014) examine how housing demand depends on age and other demographic characteristics based on a detailed cross-sectional survey of English households from 1971 to 2001.They find that housing demand is significantly determined by a household's human capital and that housing demand generally increases with age.

In the case of Japan, Ohtake and Shintani (1996) find that demographic changes have effects on house price fluctuations in the short term, but that in the long term, demographic factors do not affect house prices as housing supply decreases in response to a decrease in demand. A similar result is reported by Shimizu and Watanabe (2010) and Nakamura, Saita, Sekeine, and Tachibana (2004).

Engelhardt and Poterba (1991) examine the links between demography-induced changes in housing demand and real house prices using postwar data for Canada. They find a statistically insignificant and, in most cases, negative association between demographic demand and house prices. Green and Hendershott (1996) measure the impact of the age structure, education and income on the willingness of households to pay for a constant-quality house using 1980 US census data. They argue that holding all else constant, the demand for housing tends to be flat or rise slightly with age. In addition, they contend that since much is in fact held constant over the life-cycle, the ageing of the population should not be expected to lower real house prices. Hendershott (1991) and Berg (1996), Bodman and Crosby (2004), Otto (2007) and Chen, Gibb, Leishman, and Wright (2012) find little demographic impact on house prices, while Hort (1998) finds a positive ageing impact on house prices.

As for Korea, Kim (1999) finds that housing demand is the highest for ages ranging from 44 to 48 and indicates that housing supply is more significant than housing demand in determining house prices. Chung and Cho (2005) estimate a modified version of the Mankiw and Weil model (1989) and forecast long-term housing demand for the period from 2005 to 2030. Their modified model that takes into account changes in housing costs and real income shows that housing demand will not decrease as much as what the Mankiw–Weil model predicts.

Kim (2014) examines the impact of ageing on house prices using data from Seoul and six other metropolitan cities collected during the period between 2000 and 2012. Her empirical results show that house prices decline by 2.45% when the proportion of elderly people in the population increases by 1%. Using Korean Labor Institute and Kookmin Bank data from 1998 to 2012, Hong (2015) finds that ageing of the population lowers housing demand.

The research model and data

The research model

Hiller and Lerbs (2016) suggest that the population effect on house prices comes through three distinct channels; size of the population (the size effect), age composition of the population (the age effect) and the investment demand effect. With respect to the first channel (the size effect of the population), the total population residing in any region determines the total demand for houses, which in turn determines house prices while interacting with housing supply (DiPasquale & Wheaton, 1994). Given the finite elasticity of housing supply, the size effect suggests that if the total population in any region decreases, so do house prices. Yet, even though the total population stays the same, if the size of households shrinks and thus the number of households increases, housing demand and house price will rise (Hiller & Lerbs, 2016).

In addition to the size effect, demand for housing services underlies a life cycle (Pitkin & Myers, 1994; Flavin & Yamashita, 2002; Hiller & Lerbs, 2016). Demand for housing stays comparatively low in one's childhood, increases with labour market entry, peaks with starting and maintaining a family and decreases again in retirement (Hiller & Lerbs, 2016). This can be referred to as the age effect or the second channel. The age effect suggests that house prices decrease if the population of retirement and childhood age relative to that of working age in a given region increases.[3] The third channel, on the other hand, refers to the investment demand for owner-occupied housing as a durable asset (Hiller & Lerbs, 2016). Young households purchase houses as a conduit of savings and retirement provision and sell them to repurchase or rent smaller ones in retirement (Henderson & Loannides, 1983; Kraft & Munk, 2011; Hiller & Lerbs, 2016).

We set up a theoretical model of asset pricing by using an overlapping generation model (Samuelson, 1958; Saita et al., 2013) to consider the consumer's life cycle, which is an extension of Takats (2012) model. In the proposed model, a consumer lives through two periods (young and old). Young consumers work to earn labour income and have initial endowment bestowed by their parents as a kind of deposit for housing. They save to consume in their old age. Saving is done through a divisible fiat asset (K). The consumer's life utility function is assumed to be a log linear function of consumptions of young age and old age. The basic theoretical model is provided in the Appendix.

Consumers trade the single, divisible and otherwise useless fiat asset (K) for saving at old age, which is priced P_t at time t. From the first-order condition for utility maximization under the intertemporal budget constraints, the marginal rate substitution between consumptions of young age and old age (or marginal rate of time preference) is equal to the intertemporal price ratio. Young consumers buy a_t share of the asset at unit price (P_t). As consumers are identical and that equilibrium aggregate output equals aggregate output consumption, individual savings of the young ($\frac{K}{n_t^y}$) is equal to the value of assets (K) divided by the size of the current young generation (n_t^y) in equilibrium. Dividing savings and investment when "old" by savings and investment when "young" determines the asset price evolution in terms of real economic and demographic growth. Investment asset comprises stock, bond and real estate.

$$(1 + r_t) = \frac{p_{t+1}}{p_t} = (1 + g_t)(1 + d_t) \tag{1}$$

The fluctuation of asset price equals to rate of return (r_t). We define demographic growth (d_t) as $n_{t+1}^y = (1 + d_t)n_t^y$, and economic growth ($g_t$) as $Y_{t+1}^y = (1 + g_t)Y_t^y$. n_t^y is the current young generation, and Y_t^y is working income and endowment from their parents when young. In Equation (1), the fluctuation rate of asset price indicates the optimum market return, determined by the economic and demographic growth rate. When this equation applies to the housing market, the fluctuation rate of house price is determined linearly by economic and demographic growth rate. The economic growth rate reflects the income effect, while demographic growth rate does the size effect and the ageing effect.

If income and working population increase, housing demand and prices increase as well. But, when they get old, namely, over 60 years old, they enter the retirement phase. Their housing consumption declines in accordance with their decrease in earning capability. The population group with ages above 60 is a passive group and usually do not directly engage in income generating activities. Therefore, the dependency ratio is defined as the ratio of the population aged above 60 to the working population, which can be signified as the dependency ratio (DER_t) indicating the ratio of the older dependency population (n_{t-1}) to the working population (n_t),

$$\mathrm{DER}_t = \frac{n_{t-1}}{n_t} = \frac{n_{t-1}}{n_{t-1}(1 + d_{t-1})} = \frac{1}{(1 + d_{t-1})} \tag{2}$$

Interest rate is another factor which determines house prices. If the interest rate falls, consumers tend to buy houses instead of renting houses. As a result, housing demand and house prices go up.

House prices are also affected by housing supply as well as housing demand. Meen (2002) suggests that housing supply is determined by the fluctuation rate of house price and construction costs. Construction costs can be represented by interest rate for financial costs of construction.

Considering both housing demand and housing supply at the equilibrium, the equation implied by this model is as follows:

$$\hat{p}_{it} = \alpha_i + \beta_{1i} g_{it} + \beta_{2i} d_{it} + \beta_{3i} \mathrm{DER}_{it} + \beta_{4i} \hat{H}_{it} + \beta_{5i} r_t + e_{it} \tag{3}$$

where $\hat{p}_{it}$ represents the fluctuation rate of house price for region i in year t, g_{it} is the fluctuation rate of per capita GRDP, d_{it} is the fluctuation rate of the population, DER_{it} is the dependency ratio, $\hat{H}_{it}$ is the fluctuation rate of housing supply and r is the interest rate as a proxy for construction costs. In theory, β_1 which represents the income effect on house prices should have a positive coefficient. β_2 represents the size effect on house prices, and has a positive coefficient. β_3 represents the ageing effect, and this should have a negative coefficient. β_4 represents the coefficient of housing supply variable, and should have a negative coefficient since the increase of housing supply causes the decrease in house prices. β_5 represents the interest variable which should have a negative coefficient since the decrease of interest rate causes the increase in housing demand and house prices.

The panel regression equation which uses the basic three variables among the variables of Equation (3) is written under the assumption of inelasticity of house supply as follows:

$$\ln P_{it} = a_i + b_1 \ln \mathrm{GRDP}_{it} + b_2 \ln \mathrm{TPOP}_{it} + b_3 \ln \mathrm{DER}_{it} + e_{it} \tag{4}$$

where $\ln P_{it}$ denotes the log of real house price for region i in year t, $\ln \mathrm{GRDP}_{it}$ is the log of real GRDP per capita for region i in year t, $\ln \mathrm{TPOP}_{it}$ is the log of total population for region i in year t and $\ln \mathrm{DER}_{it}$ is the log of dependency ratio for region i in year t. We will use Equation (4) as our baseline regression equation in our empirical exercises. We first analyse the stationary property of our data-set with established panel stationary and panel co-integration tests. We then estimate a panel correction model.

If house prices, GRDP, total population and dependency ratios have a co-integration relationship, we assume a long-run equilibrium relationship between house prices and our three basic variables of all regions (Saita et al., 2013). The short-run dynamics of non-stationary series variables can be described by the error correction model. The error correction model we employed in this analysis is as follows:

$$\Delta \ln P_{it} = \alpha_i + \beta_{1i}\Delta \ln \mathrm{GRDP}_{it} + \beta_{2i}\Delta \ln \mathrm{TPOP}_{it} + \beta_{3i}\Delta \ln \mathrm{DER}_{it} + ECT_{it-1} + e_{it} \quad (5)$$

where *ECT* is the error correction term which represents the adjustment speed to long-run equilibrium after shock. If the variables return to long-run equilibrium after shock, the *ECT* parameter is expected to have a negative sign.

Data

We obtained house price data between 1990 and 2014 from Kookmin Bank. The data cover six metropolitan cities and seven regional provinces. These regional house price data are available only from 1990 onwards in Korea. Our initial attempt to cover all regional markets of Korea nationwide was frustrated due to the lack of required data of some regions. For this reason, Ulsan Metropolitan City, Gyungnam Province and Jeju Province are excluded from our analysis. Except for these three regions, we cover all other regional markets of Korea in this analysis. In fact, Korea consists of 7 metropolitan cities and 9 provinces (Figure 1). The population is concentrated in Seoul, the capital city of Korea, and its surrounding area (Incheon metropolitan city and Gyeonggi province). So the population of these regions altogether accounts for almost 50% of the total population of Korea. Gangwon, Jeonbuk, Jeonnam and Gyeongbuk are relatively less urbanized and industrialized provinces.

For regional income, we employ regional per capita industrial production reported by the Korea Statistical Office. We also adjust the nominal house price and nominal income to the consumer price index.

Total regional population and age group data are obtained from the resident registration population data from the Korea Statistical Office. The dependency ratio is calculated by the ratio of population aged 60 and more and under 20 to the working population (i.e. population aged 20–59). In previous studies of advanced countries, people aged 65 and above are considered as dependent members of the population. However, since in the case of Korea, most people retire at around 60 years of age, we consider the population aged 60 and more as the dependent population in this research. As for regional housing supply data, we use new housing construction permit data obtained from the Korea Statistical Office.

Interest rate data are obtained from the 90-day negotiable certificate of deposit (CD) yield of Bank of Korea. Access to the mortgage loan rate is limited only from 1996 onwards. On the other hand, the 90-day CD yield was used as the base rate for mortgage loans until 2010.

Empirical results

Tests on unit root

We employ two types of tests to check for stationarity of our panel data: (1) common unit root test (Breitung, 2001) in which the null is that the time series in each region share a common unit root, and (2) individual unit root test (Maddala & Wu, 1999) in which the null

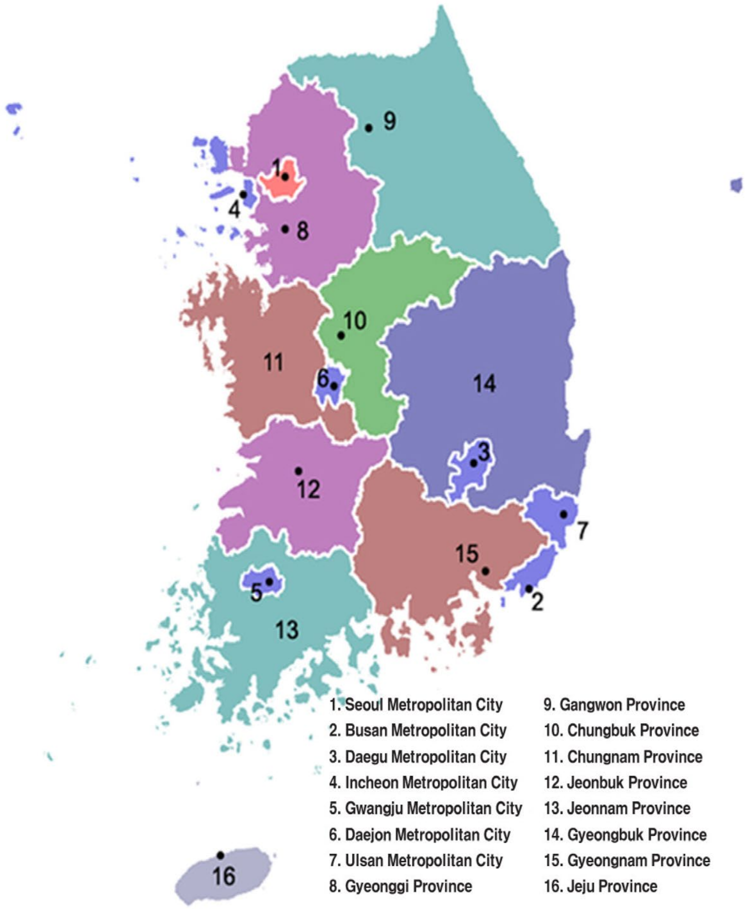

Figure 1. Map of Korea with its metropolitan cities and provinces. Source: Korean Government.

Table 1. Unit root test results.

Variables	Common unit root (Breitung)		Individual unit root (ADF-Fisher)	
House price	7.05	(1.00)	38.00	(0.06)
GRDP	−0.20	(0.41)	16.12	(0.93)
Population	3.85	(1.00)	118.13	(0.00)
Dependency ratio	−0.47	(0.31)	139.85	(0.00)
Interest rate	−2.11	(0.01)	15.69	(0.94)
Housing supply	−4.61	(0.00)	82.23	(0.00)

Notes: Figure in the table represents test statistics with the associated *p*-values in parentheses. The testing results are based on a constant and a time trend, with the lag chosen based on the SIC criterion.
Source: Authors.

is that the time series in each region have a different unit root. The reason we apply these two types of tests is that we have no clue about the characteristics of the time series data.

More specifically, we apply the unit root tests to all variables such as house price, GRDP, population, dependency ratio, interest rate and housing supply. The results are given in Table 1. The variables "house price" and "GRDP" cannot reject either of the null hypotheses of the two types of tests. "Population" and "dependency ratio" variables cannot reject the null of a common unit root test. The "interest rate" variable cannot reject the null of the individual unit root test. The "housing supply" variable rejects both the null hypotheses. The test results are based on a constant and a time trend, with the lag chosen based on the SIC criterion. For each of the six variables, the null hypotheses are rejected when the first difference is taken.

Tests on cointegration

We apply both the Kao test (Kao, 1999) which assumes that cointegration relationship in each region is identical and the Pedroni test (Pedroni, 1999) which assumes the cointegration relationship is heterogeneous across each region. We conduct cointegration tests for Equation (4). The results are presented in Table 2, showing the presence of cointegration relationship among the four variables except for the Group rho of the Pedroni test. The lag of each test is chosen based on the SIC criterion.

Regression

Given that the four variables are cointegrated, it is possible to estimate both the short-term and long-term effects of independent variables on the dependent variable by the error correction model. The Hausman test indicates the presence of regional fixed effects, so we add regional dummy variables to Equation 5 in our baseline model, which controls for the average differences across regions in any observed or unobserved predictors. The results of the error correction regression are presented in Table 3.

We see that each of the estimated coefficients except for the total population variable is statistically significant and meets the corresponding sign condition. An estimated coefficient of the dependency ratio has a negative sign (−0.7057) and is statistically significant as expected. It means that an increase in the dependency ratio of one per cent decreases house price by 0.70%. Unlike our expectation, however, the total population variable turns out to be statistically insignificant. Besides, previous literatures suggest that the total population

Table 2. Cointegration test results.

Kao test		Pedroni test							
ADF		Panel rho		Panel ADF		Group rho		Group ADF	
−1.666	(0.04)	−1.788	(0.04)	−3.443	(0.00)	−0.341	(0.37)	−2.593	(0.00)

Notes: Figure in the table represents test statistics with the associated *p*-values in parentheses. The lag of each test is chosen based on the SIC criterion.
Source: Authors.

Table 3. Regression test results of baseline model.

	GRDP	Population	Dependency ratio	$ECT_{(t-1)}$
Coefficient	0.3023	−0.2551	−0.7057	−0.0669
Standard error	0.1588	0.3148	0.1778	0.0297
t-statistics	1.9036	−0.8103	−3.9687	−2.2498
p-value	0.0579	0.4184	0.0001	0.0252
Adj. R^2	0.2592			

Notes: Panel regression in log-difference. Dependent variable: difference in logged real house prices. Independent variables: difference in logged real GRDP per capita, total population and dependency ratio.
Source: Authors.

Table 4. Robustness check.

Specification	GRDP	Population	Dependency ratio	Interest	Housing supply	ECT (t−1)	Adj.R^2
BS+Interest	0.4171***	0.0259	−0.6709**	−0.0094***		−0.0689***	0.2081
BS+Housing supply	0.2736**	−0.2701	−0.7098***		0.0090	−0.0690**	0.2091
BS+Interest+Housing supply	0.3863***	0.0105	−0.6735**	−0.0095***	0.0098	−0.0710**	0.2323
BS+Interest+Housing supply$_{(t-1)}$	0.4192***	0.0281	−0.6815***	−0.0099***	0.0119	−0.0735***	0.2154

Notes: **, *** denote statistical significance at the 5 and 1% levels, respectively.
Source: Authors.

is less important than the number of households in determining house prices. Hence, we carry out an estimation using the number of households instead of the total population in our model. The result of the estimation shows that the number of households does not have a cointegration relationship with the other three variables. So we choose not to use the "number of households" variable in this analysis.

As for the control variables, an estimated coefficient of GRDP has a positive sign (0.3023), and is statistically significant as expected. If income increases by one per cent, house price increases by 0.30%.

The coefficient estimates are also robust to various changes to the specification (Table 4). The coefficients of the baseline model are robust to the inclusion of interest rates and/or housing supply. An estimated coefficient of the interest variable has a significantly negative sign which implies that upward shifts in home financing costs move house prices downward. However, the very small coefficient of the interest variable (−0.009) implies that the size of the effect is very minimal. The effect of housing supply on house price is not statistically significant. We guess that this result is caused by time lags between the time of construction permit and that of construction completion. In this paper, construction permit data instead of construction completion serve as the housing supply variable, because the Korea Statistical Office does not publish construction completion data unlike in other countries such as the US, and Japan. In the US, the coefficient on housing supply is positive and significantly different from zero, which is consistent with the implication of stock flow models, in which housing price hikes lead to an increase in new housing supply (Saita et al., 2013).

The coefficient of the error correction term represents the speed of adjustment and the value of the coefficient tells us the percentage of correction. If the coefficient is close to −1, the departure from equilibrium is adjusted in the next period. The result of this test which is negative and significant is in line with the theoretical expectation that house prices return to their long-run equilibrium prices after shocks. Yet, the small size of the adjustment parameter means that house prices stay away from their equilibrium prices for a long time (Hiller & Lerbs, 2015). In this analysis, the coefficient on error correction terms (−0.0669) implies that the gap from long-run equilibrium is adjusted by 6.69% in the next year. In other words, it takes more than 15 years for the Korean housing market to return to long-run equilibrium after shocks.

Historic and forecasted ageing impact on house prices

The estimates on the dependency ratio and income are not only statistically significant, but also meaningful from an economic viewpoint. For both historic and forecasted ageing

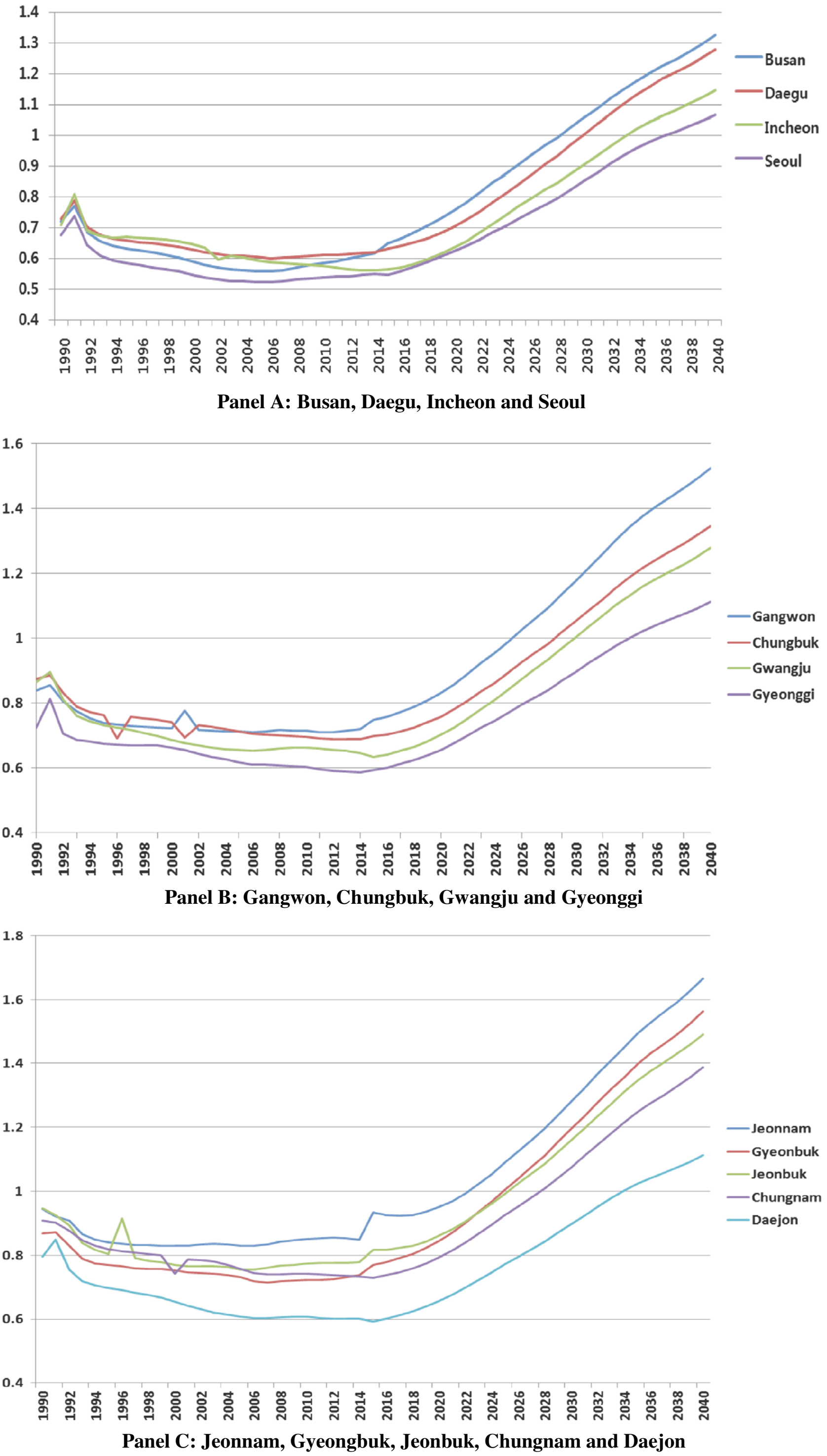

Figure 2. Regional dependency ratio trend and forecast (1990–2040). Source: Korea Statistical Office (2015).

impact, we use the Korean Statistical Office's data and projections, respectively. As shown in Figure 2, the dependency ratio keeps decreasing until 2014, and then increases thereafter. In particular, Jeonnam, Gyeongbuk and Gangwon which have relatively lower levels of urbanization, and Busan, the second largest city but located far from Seoul, all have higher dependency ratio levels than the other regions in 2030.

Table 5 shows the regional marginal effects of the dependency ratio and income on house prices. Such regional marginal effects of the dependency ratio on house prices are statistically significant in eight regions. The size of the regional marginal effects of the dependency ratio on house prices is similar to that of the basic model except for some regions such as Seoul, Chungnam and Jeonnam. The marginal effects of the dependency ratio in Seoul are by far the biggest as well as statistically significant. This suggests that Seoul tops other regions in terms of the extent of the increase in house prices during the period of analysis.

We use the coefficient of marginal effect in each region to measure the impact of ageing on local house prices. To this end, we multiply the differences of dependency ratios between two points of time in each region (Table 6) with their respective house price elasticity of the dependency variables estimated in the sensitivity analysis – regional level heterogeneity (Table 5).[4] The estimated coefficient in the sensitivity analysis is the elasticity which allows estimation of the ageing effect.

Figure 3 shows that ageing tailwinds increase house prices in the past 15 years between 1990 and 2014 compared to neutral demographics. On the other hand, ageing headwinds decrease house prices in the future. Figures 4 and 5 show the forecasted house price impact in 2020 and 2030. In the past, home purchases of baby boomer generation raised house prices. However, their home sales will lower house prices in the future. Thus, the future impact is negative in all regions. It is forecasted that the increase in the dependency ratio will drive down house prices by 3–13% in 2020 and that it will be above 20% in 2030 nationwide. It is noteworthy to point out that each region experiences substantial heterogeneity. The headwinds are the largest for fast ageing Jeonnam and Geongbuk which are located far

Table 5. Sensitivity analyses showing regional level heterogeneity.

Models	Regional fixed effects	Interaction for dependency ratio	Interaction for GRDP
GRDP	0.3023**	0.3710**	
Dependency ratio	−0.7057***		−0.7871***
Population	−0.2551	−0.3792	−0.4165
Adjusted R^2	0.2592	0.2416	0.2519
Seoul	−0.0835**	−1.5339***	0.3842
Busan	−0.0606**	−0.8581*	0.3915
Daegu	−0.0352**	−0.9656*	0.5867
Incheon	−0.0292**	−0.7684*	0.6730*
Daejon	−0.0094**	−0.7270*	0.7792
Gwangju	0.0247**	−0.6162	0.3570
Gyeonggi	−0.0061**	−0.7030	0.5866
Gangwon	−0.0742**	−0.6431	1.9116***
Chungbuk	0.0360**	−0.9264	0.3641
Chungnam	0.0586**	−1.3564	0.3643
Jeonbuk	0.0635**	−0.9264*	0.3534
Jeonnam	0.0778**	−1.3564***	0.3154
Gyeongbuk	0.0377**	−1.0774*	0.3140

Notes: The second column shows the regional fixed effect estimates for all regions while the third column shows the coefficient on the regional dummy × log changes in the dependency ratio. The last column shows the coefficient on the regional dummy × log changes in real GRDP per capita. *, **, *** denote statistical significance at the 10, 5 and 1% level, respectively.

Source: Authors.

Table 6. Historical and forecasted regional dependency ratio.

Region	1990(A) (%)	2014(B) (%)	B–A (%)	2020 projection (C) (%)	C–B (%)	2030 projection (D) (%)	D–B (%)
Seoul	67.70	55.03	−12.68	62.21	7.18	85.30	30.27
Busan	71.91	61.83	−10.08	76.39	14.56	105.91	44.08
Daegu	72.89	62.07	−10.82	70.23	8.16	100.41	38.34
Incheon	70.88	56.00	−14.87	63.43	7.43	90.58	34.58
Daejon	79.61	60.20	−19.41	65.63	5.43	89.68	29.48
Gwangju	86.44	64.71	−21.73	68.50	3.79	93.26	28.55
Gyeonggi	72.43	58.67	−13.76	63.86	5.19	89.31	30.64
Gangwon	84.01	72.06	−11.94	83.20	11.14	117.66	45.60
Chungbuk	87.57	68.88	−18.69	75.91	7.03	105.41	36.53
Chungnam	90.78	73.36	−17.42	79.46	6.10	107.54	34.18
Jeonbuk	94.73	77.80	−16.93	86.04	8.24	115.90	38.10
Jeonnam	94.41	84.93	−9.48	95.02	10.09	128.22	43.29
Gyeongbuk	86.69	73.69	−13.00	84.45	10.76	119.70	46.01

Source: Korea Statistical Office (2015).

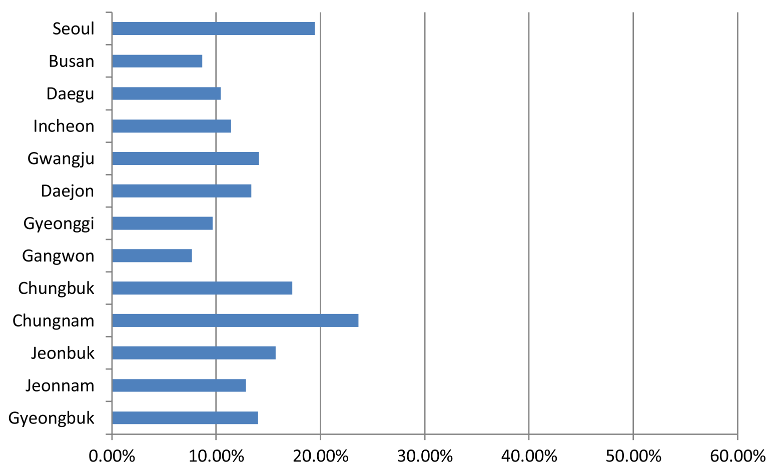

Figure 3. Historic ageing impact on house prices in 2014. Source: Authors.

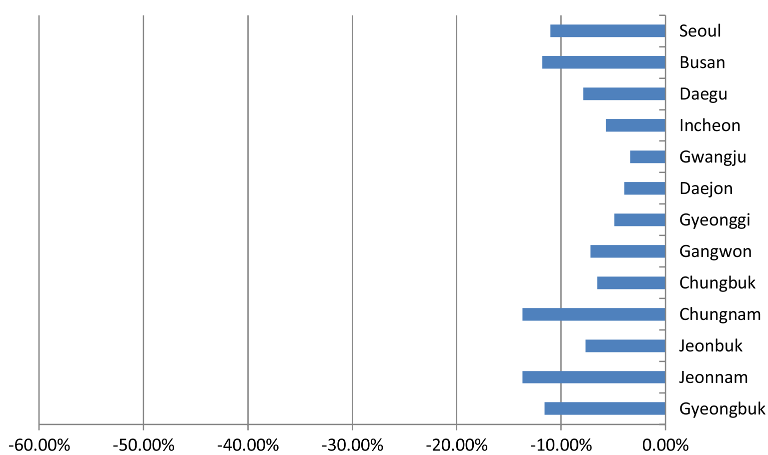

Figure 4. Forecasted ageing impact on house prices in 2020. Source: Authors.

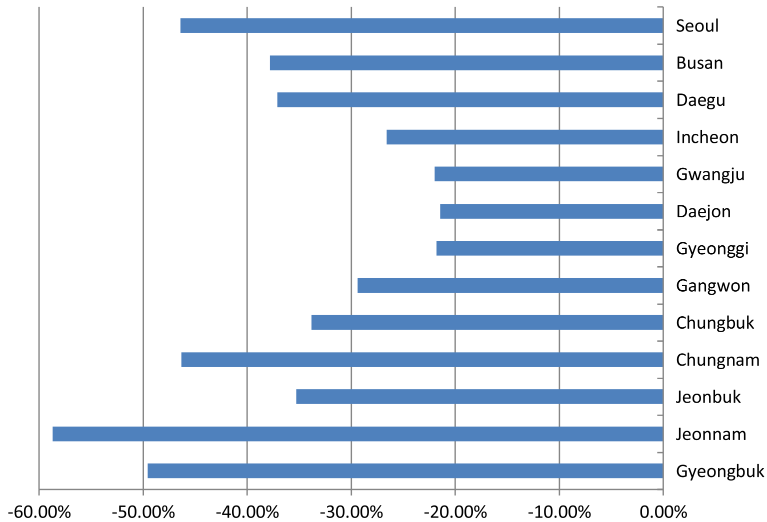

Figure 5. Forecasted ageing impact on house prices in 2030. Source: Authors.

from Seoul. The negative effects in Seoul and Chungnam are relatively larger due to their high coefficients of the ageing impact.

As with any projections, the results of our forecast of regional ageing effects on house prices should be treated carefully. First, the causal mechanisms underlying the empirical links between house prices and ageing can and do change with shifts in household preferences, housing finance institutions and household size (Hiller & Lerbs, 2015). Second, another factor that influences the price is housing supply. Yet, our empirical results show that house prices are not influenced by housing supply. However, increases in the elasticity of housing supply in the future can reduce the effects of the shifts in housing demand on the price (Hiller & Lerbs, 2015). Third, we cannot forecast precisely the impacts of ageing on future house prices with the estimated coefficient from the past when house prices increase due to the decreasing dependency ratio. In short, house price dynamics between periods of price rise and decline may be asymmetric. Evidence from the California housing market shows downward price rigidity (Li, 2015). If the Korean housing market exhibits downward price rigidity, the degree of house price decrease may diminish in a falling market in the future. Fourth, the price decrease caused by ageing can be offset by the income increase due to the improved productivity through innovation. However, Korea has been experiencing low economic growth and it will continue to post two per cent economic growth in the future. This two per cent growth rate will cause a 0.6% increase in house prices every year, according to our basic model which estimates the coefficient of the GRDP variable as positive (0.3023).

Fifth, even if house prices of most regions are expected to decrease in the future as seen in these results, prices of houses with ocean views or river views in regions like Seoul or Busan may increase, since the economic value of amenities like scenic views tends to increase in accordance with rising income levels (Quah & Tan, 1999; Kim, Park, Lee, & Xue, 2015).

On the other hand, we are concerned that the sharp drop of income after retirement partly from our insufficient pension scheme may influence the housing market negatively.

Conclusion

This paper investigates how ageing affects the Korean regional housing market. It uses a regional house price data covering six metropolitan cities and seven provinces in Korea during the period from 1990 to 2014. The main contribution of this paper is that it presents an analysis of the impact of ageing on regional house prices in fast ageing Korea. Additionally, we offer an estimation of future house prices using ageing projections of the Korea Statistical Office. The fluctuation in house prices is very important to homeowners, banks and policy-makers since real estate accounts for a high share among household assets in Korea.

This empirical analysis finds that income and dependency ratio affect house prices significantly. However, population itself does not affect house prices significantly. Ageing effects on house prices are twice as large as income effects. That is, a 1.0% increase in the dependency ratio causes a 0.7% decrease in house prices, while a 1.0% increase in income causes a 0.3% increase in house prices on the average.

During the analysis period between 1990 and 2014 when baby boomers became the working generation, the increase in the overall population and working population came as a tailwind into the Korean housing market. However, it is estimated that ageing of this generation will cause house prices to decline sharply after 2014. Likewise, by 2020, ageing will drive down house prices by 3–12% in comparison with 2014 nationwide house prices. However, ageing will further cause house prices to fall by 20–58% by 2030 compared to 2014 nationwide house prices. Therefore, in 2030, an actual meltdown of the Korean housing market will occur, as predicted in a previous study (Takats, 2012).

The speed of future ageing varies from region to region. The headwinds are the largest for fast ageing Jeonnam and Geongbuk which are located far from Seoul and relatively less urbanized. The vacant houses increasing in these rural areas are becoming one of the major social issues in Korea

We advise our readers, however, to approach our results carefully since relationships between house prices and ageing variables or economic variables can vary due to changes in household preferences, housing finance institutions, the size of household and income level (Hiller & Lerbs, 2015). The decrease in the housing supply and interest rate drops may offset the downward pressure caused by ageing. While housing supply may decrease in response to the fall of house prices, the decrease in the housing supply may rather drive up house prices. Falling interest rates may propel housing demand and house prices upward. On the other hand, what we are concerned about most is that the fast decline of income after retirement due to Korea's underdeveloped pension system may have a negative impact on the housing market.

Here are our suggestions to policy-makers to stabilize the Korean housing market:

First, the government needs to adjust proactively housing supply through policies aimed at limiting housing supply with a view to stabilizing house prices. Second, the government should improve and complement the current pension system in order to stabilize income after retirement. Under the current national pension, income after retirement is decreasing rapidly, which may critically threaten the economic status of retirees. Third, the government might consider delaying the retirement age and revitalizing reverse mortgage.

Notes

1. According to the survey of World Population Prospects (2015) in Korea, the ratio of people aged 60 and above to the total population will be 41.5% by 2050 while the ratio of people aged

80 and above will be 13.9% in the same year. In Japan, the ratio of people aged 60 and above to the total population will be 42.5% while the ratio of people aged 80 and above will be 15.1% in 2050. While these two countries show similar patterns in terms of population ageing, the degree of population ageing in the US is less severe compared to Korea and Japan. The low proportion of ageing individuals in the US relative to its total population may be attributed to the large immigration inflow to this country.

2. According to the household finance survey of the Korea Statistical Office, the ratio of actual assets relative to total household assets is 73.3% and that of real estate to total household assets is 67.8% in 2013, which is the biggest in the world. The ratio of actual assets relative to total household assets is 31.5% in the US and 40.9% in Japan. These figures appear to be lower than that of Korea (Yunhap News, April 7, 2014).
3. According to the survey of Land and Transportation Agency of Korea (2014), people until 60 of age tend to move to more expensive houses than before while in their sixties and after they move to houses of lower prices.
4. For example, to calculate the change of the house price of Seoul related to ageing between 2014 and 2020, we multiply the difference of dependency ratios between the two points of time (−7.18%) with its house price elasticity of the dependency ratio (−1.5339).

Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix. The basic theoretical model

A consumer lives in two periods (young and old). Young consumers work to earn labour income and have initial endowment bestowed by their parents as a kind of deposit. They save to consume in old age. Saving is done through a divisible fiat asset. The consumer's life utility function is a log linear function of consumptions of at a young age (C_t^y) and at an old age (C_{t+1}^o).

$$U = \ln(C_t^y) + \beta \ln(C_{t+1}^o) \tag{A1}$$

where U is a life utility function, C_t^y is consumption when young, C_{t+1}^o is consumption when old, β is the discount factor and t is the time period index. Consumption when young and the discount value of consumption when old are slightly less than exogenous work income when young.

$$C_t^y + \frac{C_{t+1}^o}{1 + r_t} \leq Y_t^y \tag{A2}$$

r_t is the interest rate determined endogenously, while Y_t^y is a sum of labour income and endowment when young and both are determined exogenously. Consumers trade the single, divisible and otherwise useless fiat asset; (K), which is priced p_t at time t. Young consumers buy a_t share of the asset at unit price p_t As consumers are identical and that equilibrium aggregate output equals aggregate output consumption, individual savings of the young ($\frac{K}{n_t^y}$) are equal to the value of assets (K) divided by the size of the current young generation (n_t^y) in equilibrium.

$$Y_t^y = C_t^y + p_t a_t = C_t^y + p_t\left(\frac{K}{n_t^y}\right) \tag{A3}$$

When the consumer is old, his future consumption depends on initial savings $\left(\frac{p_t K}{n_t^y}\right)$ and returns on these savings $(1 + r_t)$.

$$C_{t+1}^o = p_{t+1}\left(\frac{K}{n_t^y}\right) = \frac{p_{t+1}}{p_t}\left(\frac{p_t K}{n_t^y}\right) = (1 + r_t)\left(\frac{p_t K}{n_t^y}\right) \tag{A4}$$

We define demographic growth (d_t) as $n_{t+1}^y = (1 + d_t)n_t^y$, and economic growth ($g_t$) as $Y_{t+1}^y = (1 + g_t)Y_t^y$. From the first-order condition for utility maximization under the budget constraints, the marginal rate substitution between consumptions of young age and old age (or marginal rate of time preference) is equal to the intertemporal price ratio. Then, the relationship between the old age and the young age is $C_{t+1}^o = \beta(1 + r_t)C_t^y$. Likewise, the equilibrium consumption when young is $C_t^y = \frac{Y_t^y}{1+\beta}$.

Using the equilibrium consumption in Equation (A3), equilibrium investment when young is determined by $Y_t^y\left(1 - \frac{1}{1+\beta}\right) = \frac{p_t K}{n_t^y}$, the equilibrium savings and investment when old is determined by $Y_{t+1}^y\left(1 - \frac{1}{1+\beta}\right) = \frac{p_{t+1} K}{n_{t+1}^y}$. Dividing savings and investment when old by savings and investment when young determines the asset price evolution in terms of real economic and demographic growth. Investment asset comprises stock, bond and real estate.

$$(1 + r_t) = \frac{p_{t+1}}{p_t} = (1 + g_t)(1 + d_t) \tag{A5}$$

In Equation (A5), the fluctuation rate of asset price indicates the optimum market return, determined by the economic and demographic growth rate. When this equation applies to the housing market, the fluctuation rate of house price is determined linearly by economic and demographic growth rate. The economic growth reflects the income effect, while the demographic growth rate exhibits the size effect and the ageing effect.

If income and working population increase, housing demand and prices increase as well. But, when working people get old, or are over 60 years old, they enter into the retirement phase. Their housing consumption declines in accordance with their decrease in earning capability. Therefore, we define the population group with ages above 60 as the dependent population because these groups are passive and usually do not directly engage in income generating activities. The dependency ratio is defined as the ratio of the population aged above 60 to the working population, which can be signified as the dependency ratio (DER_t) indicating the ratio of the older dependency population (n_{t-1}) to the working population (n_t).

$$\mathrm{DER}_t = \frac{n_{t-1}}{n_t} = \frac{n_{t-1}}{n_{t-1}(1 + d_{t-1})} = \frac{1}{(1 + d_{t-1})} \tag{A6}$$

Interest rate is another factor which determines house prices. If the interest rate falls, consumers tend to buy houses instead of renting houses. As a result, housing demand and house prices go up.

House prices are also affected by housing supply as well as housing demand. Meen (2002) suggests that housing supply is determined by the fluctuation rate of house price and construction costs as follows:

$$\frac{h_{t+1}}{h_t} = \lambda\left(\frac{p_{t+1}}{p_t}\right) - \delta cc_t \tag{A7}$$

where h is house supply, λ the house supply elasticity with respect to house price, and cc is construction cost. On the other hand, δ is house supply elasticity on construction cost. When Equation (A7) is transferred to an inverse function, the fluctuation rate of house prices is indicated as the function of the fluctuation rate of housing supply and that of construction costs. Construction costs can be represented by interest rate for financial costs of construction.

$$\frac{p_{t+1}}{p_t} = \lambda^{-}\left(\frac{h_{t+1}}{h_t}\right) + \lambda^{-}(\delta cc_t) \tag{A8}$$

As house supply and construction costs increase, house prices are assumed to decrease. Using the demand (A5) and supply Equations (A8) of housing, we get the equilibrium price of housing at the market equilibrium. That is, the fluctuation rate of house price for region i in year t is a function of the fluctuation rate of per capita GRDP, the fluctuation rate of population, the dependency ratio, the fluctuation rate of housing supply and the interest rate as a proxy for construction costs.