Korea and the World Economy, Vol. 13, No. 2 (August 2012) 307-328

# Demographic Structure and Financial Markets in Korea*

Cheolbeom Park** · Dong Heon Kim***

This paper examines the relationship between the demographic structure and asset prices in Korea based on the standard life-cycle model. To this end, this paper employs a non-parametric model which has an advantage of no functional form for the relationship *a priori*. We find that the estimated relation between the real interest rate and population density function is consistent with the implication from life-cycle models, whereas the relation between the normalized stock price and population density function is not. The projection based on the projected population estimates indicates that the real interest rate is going to rise until the 2020 due to the increase trend of old consumers and their dissaving behavior after the retirement.

JEL Classification: J14, G12, C14
Keywords: aging, demographic structure, asset prices, nonparametric approach, life-cycle hypothesis

---

* Received November 4, 2011. Revised April 11, 2012. Accepted June 19, 2012. We are grateful to two anonymous referees and the editor for their helpful comments. We acknowledge financial support from National Research Foundation of Korea Grant funded by the Korean Government (KRF-2007-411-J03301). Usual disclaimers apply.
** Professor, Department of Economics, Korea University, E-mail: cbpark_kjs@korea.ac.kr
*** Author for correspondence, Professor, Department of Economics, Korea University, 5-1 Anam-dong, Seongbuk-Gu, Seoul, 130-761, South Korea, E-mail: dongkim@korea.ac.kr

## 1. INTRODUCTION

Economists and policy makers are concerned about the consequence of aging demographic structure on asset prices because asset prices are ultimately determined by saving which depends on different financial needs over life-cycle stages. In the US, there have been many studies on this issue. Abel (2001, 2003) and Geanakoplos, Magill, and Quinzii (2004) have developed theoretical models which imply that variations in the population age distribution result in different demand sizes for financial assets and thus variations in the demographic structure will be reflected in asset prices. Bakshi and Chen (1994), Geanakoplos, Magill, and Quinzii (2004), DellaVigna and Pollet (2007), and Park (2010) find significant relation between demographic structure and the US stock market.[1] Also, Ang and Maddaloni (2005) have found a significant negative impact of the proportion of retired consumers on stock returns from international data, although they were not able to find a strong relation in the US stock market.

In this paper, we investigate the impact of demographic structure on the financial market in Korea. The Korean demographic structure is aging most rapidly among OECD member countries due to the development of medical science and the extremely low birth rate.[2] KOSIS (2006) reports that the Korea soceity entered into the aging society in 2000 and is estimated to enter the aged society in 2018 and the super-aged society in 2020.[3] Hence, the consequence of aging demographic structure on asset prices is a particularly important and interesting issue not only for policy makers in Korea but also economists and investors in other countries. More specifically, we would like to examine whether asset prices are related with the demographic structure, as explained by standard life-cycle models.

Using the decompostion analysis and the synthetic cohort analysis, Park

[1] In contrast with these studies, Poterba (2001) argues that no significant relation between stock returns (or stock prices) and demographic measures has been found for the US stock market.

[2] Tung and Wan (2010) relate the low fertility rate in Korea to its cultural industrial policy.

[3] Generally, the ratio of 65 years old or over to total population exceeds 7% for aging society, 14% for aged society, and 20% for super-aged society respectively.

and Rhee (2005) find that the aggreation effects such as the effects of the change in the age structure of population and the change in the relative size of income across age chorts cannot explain the rapid rise in the aggregate household saving rate in Korea but the rapid economic growth combined with habit persistence as well as the drastic changes in demographic variables such as dependency ratio, fertility rate and life expectancy have the potential to explain the rise in the saving rates of all age cohorts. Choi, Park, Rhee, and Nahm (2005) report that the savings and investment ratio would fall by 2.8% and 0.9% by 2010 and by 11.8% and 2.6% by 2030, respectively and that there would be a longer-term current account deficit because the reduction in saving is more pronounced than that of investment. They state that an increase in the 40 to 65 year-old age group as a percentage of the total population contributes to increased demand for stocks at an earlier stage of population aging and by the time these people begin retiring, stock prices would become subject to larger adjustments and some of the public savings programs would face a serious shortfall. Choi and Nahm (2005) argue that the rate of aging would induce slowed growth, reduced consumption, and low investment, causing an economic downturn and a sound capital market is essential toward mitigating the effects of aging.

On the other hand, Kim and Yoo (2008) show that per capita investment in education would be increased by 67-78% as the number of sibling is decreased and thus the human capital investment might be increased as the fertility declines in Korea and that the return of capital changes around 3% and the proportion of safe assets such as deposits and bonds, would be increased as the population is aging and more financial assets would be accumulated when the human capital is efficiently used. They argue that demographic change in Korea may not necessarily have an adverse effect on financial markets and economic variables.[4)]

Facing different results from previous studies, we employ a nonparametric approach which does not impose any functional form for the relation between

---

[4)] For extensive study on the effect of population aging in Korea on Korea economy, please see KDI (2003, 2004).

population distribution and financial variables in order to examine the effect of demographic change on Korean economy. The approach utilizes the entire population distribution instead of one or a few aspects of population distribution. Similar approaches were employed recently in Park, Shin, and Whang (2010) to examine consumption and saving behavior based on population distribution in the US. Taking a similar approach, Park (2010) has also analyzed the impact of demographic structure on stock prices in G5 countries. Once the age response function is estimated by the nonparametric regression, we will examine whether the estimated age response function is consistent with the implication from standard life-cycle models. That is, the life-cycle models imply that the age response function for the normalized stock price (for the real interest rate) will be positive (negative) over the prime working age range as consumers in that age rage are purchasing financial assets or saving for their retirement period. However, the age response function for the normalized stock price (for the real interest rate) is expected to be negative (positive) for young ages and old ages because these two groups are dissaving according to the life-cycle models. We are going to check whether these implications are consistent with the shpaes of estimated age response functions for several financial assets.[5)]

Furthermore, we make projections for normalized stock prices and the real interest rate in Korea using the estimated coefficients from the nonparametric regression and Korean population projections.

The main findings in this study are as follows. First, we can observe a significant relation between the movements of the real interest rate and population distribution in Korea. However, such a tight relationship is not clearly observed for the relation between the normalized stock price and population distribution. These results seem consistent with the saving

5) Similarly to studies (e.g., Park, 2010) in this literature, we are not relating the long-term trend in the population distribution to short-run fluctuations in the real interest rate or normalized stock prices. Instead, we examine the relationship between the long-term trend in the population distribution and the long-term persistent but unobservable component contained in financial variables by running a nonparametric regression of stock returns on the population density function.

behavior in Korea. Sohn and Chung (2011) report that more than 80% of Korean households have chosen to put saving into saving deposits at banks or insurance companies, while merely 4.3% of households are participating directly in the stock market.[6) ] Hence, movements of the real interest rate are closely related with the demographic structure in Korea, while the stock price is not. Moreover, when we make a projection on the interest rate based on the projection of population distribution only, we can see that the interest rate in Korea is expected to rise until year of 2020. This rise in the interest rate seems to be caused by dissaving behavior of old consumers and an increasing fraction of retired consumers. Again, we are not able to obtain a robust projection about normalized stock prices.

The organization of this paper is as follows. Section 2 provides a brief presentation about the nonparametric approach employed in this paper. A description of the data utilized in this paper is provided in section 3. Section 3 also discusses how we have selected the number of series functions to approximate the age response function in the analysis. The main empirical results and projections are discussed in section 4. Section 5 provides the concluding remarks.

## 2. ECONOMETRIC METHODOLOGY

The life-cycle income hypothesis states that consumer's saving decision differs over the life-cycle. As consumer's saving is ultimately related with the purchase/resale of assets, demographic structure must be related with asset prices through the demand. However, a specific functional form of the relationship between the demographic structure and asset prices (for example, the relationship is linear or non-linear) is not known *a priori*. To assess the relationship between demographic structure and the aggregate asset price,

---

[6)] Even if indirect investment into the stock market through mutual funds is added, the participation rate in the stock market is still lower than 16% in Korea. See Sohn and Chung (2011).

previous studies often consider the following linear regression:

$$y_t = \alpha + \beta x_{it} + \varepsilon_t, \tag{1}$$

where $y_t$ is asset prices, and $x_{it}$ is a wide range of measures for demographic structure that have been utilized in previous studies. However, Park (2010) report misspecification evidence from the linear regression analysis between demographic measures and normalized stock prices for G5 countries. Following the findings in Park (2010), we consider the following econometric model:

$$y_t = \int_T f_t(s)g(s)ds + u_t, \tag{2}$$

where $y_t$ is asset prices, which is either the log price-dividend ratio, the log price-earnings ratio, or the real interest rate, $f_t$ denotes the density function of age distribution at time $t$, $T$ is the entire interval corresponding to the total population, and $g(s)$ can be interpreted as an age response function which reflects the impact of demographic distribution on the asset price, $y_t$. As the regressor, $f_t$, is the density function of age distribution, $\int_T f_t(s)ds$ (where $T_j$ is a subinterval of $T$) is the fraction of individuals for age group $T_j$ in the total population. Since we assume that the variation in the population age distribution is independent of financial variables, $g(s)$ can be consistently estimated without any additional variables which might affect financial variables.[7)]

The above econometric model is more robust than the linear regression model in two respects. First, no functional form is imposed for $g(s)$ in equation (2), whereas the linear regression imposes a linear function for the relation and is subject to misspecification problem in relating the asset prices to demographic measures (see Park, 2010). The only assumption required

7) This assumption may be strong but could be relaxed by the inclusion of appropriate variables to control for business cycles or some other factors which might not be orthogonal to the population density function.

for $g(s)$ is that it is smooth enough to be approximated by a series of polynomials, trigonometric functions, or a mixture of both series. That is, we assume that $\|g_\kappa - g\| \to 0$ as $\kappa \to \infty$, where $g_\kappa(s)$ is an approximation of $g(s)$ given by a combination of a finite series of functions $\varphi_1, \ldots, \varphi_\kappa$. Second, the econometric model in equation (2) relates the variation in the asset price to the variation of the entire age distribution instead of choosing a specific age range (for example, the fraction of individuals who are 65 or above, the fraction of individuals who are prime working ages, etc.) or a particular demographic measure *a priori*. Hence, when $g(s)$ is estimated, we are able to see which age group has a significant impact on the movement of asset price instead of choosing an arbitrary age group *a priori*. Therefore, we can see whether the estimated $g(s)$ is consistent with the implications from the life-cycle income hypothesis, and whether the movement of an asset price can be explained by variations in population age distribution. Also, we can make a projection about the movements of the asset price using the estimates of $g(s)$ and population projections in the future.

When $g_\kappa(s) = \sum_{j=1}^{\kappa} \alpha_j \varphi_j$, it is straightforward to have the following expression for equation (2):

$$y_t = \sum_{i=1}^{\kappa} \alpha_i \int_T f_t(s)\varphi_i(s)ds + u_{\kappa,\,t} = z_t' \alpha_\kappa + u_{\kappa,\,t}, \tag{3}$$

where $u_{\kappa,\,t} = u_t + \int_T f_t(s)(g_\kappa - g)(s)ds,$ $z_t = [\int_T f_t(s)\varphi_1(s)ds, \ldots, \int_T f_t(s)\varphi_\kappa(s)ds]$, and $\alpha_\kappa = [\alpha_1, \ldots, \alpha_\kappa]'$. Letting $Y$ and $Z$ be a vector of $y_t$ and $z_t$, respectively, the LS estimator of $\alpha_\kappa$ can be written as $\hat{\alpha}_\kappa = (Z'Z)^{-1}Z'Y$. Then, the estimate of the age response function by the corresponding series functions can be written as

$$\hat{g}(s_h) = \sum_{j=1}^{\kappa} \hat{\alpha}_j \varphi_j(s_h) = \Pi_\kappa(s_h)' \hat{\alpha}_\kappa, \tag{4}$$

where $\Pi_\kappa(s_h) = [\varphi_1(s_h), \ldots, \varphi_\kappa(s_h)]'$ and $s_h$ is an interval on *T*. Once

$\mathrm{Var}(\hat{\alpha}_{\kappa})$ is obtained from the regression residuals with the use of the Newey and West (1987) procedure, $\mathrm{Var}(\hat{g}(s))$ can be written as $\mathrm{Var}(\hat{g}(s)) = \prod_{\kappa}' \mathrm{Var}(\hat{\alpha}_{\kappa}) \prod_{\kappa}$ where $\prod_{\kappa} = [\prod_{\kappa}(s_1),\ \ldots,\ \prod_{\kappa}(s_h)]$.

While we do not impose any functional form for $g(s)$, a series of functions are needed in order to approximate $g(s)$. While Fair and Dominguez (1991) impose a quadratic form for $g(s)$ in estimating the consumption age response function, Park, Shin, and Whang (2010) and Park (2010) attempt the Fourier Flexible Form (FFF) for the age response function of consumption and the aggregate stock price, respectively. Hence, we attempt both polynomial series functions and FFF expansion which is a mixture of quadratic functions and trigonometric functions. The polynomial series functions can be written as

$$g_{\kappa}(s) = \sum_{j=0}^{\kappa} \alpha_j s^j. \tag{5}$$

Also, the FFF expansion of $g(s)$ can be expressed as

$$g_{\kappa}(s) = \alpha_0 + \alpha_1 s + \alpha_1 s^2 + \sum_{j=1}^{J} [\alpha_{3,j} \cos(js) + \alpha_{4,j} \sin(js)], \tag{6}$$

where $\kappa = 2 + 2J$.[8] The selection of $\kappa$ is made so that the representation of $g(s)$ by a series of functions gives a good approximation in the empirical analysis.

[8] Due to the characteristics of trigonometric functions, it is desirable to scale the data into the interval [0,1]. That is, with a given common support $T = [\lambda_1, \lambda_2]$ for $f_t$, $f_t$ is transformed by $f_t^*(s) = f_t(\lambda_1 + (\lambda_2 - \lambda_1)s)$, such that $f_t^*(s)$ has common support [0,1]. The original response function $g$ with respect to $f_t$ can be recovered from the response function $g^*$ with respect to $f_t^*(s)$ by the transformation $g(s) = g^*(\frac{s - \lambda_1}{\lambda_2 - \lambda_1})$.

## 3. DATA AND THE SELECTION OF $\kappa$

The Korean stock market data are obtained from Datastream, and include the price index, dividend yield, and price-earnings ratio. After recovering the level of dividends from the product of the dividend yield and price index, we construct two types of the normalized stock price, which are the log price-dividend ratio and the log price-earnings ratio. We utilize the normalized stock price instead of the price index because the asymptotic results of the LS estimators for equation (3) can be applied to stationary time series data (see Andrews, 1991). The real interest rate is constructed by the three-month CD rate which is downloaded from the Economic Statistics System (ECOS) in the Bank of Korea.[9] The three-month CD rate is considered as a representative interest rate in many studies on the financial market in Korea (for example, see Kim (2010), Kim and Lim (2011) and references therein).[10] The CPI inflation rate is also constructed from the CPI index of the ECOS. Data for the age distributions of the Korean population and projections of the future Korean population are taken from the Korean Statistical Information Service (KOSIS) managed by the Korean government.[11] The population data at KOSIS are provided as 81 single year age groups (ages 0, 1, …, 79, 80 +). The sample period for the stock market data is 1987-2010, while the sample period for the real interest rate is 1991-2010. All data used in this paper are annual data.

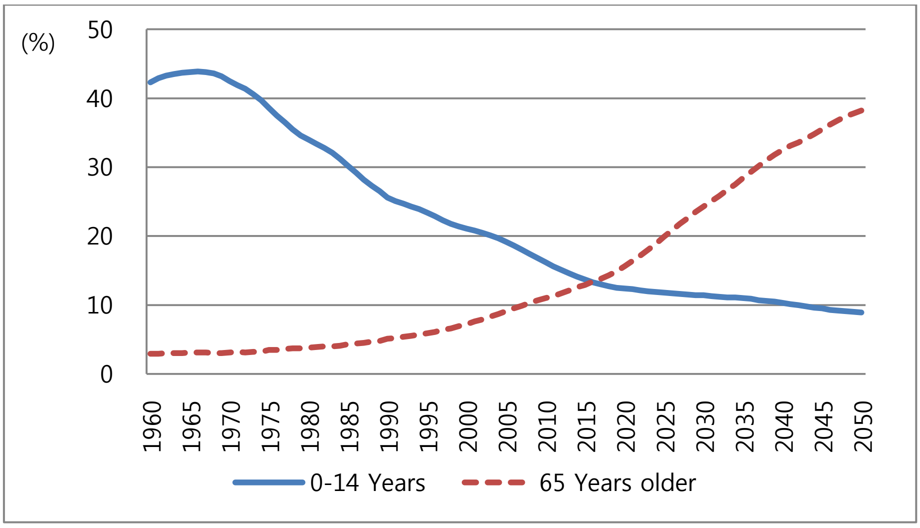
Before presenting the results of non-parametric regressions, we examine how serious the aging demographic structure in Korea is. Figure 1 plots the estimated trend of population distribution between the age 0-14 population and the age 65 over population. The ratio of the age 0-14 population over

[9] The web address of the Economic Statistics System of the Bank of Korea is http://econ.bok.or.kr

[10] Consumers might be more interested in the one-year interest rate or longer-term interest rate. However, we use the CD rate because the CD rate provides longer sample than other long-term rates and the Expectations Hypothesis (Campbell and Shiller, 1991) indicates that the long-term rate is an average of current and expected future short-term rates over the life of the long-term rate and thus the CD rate is strongly correlated with the long-term rate (e.g., Kim, 2008; Kim, 2010; Kim and Lee, 2008).

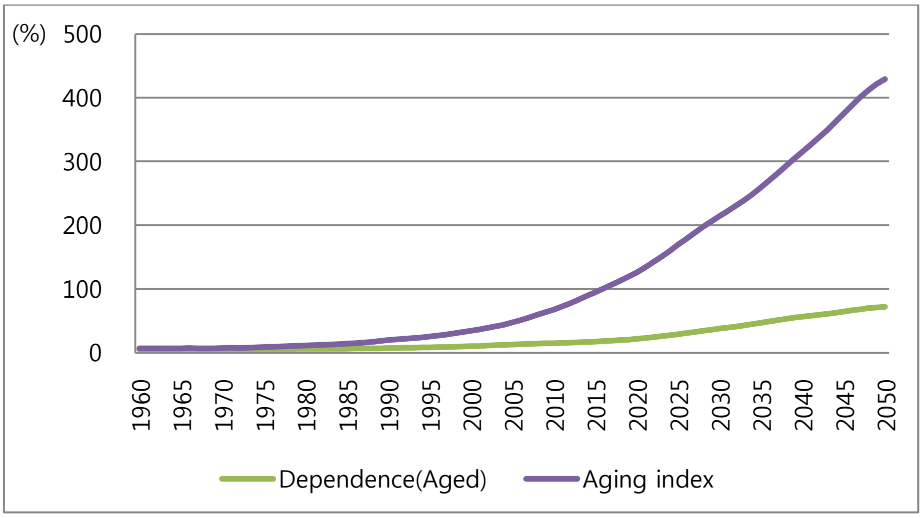
[11] The website address the Korean Statistical Information Service is http://kosis.kr/

**Figure 1 The Estimated Trend of Korean Population Distribution: 0-14 versus 65 Over**




Source: Population Projections for Korea, Korea Statistical Information Services.

**Figure 2 The Projected Trend of Korean Aging Index and Dependence Ratio**




Note: Dependence (Aged) denotes the ratio of the age 65 over population to the age 15-64 population and "Aging index" denotes the ratio of the age 65 over population to the age 0-14 population.

total population has decreased continuously since 1970 and is 16.2 % in 2010 while the ratio of the age 65 over population has increased substantially since 2000 and is 11% in 2010. The growth rate of the age 65 over population is expected to rise continuously over the next 40 years. Figure 2 shows the projected trend for the ratio of the age 65 over population to the age 0-14 population as an aging index and for the ratio of the age 65 over population to the age 15-64 population as a dependence ratio of aging group. The aging index appears to increase rapidly since 2000 and the dependence ratio is expected to increase substantially since 2020. Both figures imply that Korean society seems to have a significant change in demographic structure over several decades.

In order to apply the nonparametric approach presented in section 2, it is critically important to decide how many series functions should be included to achieve a good approximation in the empirical analysis. Since the dependent variable (*Y*) and regressors (*Z*) are assumed to have no stochastic trend, the *h*-block cross-validation (*CV*) and the modified *h*-block *CV* criteria, which are suggested by Burman, Chow, and Nolan (1994) and Racine (1997), are used as the selection criteria for $\kappa$ which denotes the number of series functions in the approximation. For a given block size (*h*), the *h*-block *CV* criterion can be written as:

$$CV_{\kappa} = N^{-1}\sum_{t=h}^{N-h}(y_t - z_t'\hat{\alpha}_{\kappa}(t,\ h))^2, \tag{7}$$

where *N* is the sample size, and $\hat{\alpha}_{\kappa}(t,\ h)$ is the estimator of $\alpha_{\kappa}$ acquired by removing the *t*-th observations in $y_t$ and $z_t$ and *h* observations preceding and following the *t*-th observations in both $y_t$ and $z_t$. The modified *h*-block *CV* criterion, motivated by cases in which $\kappa$ is not negligible compared with *N*, can be written as follows:

$$\begin{aligned} MCK_{\kappa} = {} & N^{-1}\sum_{t=h}^{N-h}(y_t - z_t'\hat{\alpha}_{\kappa}(t,\ h))^2 + N^{-2}\sum_{t=h}^{N-h}\sum_{n=1}^{N}(y_n - z_n'\hat{\alpha}_{\kappa}(t,\ h))^2 \\ & + N^{-1}\sum_{n=1}^{N}(y_n - z_n'\hat{\alpha}_{\kappa})^2. \end{aligned} \tag{8}$$

**Table 1 *h*-block and Modified *h*-block Cross-Validation Criteria**

| | | $1, s, s^2$ | $1, s, s^2, s^3$ | $1, s, s^2, s^3, s^4$ | $1, s, s^2$, cos($s$), sin($s$) | $1, s, s^2$, cos($s$), sin($s$), cos($2s$), sin($2s$) |
|---|---|---|---|---|---|---|
| Price-dividend Ratio $(p_t - d_t)$ | *h*-block *CV* | 0.1223 | 0.1452 | 0.5375 | 0.5359 | 5,609 |
| | Modified *h*-block *CV* | 0.3326 | 0.3582 | 1.2446 | 1.2417 | 11,173 |
| Price-earnings Ratio $(p_t - e_t)$ | *h*-block *CV* | 0.2289 | 0.2278 | 0.3078 | 0.3079 | 2,028.9 |
| | Modified *h*-block *CV* | 0.7645 | 0.6721 | 0.7489 | 0.7487 | 4,044.8 |
| Real Interest Rate | *h*-block *CV* | 0.00045 | 0.0009 | 0.0030 | 0.0027 | 0.8184 |
| | Modified *h*-block *CV* | 0.00084 | 0.0014 | 0.0051 | 0.0045 | 1.6319 |

Notes: *h*-block cross-validation and modified *h*-block cross-validation are data-dependent criteria for the selection of the optimal order of $\kappa$ of the series representation. Statistics for *h*-block cross-validation and modified *h*-block cross-validation are computed from equations (6) and (7), respectively. The $\kappa$ that minimizes the above *CV* criteria is selected. See Burman, Chow, and Nolan (1994), and Racine (1997) for further discussion.

The $\kappa$ that minimizes the above $CV_\kappa$ or $MCV_\kappa$ criteria is selected.

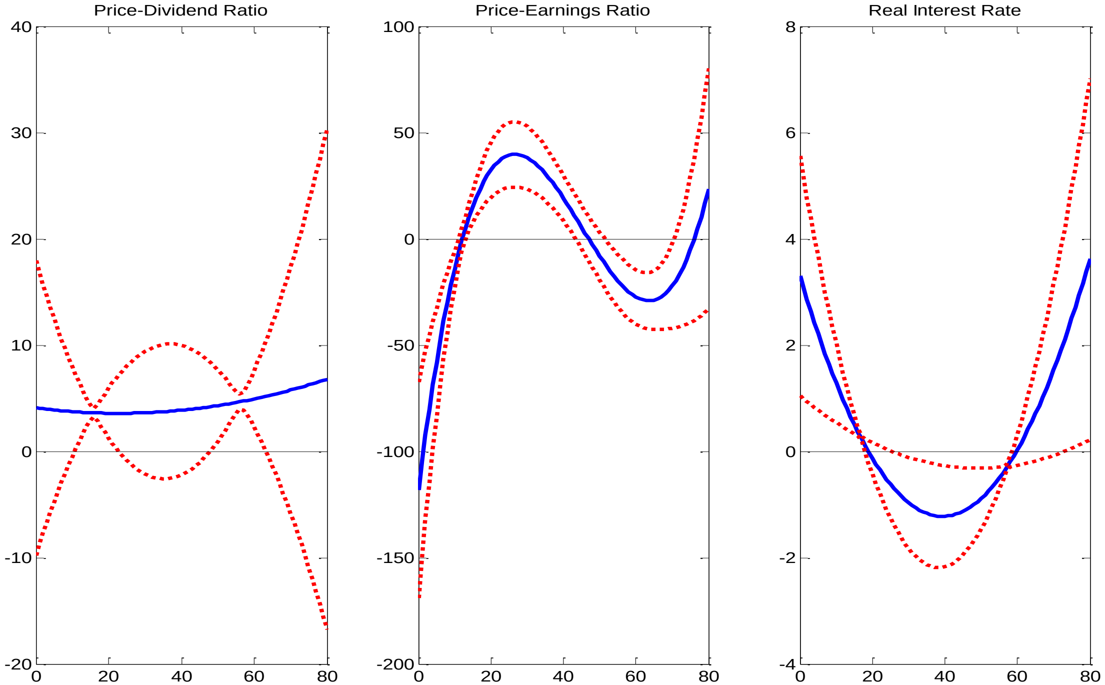
We compute $CV_\kappa$ and $MCV_\kappa$ for various values of $\kappa$ in polynomial representations or the FFF representations. While computing $CV_\kappa$ and $MCV_\kappa$, the block size, $h$, is set as the integer nearest to $N/6$ in accordance with the suggestion of Burman, Chow, and Nolan (1994). The results are shown in table 1 and are robustly consistent for both $CV_\kappa$ and $MCV_\kappa$ criteria. For the price-dividend ratio and the real interest rate, $CV_\kappa$ and $MCV_\kappa$ are minimized with $g_\kappa(s)=\alpha_0+\alpha_1 s+\alpha_2 s^2$, whereas $CV_\kappa$ and $MCV_\kappa$ are minimized with $g_\kappa(s)=\alpha_0+\alpha_1 s+\alpha_2 s^2+\alpha_3 s^3$ for the price-earnings ratio. Hence, we employ the quadratic approximation for $g(s)$ in cases of the price-dividend ratio and the real interest rate, while the cubic approximation is employed in the case of the price-earnings ratio. Empirical results presented in the next section are based on these selected values for $\kappa$.

## 4. EMPIRICAL RESULTS

### 4.1. Estimated Age Response Function

Life-cycle models in economics state that consumers at different stages in the life-cycle have different financial needs. As a result, the demographic structure will be reflected in asset prices through the demand side. More specifically, consumers at prime working age range will purchase financial assets or save for their retirement period while young consumers or old consumers will dissave their wealth. As a result, the age response function is expected to be hump-shaped for the normalized stock price because the purchase of stocks by prime-working-age consumers will raise the stock prices and young and old consumers' dissaving will reduce the stock prices. Also, the age response function will be u-shaped for the interest rate. Prime-working-age consumers' savings will raise the supply in the loanable fund market and reduce the interest rate, while old or young generations' dissaving

**Figure 3 Estimated Age Response Functions**



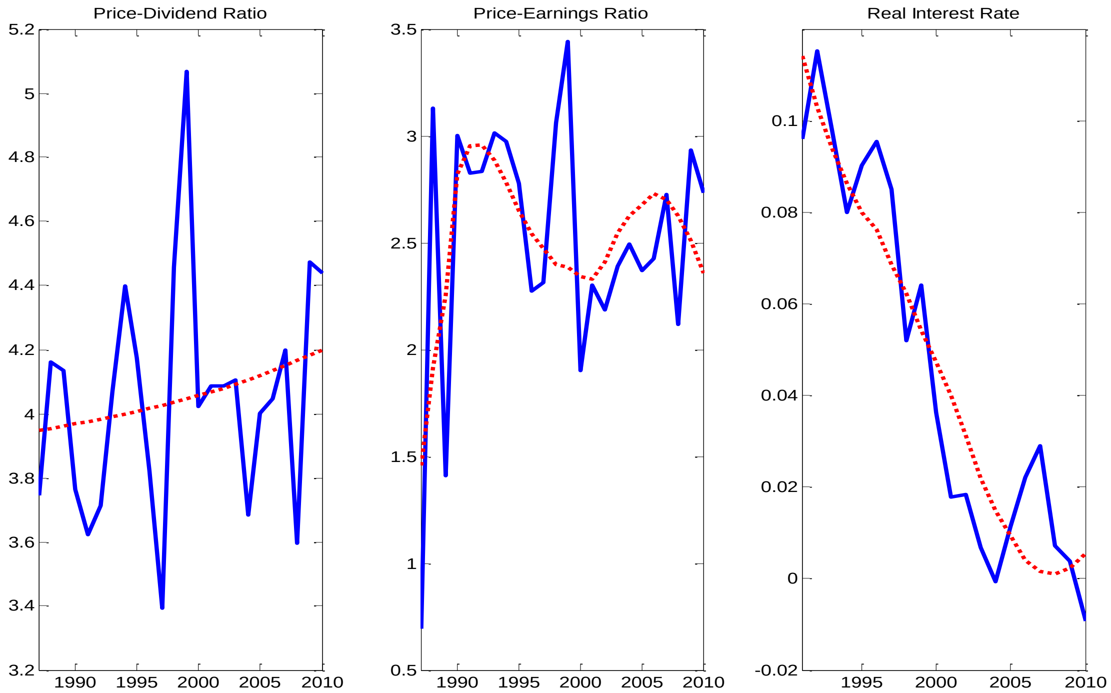
will reduce the supply and raise the interest rate. We are going to check whether these implications are supported by the data in this sub-section.

Figure 3 shows the estimated age response functions for the log price-dividend ratio, the log price-earnings ratio, and the real interest rate. For the price-dividend ratio, the estimated age response function is almost flat regardless of the age, and is significantly positive around age 20 and age 60, which is incosistent with the life-cycle inocme hypothesis. Although the estimated age response function for the price-earnings ratio is hump-shaped, it is significantly positive over ages between 15 and 45, becomes significantly negative over ages between 53 and 72, and becomes positive again over ages above 78, which is also odd compared with theoretical models based on the life-cycle income hypothesis. The odd age response function seems to be related with the low participation in the stock market in Korea (see Sohn and Chung, 2011).

However, the estimated age response fuction for the real interest rate is remarkably consistent with the idea of the life-cycle income hypothesis. Different age groups have different impacts on the determination of the interest rate. In particular, the estimated age response function is significantly negative and u-shaped over prime working ages between 27 and 59. In addition, the estimated age response function becomes significantly positive over ages below 18 and over ages above 74. Savings done by prime working age consumers have negative impact on the interest rate, while dissavings done by young consumers or old consumers have positive impact on the inerest rate. These patterns of the age response function are consistent with the distinct financial needs and saving decisions at different life-cycle stages of consumers, as predicted by life-cycle models.

In order to check whether variations in age distribution play an important role in explaining the movements of asset prices, the fitted values from the nonparametric regression are plotted in figure 4. The fitted values for the price-dividend ratio does not appear to explain fluctuations in the actual price-dividend ratio, whereas the fitted values of the price-earnings ratio track the actual price-earnings ratio quite closely. The $\bar{R}^2$ is –0.05 and 0.21

**Figure 4 Fitted Values**



for the price-dividend ratio and the price-earnings ratio, respectively. However, consistent with the remarkable age response function, the fitted values of the real interest rate are impressive, as shown in the right-hand side panels of figure 4. The fitted values from the nonparametric regression model track the actual movements of the interest rate closely, even if other factors that affect the interest rate are ignored. The $\bar{R}^2$ is 0.85.

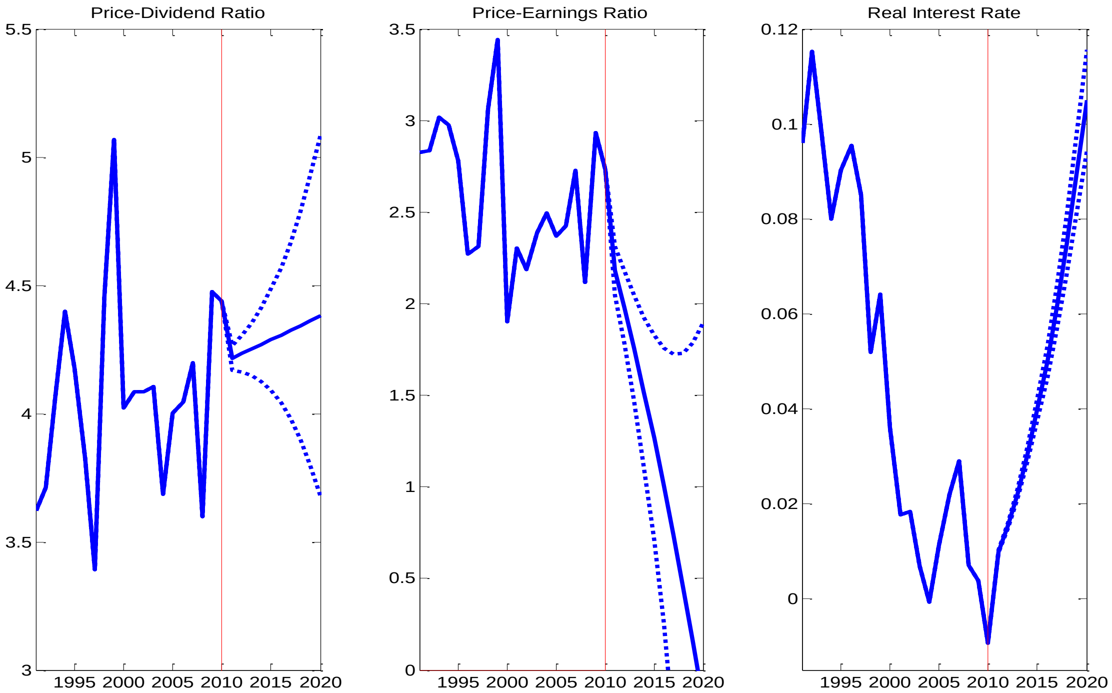
### 4.2. Forecasting Asset Prices Based on Demographic Distribution

One of the reasons to study the relation between the population age distribution and asset prices is a concern about whether asset prices will fall or rise drastically in Korea, as demographic structure becomes more and more aging. Since the interest rate is strongly related with the demographic structure, we address the above concern using the estimates of the individual parameters in the nonparametric regression of this study and population projections provided by the KOSIS. The population projections used in this study are for the period from 2011 to 2020 can be found at KOSIS website.

Three sets of estimated coefficients in the nonparametric regressions are used for the projection, depending on the dependent variable of the estimation (the log price-dividend ratio, the log price-earnings ratio, or the real interest rate). As a result, three projections with 95% confidence intervals are formed and presented in figure 5. The time (year 2011) when the projection starts is indicated as the vertical line in each panel.

The projected log price-dividend ratio is shown in the left-hand side panel of figure 5. The price-dividend ratio is expected to fall in the year 2011 and to rise steadily from the year 2012 until 2020. The projected log price-earnings ratio, shown in the middle panel of figure 5, continues to decline until the year 2020 reaching to zero level, which does not seem sensible. These two conflicting projections confirm the finding in the previous sub-section that the estimated age responses for normalized stock prices are not consistent with life-cycle models. Hence, the projections based on the age distrbution look awkward in these cases. However, the projected real interest

**Figure 5 Projections**



rate is rising continuously until year 2020. The rise in the interest rate until 2020 appears to be related to aging demographic structure. Since the impact of retired consumers on the interest rate is positive due to their dissaving behavior, increasingly higher fraction of retired consumers in the population projections implies higher interest rate in the future.

However, this projection based on the age distribution should not be used for forecasting short-run fluctuations of the financial variables because a myriad of other factors (economic growth, macroeconomic risk, etc.) are not considered. Moreover, the projections should be interpreted with caution because they implicitly assume a closed economy for Korea. The ongoing globalization phenomena could break the tight historical relation between the population age distribution and the real interest rate, and create a new relation between the joint demography of countries and the real interest rate. Finally, the confidence intervals of the projections are meant to reflect the uncertainty associated with the estimates of regression coefficients but not to reflect the uncertainty associated with population projections. If uncertainties from both sources are combined, the confidence intervals could become wider.

## 5. CONCLUSION

A nonparametric regression model is employed in this study to determine whether variations in population distribution has influenced asset prices in Korea as predicted by the life-cycle models. The advantage of the nonparametric approach is that no functional form for the relationship between the demographic structure and asset prices is imposed *a priori*.

The main findings of this study are as follows. First, the relation between the real interest rate and population distribution in Korea is consistent with the standard implication of the life-cycle models. The estimated age response implies that the prime working age groups have a significantly negative impact on the real interest rate, that dependent consumers (who are very young or who have already retired) have a significantly positive influence on the real interest rate, and that the fitted values track the actual interest rate remarkably. However, such a tight relationship with the demographic structure is not observed for the stock price. Finally, when we project the real interest rate based on the projected population estimates only, the interest rate is going to rise until the year 2020 due to the increasing trend of old consumers and their dissaving behavior after the retirement.

Given this projection, this paper suggests that the government may need to consider this effect of demographic change on the real interest rate to stabilize national pension scheme and to booster economic investment. Furthermore, the increase in the real interest rate may be a burden of the Bank of Korea for supporting stable nominal interest given the inflation targeting.

## REFERENCES

Abel, A. B., "Will Bequests Attenuate the Predicted Meltdown in Stock Prices When Baby Boomers Retire?," *Review of Economics and Statistics*, 83, 2001, pp. 589-595.

____________, "The Effects of a Baby Boom on Sstock Prices and Capital Accumulation in the Presence of Social Security," *Econometrica*, 71, 2003, pp. 551-578.

Andrews, D. K., "Asymptotic Normality of Series Estimators for Nonparametric and Semiparametric Regression Models," *Econometrica*, 59, 1991, pp. 307-345.

Ang, A. and A. Maddaloni, "Do Demographic Changes Aaffect Risk Premiums? Evidence from International Data," *Journal of Business*, 78, 2005, pp. 341-379.

Bakshi G. and Z. Chen, "Baby Boom, Population Aging, and Capital Markets," *Journal of Business*, 67(2), 1994, pp. 165-202.

Burman P., E. Chow, and D. Nolan, "A Cross-validatory Method for

Dependent Data," *Biometrika*, 81, 1994, pp. 351-358.

Campbell, John Y. and Robert J. Shiller, "Yield Spreads and Interest Rate Movement: A Bird's Eye View," *Review of Economic Studies*, 58, 1991, pp. 495-514.

Choi, G. P., D. K. Park, C. Y. Rhee, and J. H. Nahm, "The Financial Challenge of an Aging Society," *Journal of Korea Money and Finance*, 19, 2005, pp. 1-60.

Choi, G. P. and J. H. Nahm, *Economic Effects and Policy Implications of Population Aging*, Korea Institute of Finance, 2005.

DellaVigna S. and J. M. Pollet, "Demographics and Industry Returns," *American Economic Review*, 97, 2007, pp. 1667-1702.

Fair R. C. and K. M. Dominguez, "Effects of the Changing US Age Distribution on Macroeconomic Equations," *American Economic Review*, 81, 1991, pp. 1276-1294.

Geanakoplos J., M. Magill, and M. Quinzii, "Demography and the Long-run Predictability of the Stock Mmarket," *Brookings Papers on Economic Activity*, 1, 2004, pp. 241-325.

Kim, D. H., "Another Look at Yield Spreads: The Role of Liquidity," *Southern Economic Journal*, 74(4), 2008, pp. 952-970.

____________, "The Role of Money in the Monetary Policy Rule," *Journal of Economic Theory and Econometrics*, 21(3), 2010, pp. 91-111 (in Korean).

Kim, D. H. and M. J. Lee, "The Analysis of Daily Korea Call Rate," *Economic Analysis*, 14(4), 2008, pp. 85-112 (in Korean).

Kim, D. H. and Y. S. Lim, "The Role of Money in the Dynamic IS Model," *Journal of Economic Theory and Econometrics*, 22(3), 2011, pp. 86-103 (in Korean).

Kim, K. H. and K. W. Yoo, "The Effects of Population Aging on Human Capital Investment and Financial Markets in Korea," *Journal of Insurance Development*, 19(3), 2008, pp. 165-207.

Korea Development Institute (KDI), *Population Aging in Korea: Economic Impacts and Policy Issues* (*I*), in K. S. Choi, H. P. Moon, I. S. Shin, J.

H. Hahn, eds., 2003.

_____________, *Population Aging in Korea: Policy Issues and Reform Agenda* (*II*), in K. S. Choi, ed., 2004.

Korean Statistical Information Services (KOSIS), *Population Projections and Summary Indicators for Korea*, Statics Korea, 2006.

Newey, W. and K. West, "A Simple, Positive Semi-definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix," *Econometrica*, 55(3), 1987, pp. 703-708.

Park, C., "How Does Changing Age Distribution Impact Stock Prices? A Nonparametric Approach," *Journal of Applied Econometrics*, 25(7), 2010, pp. 1155-1178.

Park, D. K. and C. Y. Rhee, "Saving, Growth, and Demographic Change in Korea," *Journal of The Japanese and International Economies*, 19, 2005, pp. 394-413.

Park, J. Y., K. Shin, and Y.-J. Whang, "A Semiparametric Cointegrating Regression: Investigating the Effects of Age Distribution on Consumption and Saving," *Journal of Econometrics*, 157(1), 2010, pp. 165-178.

Poterba, J., "Demographic Structure and Asset Returns," *Review of Economics and Statistics*, 83, 2001, pp. 565-584.

Racine, J., "Feasible Cross-validatory Model Selection for General Stationary Processes," *Journal of Applied Econometrics*, 12, 1997, pp. 169-179.

Sohn, M. J. and J. Y. Chung, "Report on Households' Saving Behavior and Portfolio," *SERI Reports on Consumers' Behavior*, Samsung Economics Research Institute, 2011 (in Korean).

Tung, A.-C. and H. Wan, "High Tech, Low Fertility, Korea Becomes a Role Model in Cultural Industrial Policy," *Korea and the World Economy*, 11, 2010, pp. 211-229.