論　　文

Population Aging and Its Impact on Economic Growth*
—Implications for Korea—

Hyun-Hoon LEE** Kwanho SHIN** and Donghyun PARK**

Abstract

In this paper, we systematically assess the impact of population aging on economic growth using Penn World Table 9.0's newly available national-accounts growth rates, which is recommended by PWT for comparisons of growth rates across countries. Our empirical specification is an extended partial adjustment model which allows us to estimate the effects of demographic change in both the short run and long run. We use both five and ten year intervals for the period from 1960 to 2014. We find that population aging hampers economic growth in both short run and long run. We also find that elderly participation in the labor force has a positive influence on economic growth, which suggests that the harmful effect of aging can be mitigated by more active participation of the elderly in the labor force. Interestingly, we also find that the future level of population aging, not just the past level, has a detrimental effect on economic growth. Future aging may raise concerns about future growth prospects and thus adversely affect current economic activity.

In addition, we project how aging will affect Korea's future growth prospects. The projected growth rates decline continuously to −2.7% twenty years from the last year of the sample (in 2034), which is even lower than −1.6%, Japan's fitted growth rate for the most recent year. One possible explanation for why aging has a bigger impact on Korea than Japan is that aging is progressing even more rapidly in Korea than it did in Japan. Korea's economic future may thus be even gloomier than Japan's present because its demographic prospects are even worse.

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Lastly, we offer a number of policy options for Korea to mitigate the pronounced impact of population aging on economic growth. The Korean government has already actively taken a wide range of policy measures to address the aging challenge. Those measures are centered on efforts to boost fertility, but also include support for the elderly. Unfortunately, those measures have not been effective so far, as evidenced by the continued rapid progress of population aging. Going forward, one especially promising area of government intervention, in light of our empirical findings, is raising the participation of women in the workforce through a holistic package of policies that will enable women to better balance work and family.

JEL Classification Codes: J10, O10, O40
Keywords: Population aging, demographic transition, economic growth, Korea

人口高齢化と経済成長への影響 ——韓国へのインプリケーション——

Hyun-Hoon LEE, Kwanho SHIN and Donghyun PARK

〈要　旨〉

本論文では、成長率の国際比較に新たに利用可能となったPenn World Table 9.0'sを用い、人口高齢化の経済成長への影響を検証している。実証モデルとして、短期及び長期における人口構成の変化の影響が推定可能となる拡張された部分調整モデルを用いている。また、データについては、1960年から2014年の期間について、5年及び10年のインターバルを設けている。ここでの分析結果は、人口高齢化は短期及び長期の双方において経済成長を妨げること、また、高齢者の労働参加は経済成長にプラスの影響を有し、これは高齢化のマイナスの効果が、高齢者のより積極的な労働参加によって軽減されうることを示唆している。興味深いことに、過去の水準だけではなく、将来における人口高齢化の水準も経済成長にマイナスの影響を持つことが明らかとなった。将来の高齢化は、将来の成長見通しへの懸念を高め、その結果、現在の経済活動にマイナスの影響を与える可能性がある。

加えて、本論文では、どの程度高齢化が韓国の将来の成長見通しに影響を与えるかを予測している。予測された成長率は、予測最終年である2034年には継続的にマイナス2.7%まで低下し、これは、日本において推計される直近のマイナス1.6%を下回っている。日本に比べ、韓国での高齢化の影響が大きくなる1つの要因として、韓国での高齢化の進展が日本に比べより急速である可能性が挙げられる。人口構成に関する見通しはより厳しく、韓国経済の将来は、日本の現在の状況よりもより悲観的かもしれない。

最後に、韓国について、人口高齢化の経済成長への顕著な影響を軽減するための、いくつかの政策オプションを提案している。韓国政府は、すでに積極的に高齢化に対応するための幅広い施策を行っている。そうした施策は、出生率を引き上げるための努力が中心となっているが、高齢者のための支援も含まれる。しかしながら、引き続き人口高齢化が急速に進展していることにみられるように、これまでのところ、こうした政策は効果的ではない。今後について、実証結果に基づくと、政府による介入が特に期待できる分野として、よりよいワークライフバランスを可能とする総合的な政策パッケージを通じて、女性の労働参加を高めることが挙げられる。

JEL Classification Codes: J10, O10, O40

Keywords: 人口高齢化、人口構成の変化、経済成長、韓国

1. Introduction

During the past few decades, most countries in the world have experienced a rapid demographic transition from high fertility and mortality to low fertility and mortality. This transition has resulted in a pronounced increase in the share of old population in many countries, particularly in high-income countries such as Japan. Such a demographic transition is expected to have a negative impact on aggregate economic growth. However, some previous empirical studies examining the direct impact of population aging on economic growth have failed to uncover a negative relationship. For example, using a panel dataset for the period 1960–2005, Bloom, Canning and Fink (2008) find that the effect of old age on growth is negative in the short run, but insignificant in the long run. The authors argue that much of the negative effect of aging may have been mitigated by behavioral responses such as higher savings for retirement, greater labor force participation, and increased immigration of workers from developing countries. This line of argument can also be found in Bloom, Canning and Fink (2011) and Bloom, Canning and Finlay (2008).

Similarly, using the partial adjustment model in a panel framework and a dataset of 80 countries in 1960–2005, Lee *et al.* (2013a) find that unlike the share of the youth in population, the share of the elderly in total population or relative to the working age population, does not appear to hold back economic growth. The finding holds in both the short run and long run.

However, some other studies that examine the link between population aging and economic growth have found detrimental growth effects of population aging. For example, using a sample of over 100 countries, Park and Shin (2012) find that population aging has a negative impact on labor force participation, total factor productivity (TFP) growth, and the savings rate, even though it does not affect capital accumulation.

Therefore, it is important to re-assess systematically the impact of population aging on economic growth using data that have become available recently. In this regard, we use the Penn World Table 9.0's newly available national-accounts growth rates ($RGDP^{NA}$), which is recommended by PWT for studies comparing growth rates across countries. Second, we test whether population aging affects economic growth only when it reaches a certain high level. For this purpose, we split the whole sample into two groups: aged-country group and non-aged-country group. Third, we investigate if greater participation of women and the elderly in the workforce mitigates the negative impact of population aging on economic growth.

The rest of this paper is organized as follows. Section 2 provides information on our key variables such as demographic changes and GDP per capita growth rates. Section 3 explains the empirical framework, and Section 4 reports and discusses the main results. Section 5 projects Korea's future growth based on our empirical framework. More specifically, we use our empirical estimates to project Korea's future growth trajectory and compare it with Japan's past growth trajectory. Policy implications for Korea will be discussed in Section 6. A summary and concluding remarks are provided in Section 7.

2. Data and descriptive statistics

In this section, we discuss the data used in our empirical analysis and their descriptive statistics.

2. 1. Population aging

This paper aims to assess if population aging has a detrimental effect on economic growth, focusing on implications for Japan and Korea. Data on age structures are collected from World Bank's World Development Indicators online data base. We use data for the period from 1960 to 2014. Japan has been the most aged nation in the world. Korea is also in the midst of an unprecedented demographic transition toward older populations. Indeed, Korea is closely following in Japan's demographic footsteps and has already reached advanced stages of population aging.

Figure 1 illustrates the trend of old-age share and old-age dependency ratio for Japan, while Figure 2 illustrates the same trends for Korea. In case of Japan, the share of old age population (aged over 65) has been increasing, while the share of young population (aged below 15) has been decreasing. Since 1997, old age share has been greater than youth age share. As of 2014, Japan's old age share was 27.5%, more than twice its youth age share of 12.9%. A similar pattern is observed even when we use old age dependency ratio, or the percentage of old age population relative to working age population (aged between 15–64).

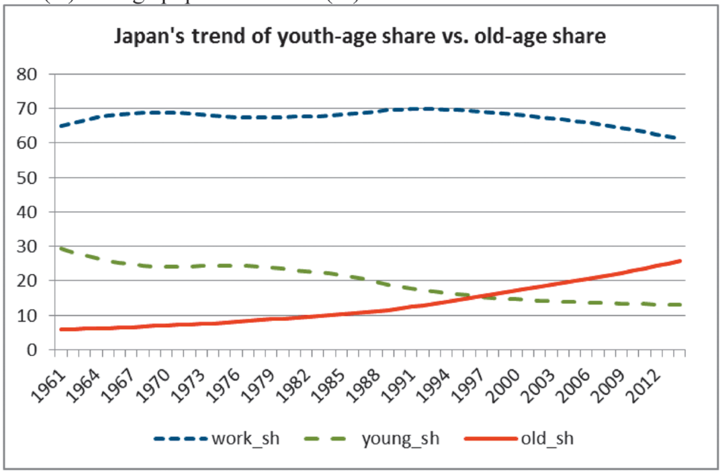
As Figure 2 shows, the pattern of increasing old age share and decreasing youth age share is also found for Korea, but as of 2014, Korea's old age share (12.6%)was still slightly smaller than youth age share (14.3). A similar pattern is also observed for dependency ratios.

Appendix Table 1 ranks 171 countries according to old age population share during 2010–2014.[1] Japan ranked top with the old age share of 24.3%, followed by Italy, Germany, Greece,

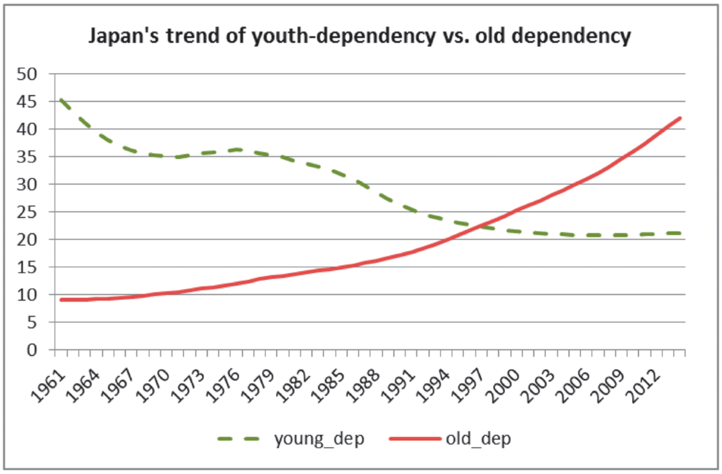
[1] In empirical analysis on the effects of population aging on economic growth, we use data on five-year averages for eleven periods of (1960–1964),(1965–1969),(1970–1974),(1975–1979),(1980–1984),(1985–1989),(1990–1994),(1995–1999),(2000–2004),(2005–2009), and (2010–2014).

Figure 1. Trend of population aging in Japan

(A) Old-age population share (%)



(B) Old-age population dependency rate (%)



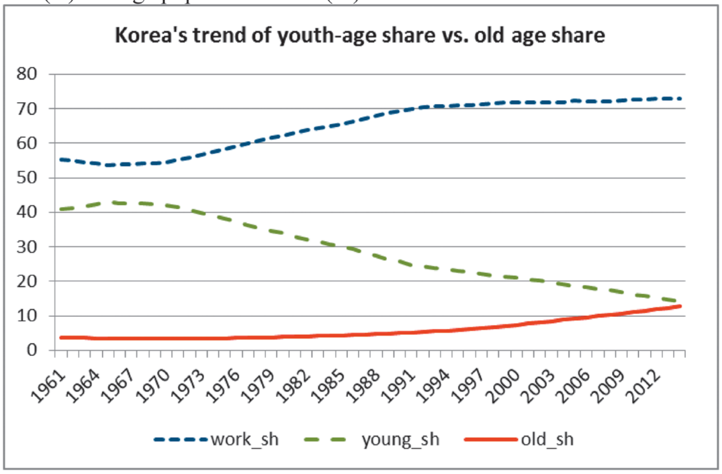
Data Source: World Bank's World Development Indicators (WDI) online database

and Portugal. Korea ranked 48th with an old age share of 11.86% during 2010–2014. Appendix Table 2 reports country ranking of five-year average changes in old age population share between period 1960–1964 and period 2010–2014. Japan stands out as the fastest aging country. Its old age population share increased by 1.84% every five years between 1960 and 2014. Korea ranked 25th, with an increase of 0.82% in its old age population share every five years. Thus, the speed of Korea's population aging speed has yet been slower than that of Japan.

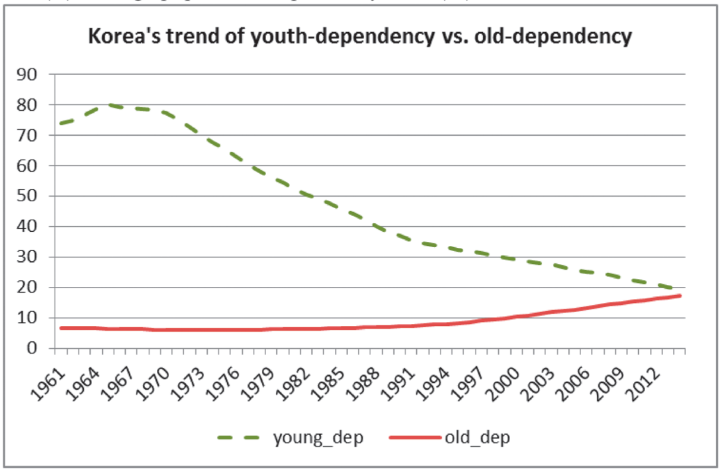
According to the U.N. (2015), Japan is projected to remain the oldest in the world with a median age of 51.5 years in 2030 and Korea is projected to become the 10th oldest nation in

Figure 2. Trend of population aging in Korea

(A) Old-age population share (%)



(B) Old-age population dependency ratio (%)



Data Source: World Bank's World Development Indicators (WDI) online database

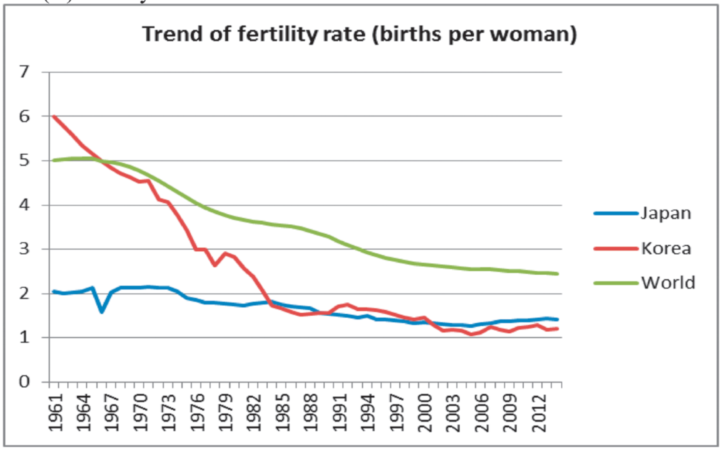
the world in 2030, with a median age of 47.5. However, Korea's population aging speed is projected to be faster than that of Japan and overtake Japan as the oldest nation in the world in 2050, with a median age of 53.9. Japan will be second, with a median age of 53.3.[2]

The main underlying reason is, of course, the rapidly declining fertility rate and increasing life expectancy, as illustrated in Figure 3. Korea's fertility rate (births per woman) has been declining very rapidly and has underperformed Japan since 2001. In contrast, Korea's life expectancy at

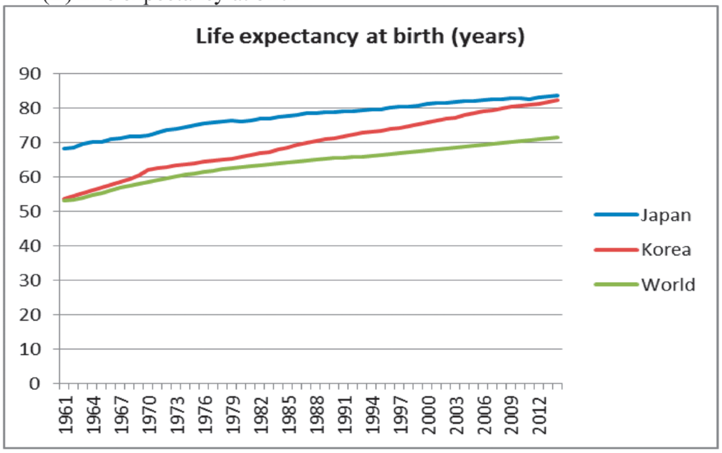
[2] World's projected median age is 33.1 in 2030 and 36.1 in 2050.

Figure 3. Trend of fertility rate and life expectancy at birth

(A) Fertility rate



(B) Life expectancy at birth



Data Source: World Bank's World Development Indicators (WDI) online database

birth has been increasing faster than Japan and is expected to reach the level of Japan soon.

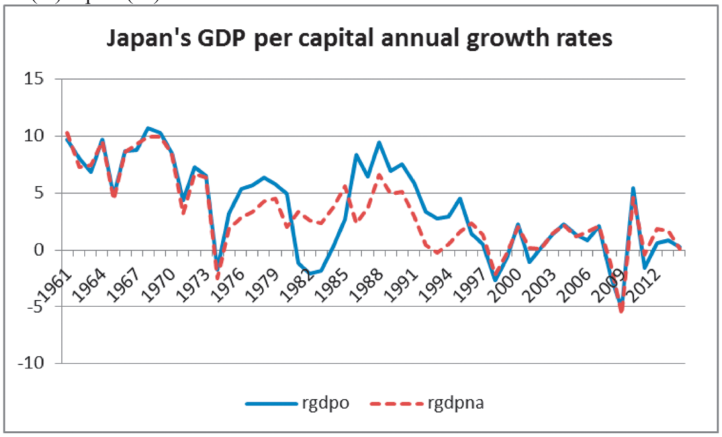
2. 2. GDP per capita growth rates

In caluculating the growth rate, we use per capita GDP reported in the Penn World Table version 9.0, released on June 9th, 2016.[3] The table increased country coverage to 182, and the

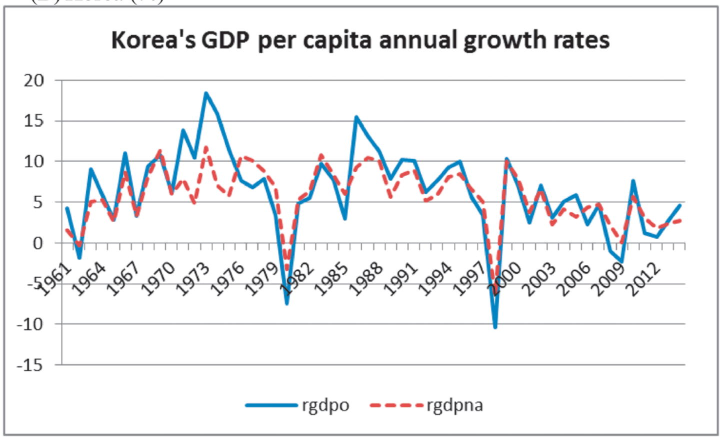
[3] As population aging progresses, GDP growth rate is more likey to be adversely affected than GNI growth rate if past savings were invested in foreign countries, generating interest income. Since we want to examine the impact of aging on real economic activity we use growth rate based on GDP data rather than GNI data.

Figure 4. Trend of GDP per capita growth rates for Japan and Korea

(A) Japan (%)



(B) Korea (%)



Data Source: Penn World Table (PWT) 9.0

time span to 2014. Most studies on determinants of economic growth have defined economic growth rate based on GDP per capita in US dollar terms. However, what matters most to the national wellbeing is not GDP per capita in US dollars but that in local currency units at constant prices. Therefore, among the five types of real GDP reported by the Penn World Table 9.0, we calculate economic growth rate using real GDP at constant 2011 national prices ($RGDP^{NA}$). PWT website recommends $RGDP^{NA}$ for studies comparing growth rates across countries (http://www.rug.nl/ggdc/productivity/pwt/).[4]

[4] Five types of real GDP are: $RGDP_{NA}$ (real GDP at constant 2011 national prices), $CGDP_e$ (expenditure-side real GDP at current PPPs), $CGDP_o$ (output-side real GDP at current PPPs), $RGDP_e$ (expenditure-side real GDP at chained PPPs), and $RGDP_o$ (output-side real GDP at chained PPPs).

We use data for the period from 1960 to 2014. Figure 4 (A) and 1 (B) present the trend of Japan and Korea's annual GDP per capita growth rates, respectively. Blue real line represents real growth rates based on national accounts (rgdpna), while red dotted line represents real growth rates of output-based GDP at chained PPPs (rgdpo).[5] In both countries, real growth rates of output-based GDP appear more volatile than those based on national accounts. This may be due to the fact that real growth rates of output-based GDP reflects changes in real exchange rates to some extent, even at chained PPPs.

While most previous studies use growth rates of GDP expressed in US dollar, we use real GDP per capita growth rates based on national accounts because as PWT recommends, it better reflects changes in national wellbeing.[6] Bloom, Canning and Fink (2008) and Lee *et al.* (2013a) also use GDP growth rates in US dollar in their study on the effects of population aging on economic growth and this may be one reason why they did not find a strong detrimental effect of population aging on economic growth.

3. Empirical specification

In this section, we describe our empirical model.

3. 1. Theoretical consideration

Following Lee *et al.* (2013a), we adopt the partial-adjustment model to regress the per capita GDP growth rates on a set of independent variables, including demographical variables. Lee *et al.* (2013a) assume that the aggregate output obeys a three-factor Cobb-Douglas production function:

$$Y=AK^{\alpha}H^{\phi}L^{1-\alpha-\phi} \tag{1}$$

where Y is gross domestic product (GDP), K is physical capital, H is human capital, L is labor force, and A is the productivity level. Dividing both sides by population, P, and taking the natural logarithm of both sides, they get

$$\ln y=\ln A+\alpha\ln k+\phi\ln H+(1-\alpha-\phi)\ln(L/P)-(\alpha+\phi)\ln P \tag{2}$$

[5] For more information, the reader is referred to User Guide to PWT 9.0 data files and Feenstra *et al.* (2015 and 2016).

[6] See the explanations on recommended uses of different GDP measures on the website http://www.rug.nl/ggdc/productivity/pwt/ (accessed on June 4th, 2017).

where y is GDP per capita and k is physical capital per capita. Equation (2) suggests that as a country's working-age population increases, it is likely to grow faster.

It is assumed that L is proxied by the working age population, so that

$$\ln y = \ln A + \alpha \ln k + \phi \ln H + (1-\alpha-\phi)\ln\left(\frac{P-C-O}{P}\right) - (\alpha+\phi)\ln P \tag{3}$$

where C is the youth population and O is the old population. Thus, Equation (3) suggests that as a country's youth-age share or old-age share increases, the country is likely to grow slower.

Following Lee *et al.* (2013a), we estimate the following growth equation.

$$(\ln y_t - \ln y_{t-1}) = -\delta \ln y_{t-1} + X_{t-1}\lambda_1 + (X_t - X_{t-1})\,\lambda_2 + \mu_t \tag{4}$$

where δ is the rate of adjustment (or speed of conversion) which is bounded by zero and one, X is a vector of explanatory variables, which are summarized in Equation (3), and μ_t is an error term.

In this partial-adjustment growth model, the λ coefficients on each level variables represents the long-run coefficient (β), while the λ coefficients on the first-difference variables represent the short-run adjustments to contemporaneous changes in the determinants of ln y. Bloom, Canning, and Finlay (2008) also estimate an equation which includes both lagged and first-differece terms of demographic variables. However, their equation includes only the lagged terms of the control variables. Therefore, our equation is more general.

3. 2. Empirical specification

We use a panel data set of 142 countries for the period 1960–2014.[7] In order to minimize the yearly fluctuations due to business cycles, we use five-year averages of variables for eleven sub-periods of (1960–1964), (1965–1969), (1970–1974), (1975–1979), (1980–1984), (1985–1989), (1990–1994), (1995–1999), (2000–2004), (2005–2009), and (2010–2014). We then calculate the growth rates of GDP per capita for 5 year interval (i.e. 1 period interval) and 10 year interval (i.e. 2 period interval).

Most studies use economic growth rate based on GDP per capita in US dollar terms. However, growth rate of GDP per capita in local currency units at constant prices is the one that matters most to the national wellbeing. Therefore, we calculate the dependent variable (GDP per capita growth rates) with $RGDP^{NA}$, real GDP using national-account growth rates of PWT

[7] 2014 is the latest year for which PWT version 9.0 is available.

9.0. Figure 1 illustrates trend of Japan and Korea's GDP per capita growth rate using 5-year interval. As seen in the figure, Korea's growth rates have been higher than that of Japan but have also been slowing down after it peaked during 1986–1990.

We control for country-fixed effects. We also include period dummies to take account of factors such as the global business cycle, global capital market shocks, and so forth. We assume that the productivity of the economy, ln (A), is a function of trade openness and time-invariant country fixed effects.

Then (4) becomes the following empirically testable equation:

$$\begin{aligned}(\ln RGDPna_{it} - \ln RGDPna_{it-1}) = &-\delta \ln RGDPo_{it-1} + \beta_1 \ln Pop_{it-1} + \beta_2 YoungSh_{it-1} + \beta_3 OldSh_{it-1} \\ &+ \beta_4 \ln Cap_{it-1} + \beta_5 hc_{it-1} + \beta_6 \ln Trd_{it-1} \\ &+ \beta_7 (\ln Pop_{it} - \ln Pop_{it-1}) + \beta_8 (YoungSh_{it} - YoungSh_{it-1}) + \beta_9 (OldSh_{it} - OldSh_{it-1}) \\ &+ \beta_{10} (\ln Cap_{it} - \ln Cap_{it-1}) + \beta_{11} (hc_{it} - hc_{it-1}) + \beta_{12} (\ln Trd_{it} - \ln Trd_{it-1}) \\ &+ \mu_i + \mu_t + \xi_t \end{aligned} \quad (5)$$

where

($\ln RGDPna_{it} - \ln RGDPna_{it-1}$)= Difference of log of real GDP per capita between t and $t-1$ (in 2011 national prices; PWT 9.0)

$\ln RGDPo_{it-1}$= Log of initial level of output-side real GDP per capita GDP (in 2011 US$; PWT 9.0)[8]

ln *Cap*= Log of capital stock at PPPs (in million 2011 US$; PWT 9.0)

hc= Human capital index (PWT 9.0)[9]

ln *Pop*= Log of total population (World Bank's WDI)

YoungSh= Population aged below 15 (youth age) as % of total (World Bank's WDI)

OldSh= Population aged above 65 (old age) as % of total (World Bank's WDI)

ln *Trd*= Log of trade as % of GDP (World Bank's WDI)

Thus, Equation (4) will be estimated using Ordinary Least Squares (OLS), with inclusion of country-specific and period-specific effects. We restrict our analysis of 1960–2014 to those countries where all series of interest are available for the full sample period, resulting in a panel of 142 countries.

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[8] For the sake of comparison across countries, the initial level of GDP per capita in the equation is real GDP per capita in US$, instead of real GDP per capita in national prices.

[9] For details of human capital index, see http://www.rug.nl/ggdc/docs/human_capital_in_pwt_90.pdf

4. Empirical results

In this section, we report and discuss the main results. Reported in Table are the benchmark results when working-age population share is included as a demographic variable. Columns (1) and (2) are our preferred results when real GDP per capita growth rates are calculated using PWT 9.0's GDP based on national accounts ($RGDP_{NA}$). Column (1) reports the results when growth rates and all explanatory variables are calculated with five-year intervals using five-year averages, while Column (2) reports the results for 10-year intervals, as explained in Section 3. For the sake of comparison, we also report in Columns (3) and (4) the corresponding results when growth rates are calculated using GDP per capita in constant 2010 US$ ($RGDP_{WDI}$), obtained from World Bank's World Development Indicators (WDI) Online database.

Let us focus on Columns (1) and (2). The coefficient on the initial level of income per capita is negative and significant at the one percent level, indicating that high-income countries grow slower than low-income countries, in line with much of the existing empirical literature on growth. The coefficient on the initial value of the log of population is negative and significant. Population growth does not appear to have a significant impact on economic growth in the short run. On the other hand, both the initial working-age population share and its change over a 5 year period carry positive and highly significant coefficients, suggesting that countries with grater shares of working-age population grow faster not only in the short run but also in the long run.

In addition, we find that countries with larger amounts of physical capital enjoy higher rates of economic growth both in the short run and in the long run. However, human capital does not have a significant impact on economic growh. This is consistent with existing literature and is perhaps due to the close relationship between the level of GDP per capita and the level of human capital, which are both included as regressors. Countries that are more open to trade grow faster.

When economic growth rates are calculated using WDI's real GDP per capita, as reported in Columns (3) and (4), the key results are qualitatively similar. But the magnitude of the coefficients for the working age population share, both lagged level and change, appear larger.

Using economic growth rates calculated with PWT's real GDP in national accounts, Table 2 reports the estimated results when the working-age population share is replaced with young-age population share and old-age population share. As seen in Column (1), both the initial youth population share and its change over the 5 year period carry negative and significant coefficients, suggesting that countries with greater youth dependency ratio grow slower both in

Table 1. Effects of working-age population on economic growth

VARIABLES	PWT9.0's $RGDP_{NA}$		WDI's Real GDP in US$	
	(1)	(2)	(3)	(4)
	5-yr interval	10-yr interval	5-yr interval	10-yr interval
$\ln RGDPo_{t-1}$	-0.214***	-0.429***		
	[0.034]	[0.054]		
$\ln RGDP_{WDI\ t-1}$			-0.197***	-0.433***
			[0.027]	[0.055]
$\ln Pop_{t-1}$	-0.088*	-0.285***	-0.148***	-0.348***
	[0.045]	[0.093]	[0.041]	[0.077]
$Work_{t-1}$	0.012***	0.021***	0.014***	0.029***
	[0.003]	[0.005]	[0.003]	[0.005]
Cap_{t-1}	0.054**	0.147***	0.035***	0.121***
	[0.022]	[0.044]	[0.014]	[0.027]
hc_{t-1}	-0.043	-0.045	-0.054	-0.077
	[0.048]	[0.097]	[0.049]	[0.105]
$\ln Ttrd_{t-1}$	0.065**	0.140***	0.070*	0.138*
	[0.030]	[0.053]	[0.039]	[0.080]
$\ln Pop_t - \ln Pop_{t-1}$	0.168	-0.099	0.296	0.159
	[0.250]	[0.198]	[0.264]	[0.307]
$Work_t - Work_{t-1}$	0.016***	0.017***	0.021***	0.026***
	[0.005]	[0.006]	[0.005]	[0.006]
$Cap_t - Cap_{t-1}$	0.122***	0.110***	0.160***	0.194***
	[0.035]	[0.039]	[0.028]	[0.039]
$hc_t - hc_{t-1}$	-0.174	-0.168	-0.122	-0.153
	[0.113]	[0.126]	[0.114]	[0.128]
$\ln Ttrd_t - \ln Ttrd_{t-1}$	0.076*	0.122**	0.053	0.096*
	[0.045]	[0.054]	[0.036]	[0.057]
Observations	1,144	559	1,188	534
Number of countries	142	141	139	138
R-squared	0.348	0.496	0.338	0.504

Notes: 1. Panel estimation with country-specific and period-specific effects. 2. Robust standard errors are in parentheses. 3. ***, **, and * indicate th esignificance levels of 1, 5, and 10 percent, respectively.

the short run and in the long run. It is also found that the coefficients on both the initial value of old population share and on its change are negative and significant. Therefore, population aging may have a negative impact on economic growth not only in the short run but also in the long run. More specifically, a 10 percentage point increase in the old age share will decrease the five-year economic growth rate by 0.2 points (or 20 percentage points) in the long run, leading to a lower steady state income per capita. If the change in the old-age share increases by one percentage point over a 5 year period, the five-year economic growth rate will decrease by 0.034 point (or 3.4 percentage points). In fact, population aging has a bigger negative impact on economic growth than the share of youth in the population.

Because Equation (4) does not specify the exact form of demographic variables, we also report the results when the old and young population shares (*YoungSh* and *OldSh*) are replaced with old and young population dependency ratios (*YoungDep* and *OldDep*). The results, shown in column (2) are similar in the sense that the old-age share has a negative impact on economic growth. For further robustness checks, we also report the results obtained from data for ten-year intervals, rather than five-year intervals, of all dependent and independent variabls. The results are reported in Columns (3) and (4) of Table 2. The results are qualitatively the same. Old-age share has a negative impact on economic growth not only in the short run but also in the long run.

For the sake of comparison, we also report the corresponding results when economic growth rates are calculated using WDI's real GDP per capita. The results are reported in Table 3. When growth rates are expressed in US$ rather than in national currencies, the demographic burden of young population share appears bigger and becomes more significant, while that of old population share appears smaller. However, the coefficient of the old age share is negative and statistically significant at the 1% level. Further its size is quite comparable to that estimated in Table 2. Therefore, while the evidence of the negative impact of aging is more significant if we use economic growth rates calculated with PWT's real GDP in national accounts, we also obtain more or less consistent results even with the WDI data.

As a second step, we test if the negative effect of population aging can be mitigated by behavioral responses. In particular, we test if high labor participation of women and elderly help increase economic growth. For this purpose, we add two sets of variables: labor force participation rate of females aged 15 and 64 (*LbrPtc_f*) and labor force participation rate of people over 65 (*LbrPtc_65*), which are both taken from International Labour Organization (ILO)'s online database (ILOSTAT).

Column 1 in Table 4 reports the results when the dependent variable is economic growth rates based on PWT9.0's real GDP in national accounts. The labor force participation rate of women does not appear to have a positive impact on economic growth. In contrast, labor participation rate of the elderly is found to influence economic growth positively and significantly in the long run as shown in Columns (1) and (3), and also in the short run as shown in Column (1). With the inclusion of labor participation variables, old age population share continues to enter with a statistically significant negative sign both in the long run and in the short run. Be-

Table 2. Effects of population aging on economic growth (PWT9.0's $RGDP_{NA}$)

	5-year interval		10-year interval	
VARIABLES	(1)	(2)	(3)	(4)
ln*RGDPo* $_{t-1}$	-0.212***	-0.209***	-0.417***	-0.419***
	[0.034]	[0.034]	[0.053]	[0.054]
ln*Pop* $_{t-1}$	-0.175***	-0.168***	-0.370***	-0.362***
	[0.054]	[0.053]	[0.101]	[0.098]
YoungSh $_{t-1}$	-0.012***		-0.021***	
	[0.003]		[0.005]	
OldSh $_{t-1}$	-0.020***		-0.041***	
	[0.006]		[0.012]	
YoungDep $_{t-1}$		-0.004***		-0.006***
		[0.001]		[0.002]
OldDep $_{t-1}$		-0.008**		-0.019***
		[0.003]		[0.007]
Cap $_{t-1}$	0.057**	0.060***	0.151***	0.158***
	[0.022]	[0.022]	[0.044]	[0.045]
hc $_{t-1}$	-0.035	-0.026	-0.024	-0.016
	[0.049]	[0.051]	[0.102]	[0.104]
ln*Ttrd* $_{t-1}$	0.067**	0.066**	0.144***	0.142***
	[0.030]	[0.031]	[0.053]	[0.054]
ln*Pop* $_t$ - ln*Pop* $_{t-1}$	-0.037	-0.048	-0.243	-0.220
	[0.260]	[0.260]	[0.189]	[0.191]
YoungSh $_t$ - *YoungSh* $_{t-1}$	-0.014**		-0.014**	
	[0.006]		[0.006]	
OldSh $_t$ - *OldSh* $_{t-1}$	-0.034***		-0.046***	
	[0.011]		[0.012]	
YoungDep $_t$ - *YoungDep* $_{-1}$		-0.002		-0.003
		[0.002]		[0.002]
OldDep $_t$ - *OldDep* $_{t-1}$		-0.020***		-0.023***
		[0.006]		[0.007]
Cap $_t$ - *Cap* $_{t-1}$	0.119***	0.120***	0.105***	0.108***
	[0.036]	[0.037]	[0.038]	[0.039]
hc $_t$ - *hc* $_{t-1}$	-0.160	-0.151	-0.146	-0.137
	[0.112]	[0.113]	[0.126]	[0.127]
ln*Ttrd* $_t$ - ln*Ttrd* $_{t-1}$	0.078*	0.079*	0.127**	0.125**
	[0.045]	[0.046]	[0.053]	[0.054]
Observations	1,144	1,144	559	559
Number of countries	142	142	141	141
R-squared	0.351	0.343	0.505	0.499

Notes: 1. Panel estimation with country-specific and period-specific effects. 2. Robust standard errors are in parentheses. 3. ***, **, and * indicate the significance levels of 1, 5, and 10 percent, respectively.

Table 3. Effects of population aging on economic growth (WDI's Real GDP in US$)

	5-year interval		10-year interval	
VARIABLES	(1)	(2)	(3)	(4)
ln*RGDPo* $_{t-1}$	-0.196***	-0.191***	-0.425***	-0.417***
	[0.027]	[0.027]	[0.055]	[0.055]
ln*Pop* $_{t-1}$	-0.150***	-0.154***	-0.355***	-0.367***
	[0.048]	[0.046]	[0.093]	[0.087]
YoungSh $_{t-1}$	-0.014***		-0.029***	
	[0.003]		[0.005]	
OldSh $_{t-1}$	-0.015***		-0.032***	
	[0.006]		[0.012]	
YoungDep $_{t-1}$		-0.004***		-0.009***
		[0.001]		[0.002]
OldDep $_{t-1}$		-0.005		-0.011*
		[0.003]		[0.007]
Cap $_{t-1}$	0.037***	0.039***	0.123***	0.128***
	[0.013]	[0.014]	[0.027]	[0.028]
hc $_{t-1}$	-0.052	-0.042	-0.074	-0.063
	[0.050]	[0.051]	[0.106]	[0.109]
ln*Ttrd* $_{t-1}$	0.071*	0.070*	0.139*	0.138*
	[0.039]	[0.040]	[0.081]	[0.082]
ln*Pop* $_t$ - ln*Pop* $_{t-1}$	0.245	0.199	0.042	0.033
	[0.292]	[0.283]	[0.348]	[0.330]
YoungSh $_t$ - *YoungSh* $_{t-1}$	-0.020***		-0.024***	
	[0.006]		[0.007]	
OldSh $_t$ - *OldSh* $_{t-1}$	-0.033***		-0.048***	
	[0.010]		[0.012]	
YoungDep $_t$ - *YoungDep* $_{-1}$		-0.005**		-0.007***
		[0.002]		[0.002]
OldDep $_t$ - *OldDep* $_{t-1}$		-0.019***		-0.023***
		[0.005]		[0.006]
Cap $_t$ - *Cap* $_{t-1}$	0.160***	0.161***	0.193***	0.197***
	[0.029]	[0.029]	[0.039]	[0.040]
hc $_t$ - *hc* $_{t-1}$	-0.119	-0.112	-0.148	-0.144
	[0.115]	[0.109]	[0.127]	[0.122]
ln*Ttrd* $_t$ - ln*Ttrd* $_{t-1}$	0.053	0.053	0.098*	0.097
	[0.037]	[0.037]	[0.058]	[0.059]
Observations	1,098	1,098	534	534
Number of countries	139	139	138	138
R-squared	0.356	0.346	0.509	0.500

Notes: 1. Panel estimation with country-specific and period-specific effects. 2. Robust standard errors are in parentheses. 3. ***, **, and * indicate the significance levels of 1, 5, and 10 percent, respectively.

Table 4　Effects of population aging and labor participation on economic growth (PWT9.0's $RGDP_{NA}$)

	Five-year interval		Ten-year interval	
VARIABLES	(1)	(2)	(3)	(4)
ln*RGDPo* $_{t-1}$	-0.265***	-0.262***	-0.613***	-0.620***
	[0.064]	[0.060]	[0.115]	[0.114]
ln*Pop* $_{t-1}$	-0.227	-0.217	-0.743**	-0.747**
	[0.153]	[0.156]	[0.291]	[0.297]
YoungSh $_{t-1}$	-0.018***	-0.018***	-0.041***	-0.039***
	[0.003]	[0.003]	[0.009]	[0.009]
OldSh $_{t-1}$	-0.016**	-0.016***	-0.043***	-0.043***
	[0.007]	[0.006]	[0.011]	[0.010]
LbrPtc_65 $_{t-1}$	0.004*		0.009*	
	[0.002]		[0.005]	
LbrPtc_f $_{t-1}$	-0.002		-0.001	
	[0.002]		[0.004]	
Cap $_{t-1}$	0.073	0.058	0.194*	0.171
	[0.066]	[0.061]	[0.108]	[0.108]
hc $_{t-1}$	-0.059	-0.088	-0.094	-0.159
	[0.128]	[0.143]	[0.185]	[0.215]
ln*Ttrd* $_{t-1}$	0.053	0.059	0.002	0.019
	[0.051]	[0.052]	[0.127]	[0.120]
ln*Pop* $_{t}$ - ln*Pop* $_{t-1}$	-0.745***	-0.693***	-0.599	-0.621
	[0.230]	[0.225]	[0.417]	[0.441]
YoungSh $_{t}$ - *YoungSh* $_{t-1}$	-0.021***	-0.021***	-0.028***	-0.028***
	[0.006]	[0.007]	[0.010]	[0.010]
OldSh $_{t}$ - *OldSh* $_{t-1}$	-0.029**	-0.022*	-0.034**	-0.028**
	[0.013]	[0.012]	[0.014]	[0.012]
LbrPtc_65 $_{t}$ - *LbrPtc_65* $_{t-1}$	0.005**		0.006	
	[0.002]		[0.004]	
LbrPtc_f $_{t}$ - *LbrPtc_f* $_{t-1}$	-0.002		-0.001	
	[0.002]		[0.003]	
Cap $_{t}$ - *Cap* $_{t-1}$	0.110**	0.097*	-0.009	-0.026
	[0.055]	[0.055]	[0.059]	[0.057]
hc $_{t}$ - *hc* $_{t-1}$	0.043	0.057	0.020	0.067
	[0.113]	[0.140]	[0.183]	[0.215]
ln*Ttrd* $_{t}$ - ln*Ttrd* $_{t-1}$	-0.032	-0.027	-0.076	-0.060
	[0.065]	[0.066]	[0.090]	[0.094]
Observations	357	357	154	154
Number of countries	80	80	72	72
R-squared	0.575	0.563	0.819	0.807

Notes: 1. Panel estimation with country-specific and period-specific effects. 2. Robust standard errors are in parentheses. 3. ***, **, and * indicate the significance levels of 1, 5, and 10 percent, respectively.

Table 5. Effects of "future" population aging on economic growth (PWT9.0's $RGDP_{NA}$)

	Five-year interval		Ten-year interval	
VARIABLES	(1)	(2)	(3)	(4)
ln*RGDPo* $_{t-1}$	-0.216***	-0.217***	-0.361***	-0.364***
	[0.040]	[0.040]	[0.082]	[0.080]
ln*Pop* $_{t-1}$	-0.273***	-0.274***	-0.485***	-0.488***
	[0.066]	[0.065]	[0.155]	[0.147]
YoungSh $_{t-1}$	-0.022***		-0.026***	
	[0.005]		[0.008]	
OldSh $_{t-1}$	0.019		-0.045**	
	[0.014]		[0.023]	
YoungSh $_{t+1}$	0.011*		0.003	
	[0.006]		[0.008]	
OldSh $_{t+1}$	-0.041***		-0.007	
	[0.013]		[0.014]	
YoungDep $_{t-1}$		-0.008***		-0.007**
		[0.002]		[0.003]
OldDep $_{t-1}$		0.013*		-0.020
		[0.007]		[0.013]
YoungDep $_{t+1}$		0.005**		0.001
		[0.002]		[0.003]
OldDep $_{t+1}$		-0.022***		-0.004
		[0.007]		[0.007]
Cap $_{t-1}$	0.060**	0.063**	0.106	0.114
	[0.026]	[0.026]	[0.074]	[0.073]
hc $_{t-1}$	-0.053	-0.044	-0.043	-0.036
	[0.064]	[0.065]	[0.132]	[0.134]
ln*Ttrd* $_{t-1}$	0.065**	0.064*	0.124**	0.124**
	[0.032]	[0.033]	[0.057]	[0.059]
ln*Pop* $_{t}$ - ln*Pop* $_{t-1}$	-0.171	-0.165	-0.387	-0.444
	[0.276]	[0.276]	[0.434]	[0.448]
YoungSh $_{t}$ - *YoungSh* $_{t-1}$	-0.031***		-0.016*	
	[0.009]		[0.009]	
OldSh $_{t}$ - *OldSh* $_{t-1}$	0.040		-0.025	
	[0.025]		[0.020]	
YoungDep $_{t}$ - *YoungDep* $_{-1}$		-0.010***		-0.003
		[0.003]		[0.003]
OldDep $_{t}$ - *OldDep* $_{t-1}$		0.022		-0.010
		[0.013]		[0.012]
Cap $_{t}$ - *Cap* $_{t-1}$	0.120***	0.124***	0.112*	0.116*
	[0.044]	[0.045]	[0.060]	[0.061]
hc $_{t}$ - *hc* $_{t-1}$	-0.194	-0.187	-0.188	-0.179
	[0.146]	[0.147]	[0.175]	[0.168]
ln*Ttrd* $_{t}$ - ln*Ttrd* $_{t-1}$	0.091**	0.090**	0.126**	0.126**
	[0.044]	[0.045]	[0.059]	[0.060]
Observations	1,005	1,005	421	421
Number of countries	141	141	134	134
R-squared	0.378	0.368	0.486	0.479

Notes: 1. Panel estimation with country-specific and period-specific effects. 2. Robust standard errors are in parentheses. 3. ***, **, and * indicate the significance levels of 1, 5, and 10 percent, respectively.

cause the inclusion of labor participations rates in regression results in the loss of many countries in the sample, Column (2) and (4) report the results without these two labor participation rate variables but using the same sample group as in Column (1).

Even if population aging has not yet reached an advanced stage, but is expected to reach such a high level in the foreseeable future, business firms and consumers alike become more pessimistic about future growth prospects, adversely affecting investment and consumption.[10] In fact, future demographic structure can be predicted with reasonable accuracy. Therefore we test if tomorrow's demographic structure affects economic growth today by re-running the regressions with inclusion of the lead variables of young and old shares (and dependency ratios). Table 5 reports the results. Indeed, the lead variables for old population share and old dependency ratio carry significant negative coefficients when growth rates are calculated using a five-year interval, as seen in Columns (1) and (2). Therefore, interestingly and significantly, we find that the future level of population aging, not just the past level, has a detrimental effect on economic growth. In contrast, future population share of the young has a positive effect on current growth. The prospects of more future workers and consumers boosts confidence and economic activity today.

In summary, our major empirical findings are:

(i) Population aging hampers economic growth in both short run and long run.

(ii) Elderly participation in labor force has a positive influence on economic growth.

(iii) The future level of population aging, not just the past level, has a detrimental effect on economic growth.

5. Projection for Korea's future growth

In this section, we will examine Korea's future aging trajectory and compare it with Japan's past experiences. We will also investigate how aging affects Korea's future growth prospects. In order to check whether the trends of Korea's other demographic charateristics closely Japan's trends, with a lag of about twenty years, Figure 5 places future projections for Korea's old dependency ratio, young dependency ratio, and working-age population ratio in parallel with Japan's, with a twenty-year-lag. In other words, the figure illustrates future projections of Korea's three ratios from 2016 to 2036 along with Japan's actual ratios from 1996 to 2016. The figure confirms that the three pairs of old dependency ratio, young dependency ratio and work-

[10] We thank Shin-ichi Fukuda for this very insightful comment.