Population Aging in Korea: Implications for Fiscal Sustainability

Sungjin Cho and Jan R. Kim

Adverse demographics in Korea impinges on its growth potential and fiscal outlook. Accordingly, this study examines the current demographic situation and recent projections related to the impacts of population aging in Korea, particularly on the looming fiscal imbalance. The focal conclusion is that a two-way effect exists from population aging. First is the anticipated stress placed on government finances due to increasing welfare expenditure for the elderly. Second is sluggish economic growth and thus the inability to collect sufficient government revenues. The prospect of large and growing deficits is therefore immediate and potentially long lasting as governments will be faced with rising spending demands and sluggish tax revenues arising simultaneously from an aging population.

Keywords: Population aging, Public spending, Tax revenues, Fiscal imbalance

JEL Classification: E62, H60, J11

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I. Introduction

Population aging is an irreversible global trend. According to the UN (2017), a total of 962 million people are aged 60 years or over in 2017 Worldwide, which is an increase of 152 percent over the 383 million in 1980. This number is projected to grow to more than double its 2017 size, reaching nearly 2.1 billion. In terms of population aging, Korea is one of the world's fastest aging countries. Owing to the continued extension of longevity couple with the steep decline in fertility rate, the size and percentage of the elderly population (*i.e.*, aged 65 and above) rapidly increased in the past three decades. As of the end of 2019, the share of people aged 65 or older was 15.5 percent out of the total population, up from 14.2 percent in 2018. A study by the National Statistics Office (2019) shows that Korea will become the world's most aged society by 2067, with the senior population to comprise 46.5 percent of the population.

Falling marriage rates and dismally low child births along with longer life are the main causes of the country's demographic crisis, calling for concern about dire macroeconomic consequences. Despite ample research over the past decades regarding the likely consequences of population aging, on macroeconomy in general and government finances in particular, policy action from the government's end has only recently begun its implementation. This current study aims to grasp the current demographic situation and recent projections regarding population aging in Korea, particularly on the macroeconomic implication of population aging.

This study provides anecdotal and empirical investigation regarding the effects of population aging on the Korean economy, focusing on the two-way effect from population aging found in recent research and projections. The first effect is the anticipated stress placed on government finances due to increasing expenditure for the elderly as examined in Hsu and Yamada (2019). As the population is getting older, municipal and central governments are forced to devote additional resources to meet the higher demands placed on programs such as senior healthcare or pension, unless significant changes are made in the structure of these programs or their benefits. The second effect arising from population aging is sluggish economic growth as discussed in Aksoy *et al.* (2019), which in turn leads to slower growth in government revenues. As a lower proportion of population will be able

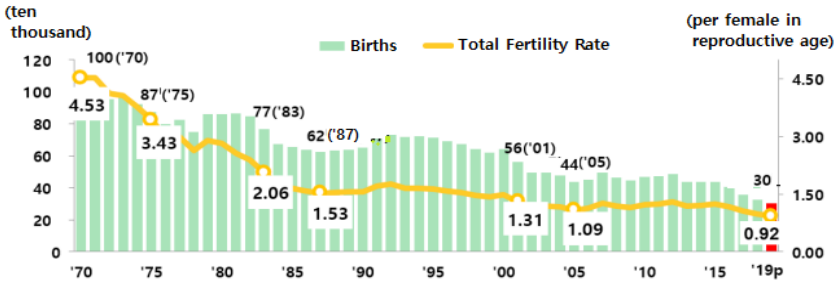
to participate in the labor market, overall rates of economic growth are bound to fall, which will in turn have negative effects on governments' ability to raise revenues. The prospect of large and growing deficits is therefore immediate and potentially long lasting, as governments will be faced with increasing spending demands but sluggish tax revenues simultaneously arising from an aging population. For example, IMF (2005) reports a one percent increase in labor force as improving fiscal balance by 0.06 percent point, whereas a one percent point increase in the aged population leads to a 0.041 percent point decrease in the per-capita GDP.

This study is structured as follows. The next section examines the trend of demographic shift in Korea and the ensuing projected changes in the near future. Possible impacts of this change on labor markets and economic growth will also be assessed. We then analyze how demographic changes are projected to impact spending on health care and welfare programs for seniors. The next section analyzes how spending surges in these areas affect the fiscal balance (deficits or surpluses) of central government. In the final section, we develop an empirical model to quantify the effect of population aging on the Korean economy, with emphasis on labor productivity, income, and healthcare spending. The paper ends with a brief conclusion.

II. Demographic Changes in Korea

The growth in a country's population is affected by three factors: birth rate, death rate, and net immigration. For much of her history, the population growth in Korea was the result of natural increases, *i.e.*, the difference between births and deaths, whereas the role of net immigration has been negligible. According to the National Statistics Office (2019, 2020), however, Korea's recent fertility rate has fallen below the level necessary to replace existing population.[1] The result of

[1] The fertility rate is commonly defined as the number of births a woman is expected to have by the end of her reproductive years. Since the 1990s, the fertility in Korea has declined dramatically. In the early 1950s and 1960s, the fertility rate in Korea was 5.6 children per women. By contrast, the figure tumbled to 0.98 in 2018 and 0.92 in 2019. The current fertility rate is far below the replacement fertility rate of 2.1, at which the size of total population is maintained.



(a) Births and Fertility Rates

(b) Population

Source: National Statistics Office (2019, 2020)

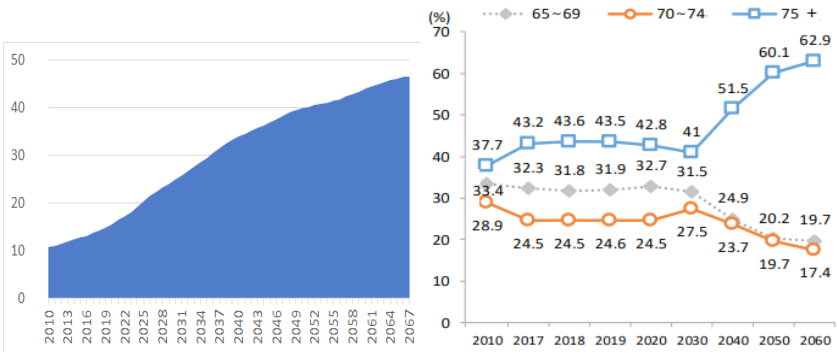
Notes: Data for 2020 and onwards are projections based on the medium-population growth scenario.

FIGURE 1

RECENT DEMOGRAPHIC TREND OF KOREA

a declining fertility rate has been a continued slowdown in population growth. Figure 1 below illustrates such a drastic shift in demographics.

The average annual population growth rate in the 1970s was 2.2 percent, which is in stark contrast to the average annual population growth rate for the most recent decade of 2009–2019 at only 0.48 percent. Compared with the 1960s, the recent figure is an 81 percent decline. Based on the medium growth projection by the National Statistics Office, Korea's future population growth rate is projected to continue declining. For example, the population growth rate is projected to turn negative by 2029. By 2067, the end point in the current forecast by the National Statistics Office (2020) predicts the population growth rate to be -1.26 percent.



(a) Share of 65 + among the Population (b) Projection of 65+ Population

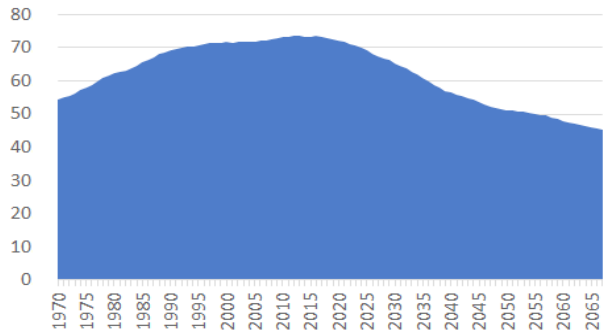
Source: National Statistics Office (2019)

FIGURE 2
POPULATION OVER 65 YEARS OLD

Apart from slower and even negative population growth, another demographic shift Korea is expected to undergo is the increase in life expectancy.[2] For example, according to OECD (2019), life expectancy at birth increased for women from 65.8 years to 85.71 years and for men from 58.7 years to 79.7 years over the period of 1970 to 2017.

One combined effect of a lower population growth and extended life expectancy is that seniors will take a fast-increasing portion of future population. Figure 2 shows two aging-related statistics. Panel (a) plots the share of those over the age of 65 among the entire population starting in 2010. From 2010 to 2067, the seniors' share in Korean population is projected to increase from a little over 10 percent to over 46 percent. The growth rate will be highest from now until the late-2030s, at which point the senior share of the population will have increased to approximately 34 percent. This rapid increase in the share of the population over 65 is a result of the aging of the so-called "baby boomers," those born in the years following the Korean War. The senior share of the population is expected to grow at a little slower rate in the decades after the late-2030s but continuously increasing to roughly 47 percent of the overall population by 2067. More striking in panel (b) is

[2] Life expectancy at birth measures the number of years a newborn infant would live if the current patterns of mortality at the time of its birth were to remain over its entire life.



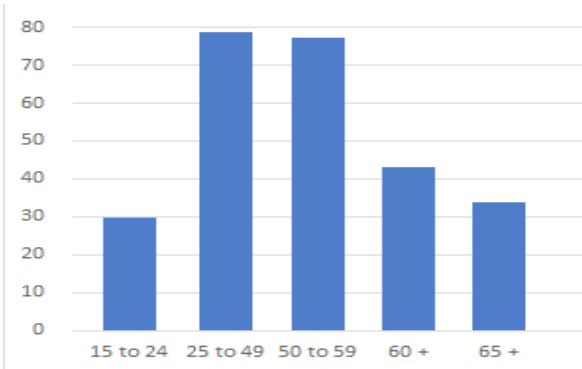
Source: KOSIS database (http://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1BPA003&conn_path=I3)

FIGURE 3
SHARE OF WORKING-AGE POPULATION

that the age composition of the seniors is expected to shift toward those over 75 years of age, whereas the share of relatively young seniors aged between 65 and 69 is projected to decline.

The share of productive population will also be affected by this trend of aging. Figure 3 shows the working age (15-64 years old) share of the population from 1970 to 2063. This period is first characterized by a rapid increase in the share of the working age population as the baby boomers entered the labor force in the early period of fast economic growth. The working age share of the total population peaked in 2013 at nearly 74 percent. As this group slowly begins to reach the age of 65, the working age share is expected to continuously decline to as low as 45 percent by 2067.

The combination of the rising share of the aged population and the falling share of the working age population inevitably affect labor force participation, which simply measures the total labor force as a share of the overall population. As Figure 4 shows, the labor force participation of those 65 and over is dramatically lower than those in other younger age categories. For example, approximately 79 percent and 77 percent of Koreans aged between 25 to 49 and 50 to 59, respectively, were either employed or actively looking for work in 2019. This demographics compares to approximately 34 percent of Koreans over 65 who were participating in the labor force. Figure 4 demonstrates that, as the share of seniors in the population increases, Korea's overall labor force



Source: KOSIS database
(http://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1DA7002S)

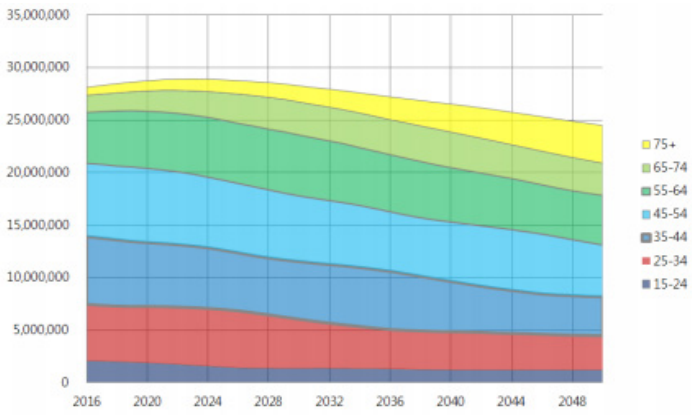
Figure 4
Labor Force Participation Rates by Age in 2019

participation rate will certainly fall, unless a marked increase happens in seniors' participation in the labor force.

This dire prediction is also reflected in Figure 5, which plots the forecasts of total labor force and its decompositions into different age groups, conditional on the labor force participation rate of 2016 and the projected demographic transitions. Korea's total labor force is expected to fall to approximately 27.4 million by 2035 and to 24.5 by 2050. On top of this prediction, age composition of labor force is also expected to shift toward the old age group. Whereas the size of young labor force (below 45 years old) is likely to decrease by roughly 40 percent by the year 2050, the share of old labor force (above 65 years old) will increase from the current level of less than 10 percent to nearly one-fourth of the total labor force by 2050.

The expected decline in the labor force will also influence the future growth of real GDP. According to the growth accounting approach, the growth in real GDP of a country can be attributed to three factors: increases in the fraction of the labor force employed, accumulation of physical capital, and increases in total factor productivity. Figure 6 displays historical (1972–2010) and projected (2021–2060) decomposition of average annual growth in real GDP into the contributions from each of the three components mentioned above.

The results of historical decomposition support the major role played by quantitative factors such as labor force and physical capital.

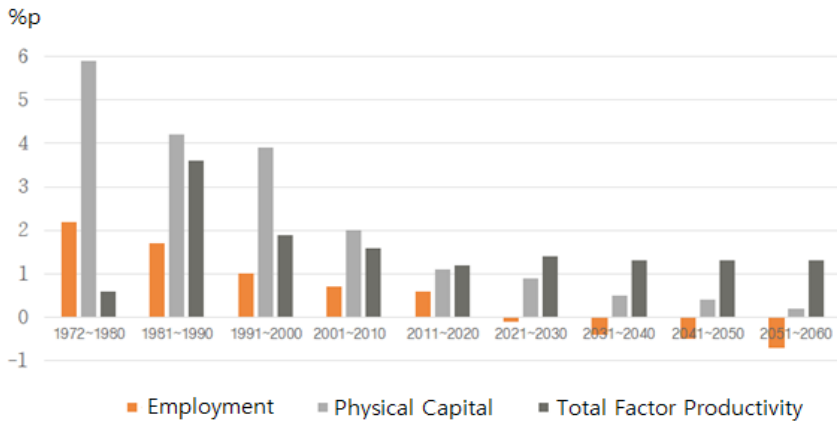


Source: Lee and Lee (2017)

Figure 5
Labor Force Projection by Age (2016–2050)

Apparently, the 70s and 80s were characterized with unprecedented fast economic growth in Korea. Most of the real GDP growth was attributable to the accumulation of physical capital. What should not be overlooked is the contribution of labor force, especially during the 80s. In the growth accounting method, qualitative gains in human capital are incorporated into the total factor productivity growth. That being the case, the marked contribution of the total factor productivity in the 80s was highly likely to have benefited from the labor force. As the baby boomers with solid public education started entering the job market in the 80s, the growth potential of the Korean economy was enhanced by the improvement in labor force at both the quantitative and the qualitative margins. This occurrence is typical of the phenomenon known as the demographic dividend: when a large percentage of a country's population is in the working ages as a result of low fertility and declining mortality, the working-age population benefits from a relatively small dependent population as the size of the elderly cohort is small, and the percentage of children is decreasing. This phenomenon in turn allows the working-age cohort to amass savings and increase productivity.

The situation will turn to the opposite direction in the future, or it may already have. As the baby boomers start to retire en masse from 2021 onwards, shrinking working age population must support a large



Source: Lee (2016)

Figure 6
Decomposition of Contributions to Potential GDP Growth

and increasing elderly population down the road. The resulting negative demographic dividend exhibits itself in the projections for the four decades from 2021, where declining labor force is projected to reduce annual GDP growth by increasing magnitudes. If the projections in Figure 6 are transformed into the per-capita term, the results are as shown in Table 1.

In the 2030s, the growth in the GPD per employed worker is approximately 2 percent or higher. Given the continued decrease in the labor force and employment caused by population aging, however, the growth in per-capita GDP over the same period is expected to be as low

Table 1
Growth in per-capital potential GDP and contributions (%, %p)

Period	Per-capita Real GDP	Employed/ Population	Real GDP per employed worker	Physical Capital per employed worker	Total Factor Productivity
	(1) + (2)	(1)	(2) = (3) + (4)	(3)	(4)
2001–2010	3.8	0.7	3.1	1.5	1.6
2011–2020	2.6	0.7	1.9	0.7	1.2
2021–2030	2.1	-0.2	2.3	0.9	1.4
2031–2035	1.5	-0.5	2.1	0.8	1.3

Source: Lee (2016)

as 1.5 percent. The predicted contribution of the physical capital per employed worker is stable at approximately 0.8 percent, reflecting that the Korean economy is close to the steady state growth path.

Two conclusions emerge from the discussion above. First, any future acceleration in real GDP growth will have to come from faster productivity growth. Second, the slower growth in real GDP, resulting from the demographic changes, will reduce the size of the Korean economy than what has prevailed in the past with a higher rate of population and economic growth. The reduction in economic growth also means that the tax base for government expenditures will also grow more slowly than in previous periods.

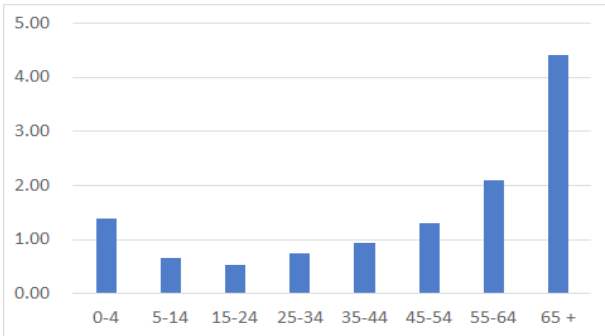
III. Demographic Changes and Public Spending

Conceptually, two opposite effects of population aging are identified on the financing of government spending programs. On the one hand, demographic shifts arising from an aging population will increase government program spending primarily via increases in health care spending and higher spending on income transfers to seniors. On the other hand, an aging population can lead to decreases in government spending associated with education and child benefit spending. In empirics, however, extant research, such as those of MacLeod and Emes (2017) and Robson (2010), has found that the impact of demographic changes on the spending requirements of education and child benefits are at most modest or unclear. We therefore concentrate on the expected increases in public spending caused by population aging in terms of the costs of healthcare and other welfare benefits for seniors.

A. Healthcare Costs

For elderly Korean on average to consume considerably higher levels of healthcare services than younger cohorts is well expected, given that higher ages are associated with higher susceptibility to illnesses and costly chronic diseases requiring more frequent medical attention.

Data confirm this prediction. According to the National Health Insurance Service (2019), in 2018, the latest year for which data are available, Koreans aged 65 and above accounted for nearly 41 percent of all health care expenditures, but they only amount to approximately 14 percent of the total population. This imbalance between the proportion



Source: National Health Insurance Service Database

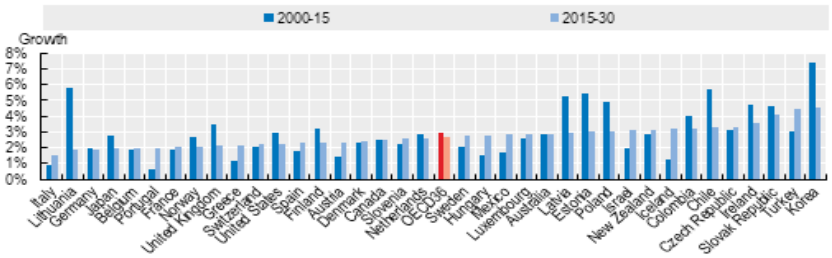
Figure 7
Healthcare Expenditure per Patient by Age Group (2018)

of the population over the age of 65 and the proportion of health care spending attributed to seniors is the result of the increases in chronic illnesses and rising ambulatory costs.

Figure 7 illustrates the average medical expenditures of different age groups. On a per-patient basis, healthcare spending is heavily skewed toward a patient's earlier (birth related) and later (post 65) stages of life after retirement. For instance, in 2018, the average per-patient medical expenditures between the ages of 15 and 64 amounted to 1.17 million won, whereas the average annual per-patient medical costs for those 65 and over was 4.41 million won, which is 3.8 times greater than the 15–64 average. The higher proportion of Koreans expected to be in the category of over 65 means increasingly higher health care costs.

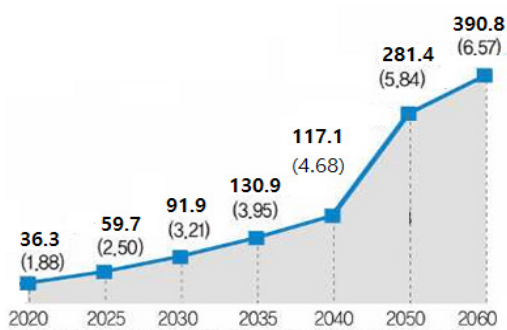
As the population of Korea continues to age over the next few decades and in the absence of concurrent reforms to the healthcare system, healthcare costs are more than likely to increase, as an increasing portion of the population enters the age brackets with the highest average healthcare costs. For example, a recent study by Lorenzoni *et al.* (2019) predicts that Korea will be one of the countries where the effects of demographic shifts on healthcare costs are the highest. More specifically, the health spending per capita in Korea is then expected to increase by 4.5 percent per year over 2015–2030, the highest rate of increase among the member countries. Figure 8 below shows this prediction.

Figure 9 shows the projections for the elderly healthcare costs by Lee *et al.* (2015). According to this study, the total medical expenditures for



Source: Lorenzoni *et al.* (2019)

Figure 8
Growth in Average per Capita Health Expenditure (2015–2030)



Source: Lee *et al.* (2015)

Figure 9
Projected Healthcare Expenditures for 65 + (trillion won)[4]

those aged over 65 are expected to increase up to 390.8 trillion won by 2060. This number is more than ten-tuple of that estimated for 2020 and is tantamount to 6.57 percent of GDP. Considering that the medical expenditures by *total* population accounted for 8.1% of GDP in 2018, the increase in elderly population accompanied by increases in chronic illness and the cost of end-of-life care poses a serious challenge.[3]

[3] As of 2008, the medical costs of a patient in the last year of life account more than 9 times larger than the average for surviving patient cost over the same period.

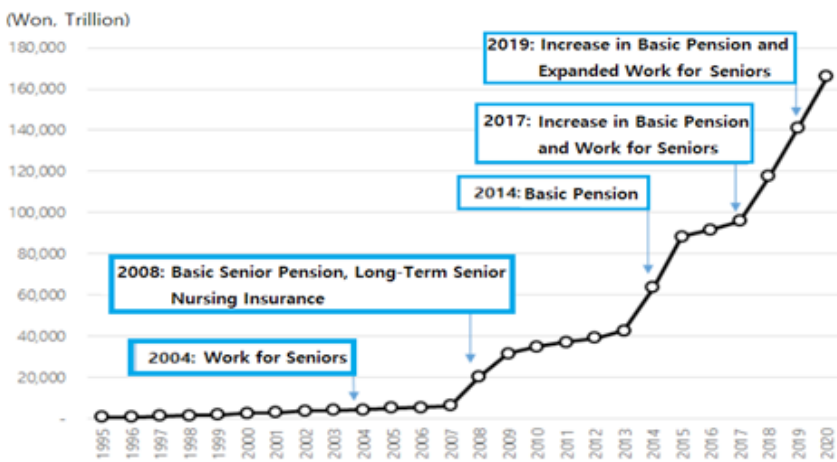
[4] Number in parentheses are the share in GDP. Projections under the scenario of pure aging and 0.8 for the income elasticity of medical expenditure.

B. Welfare Spending on Seniors

Apart from increased healthcare costs, demographic shift also requires the government to use other resources to senior welfare programs, such as Basic Senior Pensions, Guaranteed Minimum Income Payment, Work Provision of Seniors, and Long-Term Senior Nursing Insurance. As shown in Figure 10, spending (in nominal terms) by the national government on welfare programs for the elderly remained below 0.5 trillion won until 2007 and has increased mildly until 2013. However, the number has been rapidly increasing since then, as new welfare programs were introduced and exiting programs were expanded. For fiscal year 2020, spending on these programs costs approximately 16.8 trillion won. It represents 3.3 percent of the planned total government spending.

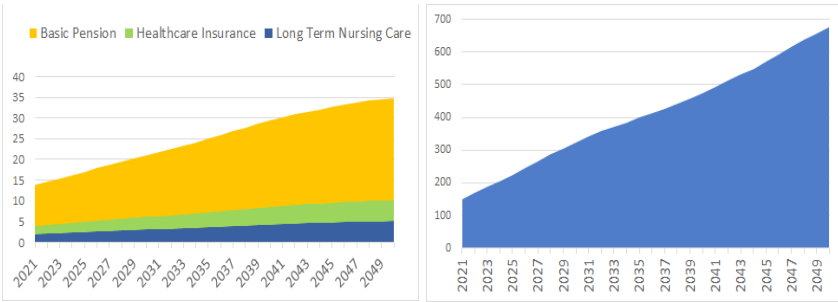
Among many possible causes for such rapid increases in welfare expenditures, the main driver is the trend of population aging caused by low fertility rate and extended life expectancy. According to Kim and Kim (2020)'s prediction, a one percent increase in the aging index (the number of elders per 100 persons aged 15 or below) is estimated to rain welfare spending for seniors by 0.12 trillion won.

Figure 11 shows how spending on elderly welfare is projected to



Source: Kim and Kim (2020)

Figure 10
Government Spending on Senior Welfare Programs



(a) Key components of senior benefits (b) Total welfare spending for seniors

Source: Kim and Kim (2020), authors' graphical presentation

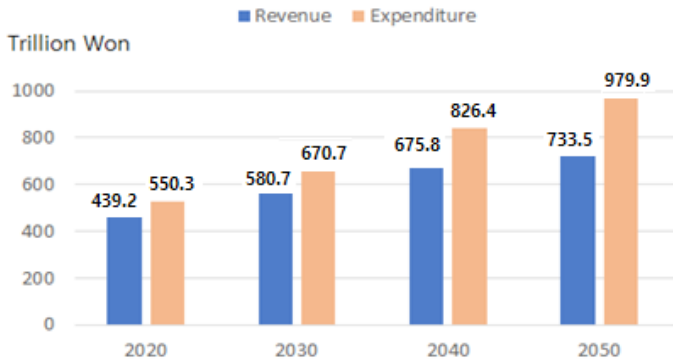
FIGURE 11
PROJECTIONS OF SENIOR WELFARE SPENDING (TRILLION WON)

increase (Kim and Kim, 2020). Panel (a) plots the predicted costs for the three major components of senior benefits, *i.e.*, Basic Pension Program, Health Insurance Subsidies, and Long-term Nursing Care. Over the next three decades, spending on these key programs is projected to increase by 3 percent every year. Panel (b) shows the projections of the overall spending on senior welfare benefits, where total senior benefits will increase to 680 trillion or so by 2050. This number represents approximately 45 percent of the total government income projection for the same year by the National Assembly Budget Office (2018).

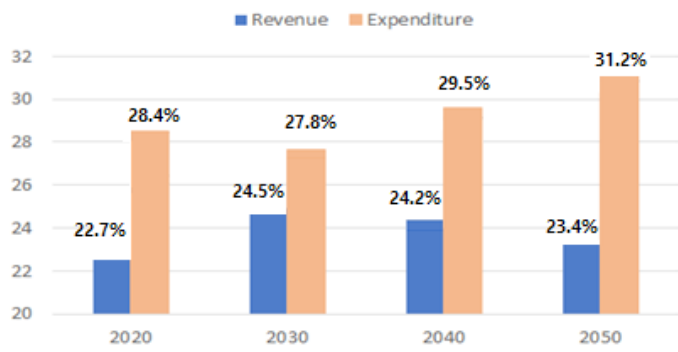
Overall, population aging will contribute to a large increase in future levels of government spending. In 2019, social welfare spending for senior benefits amounted to approximately 13 trillion, accounting for approximately 8 percent of the total government budget for social welfare. This share is expected to increase to 12 percent and 20 percent by 2024 and 2029, respectively. Consequently, mandatory government spending welfare programs are projected to reach ten percent relative to the size of the economy in 2050, an increase of approximately 4 percent point as of 2019.

IV. Fiscal Sustainability

As widely pointed out, a rapid pace of population aging poses a serious structural challenge to fiscal sustainability. Two channels for future imbalances are related to demographic shifts. The first one is



(a) Revenue and Expenditure (in fixed price of 2020)



(b) Revenue and Expenditure (% of GDP)

Source: National Assembly Budget Office (2020), author's presentation

Figure 12
Projections of Fiscal Squeeze

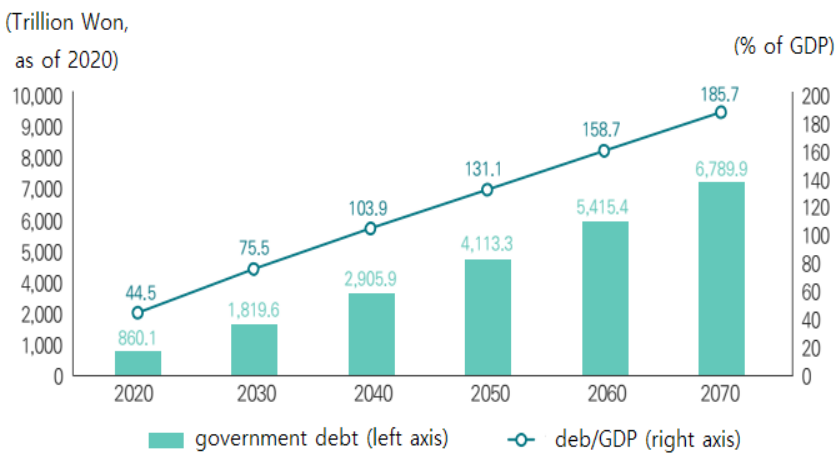
just described above: increases in spending on healthcare and other welfare programs for the elderly. The second is that the growth rate in tax revenue is expected to slow down, as taxpaying working population shrinks. These two complementary channels will create serious burden on public finance, considering that the government's ability to collect tax revenue decreases due to a smaller group of taxpayers. Conversely, the government expenditure, particularly on healthcare spending, continuously increases.

In addition, as in many high-income countries, pension also plays a crucial role, as important as the healthcare spending. As populations

age, the number of beneficiaries of public pension schemes will increase, whereas the number of contributors is expected to decline and thus resulting in deficits. Another adverse effect also comes from a reduction in economic growth due to diminishing labor productivity. Stagnation in economic growth will lead to a reduction in national revenues and savings, which in turn generates negative impacts on economic sustainability.

To illustrate the potential size of the looming fiscal imbalance, Figure 12 plots the projected government spending and revenues by the National Assembly Budget Office (2020) for 2020 to 2050. This projection assumes that the details of government expenditure are maintained as in the budget bill for 2019 and incorporates the effects of the third supplementary budget bill in 2020.

The main takeaway from Figure 12 is the looming deterioration in government finances. The projections indicate that the Korean government is expected to run a shortfall in every decade of projection. Apparently, the deficits are expected to worsen as demographic changes place increased demands on government spending. For example, the difference between government revenues and total expenditure in 2030 will amount to 900 trillion won. By 2050, the fiscal imbalance is projected to be 7.8 percent of GDP or 246.5 trillion won (using 2020



Source: National Assembly Budget Office (2020)

Figure 13
Projected Government Debt

real GDP figures). This finding is in stark contrast to the fiscal *surplus* amounting to 4.7 trillion won in 2019.

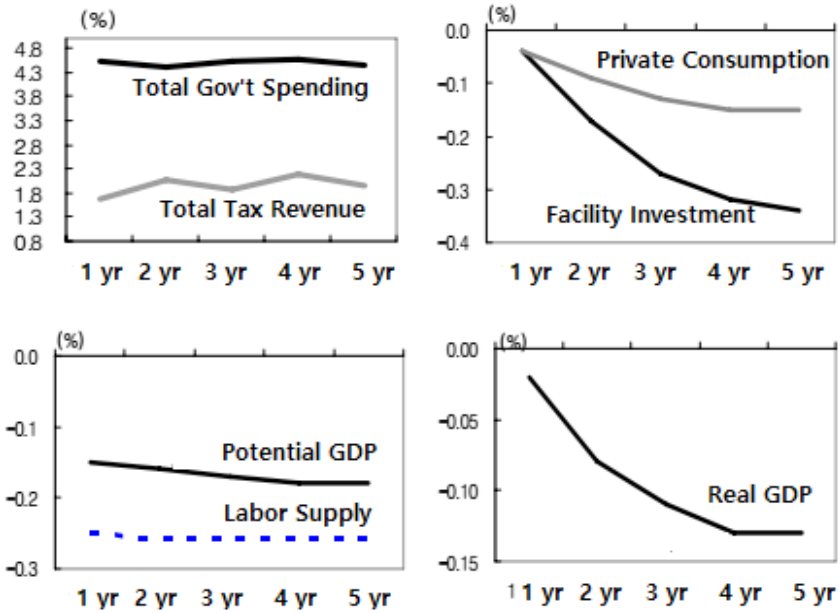
Figure 13 displays the consequences of prolonged fiscal deficit on government debt projected by the National Assembly Budget Office (2020), assuming that the imbalance between government spending and revenues in Figure 12 is financed by issuing new government bonds. According to this projection, net government debt as a percentage of GDP is predicted to be over 75 percent of GDP in ten years now and to reach over 131.1 percent by 2050.

One economic measure of societal aging is the old-dependency ratio defined as the ratio of the number of elderly people aged 65 relative to working age population, which shows how many elderly people are supported by an economically active person. As such, this ratio is frequently used for the economic analysis of the impact of population aging. For example, a study by KDI (2018) finds that, among the OECD countries where the old dependency ratio has increased by more than 10 percent point since the 1980s, a one percent increase in the ratio is associated with a 4 percent point fall in the nominal economic growth rate, a 0.8 percent increase in the social welfare expenditure relative to GDP, and a 5.7 percent point increase in the ratio of government debt to GDP.

Here, we recapitulate parts of the simulation results by Sung (2009) using the annual macro-fiscal model of the Korean economy, which examines the responses of key economic variables under the scenario that the old-dependency ratio rises by 5 percent point.[5] Figure 14 shows the results. Over the five years following the aging shock, labor force decreases by 0.26 percent per annum, and the potential GDP falls by 0.09% per annum. Owing to higher welfare spending, total government expenditure increases by 4.5 percent per year. By contrast, tax revenues are predicted to increase by a mere 1.9 percent per year due to the slowdown in labor supply and growth. Consequently, fiscal balance relative to GDP aggravates by 0.4 percent annually.

This section attempts to provide an idea of the consequences of the fiscal imbalance down the road, but a hidden implication of increasing debt is noted to such high levels: the effect of increased interest

[5] This assumption is comparable to the actual increase in the old-dependency ratio in the 2010s.



Source: Sung (2019), authors' adaptation

Figure 14
Projected Government Debt

payments on government budgets. If the burden of interest payments increases, the government could be forced to reduce spending in areas such as education or other public services. To the extent that higher levels of government debt can further lead to lower rates of economic growth as found in some empirical studies, such as those of Woo and Kumar (2015) and Checherita and Rother (2010), the overall impact of aging on debt sustainability can be graver and therefore calls for more prudent indebtedness policies.[6]

[6] Woo and Kumar (2015) found that, for a panel of 38 countries, a ten percent point increase in the initial debt-to-GDP ratio is associated with a slowdown in annual real per capita GDP growth of around 0.2 percentage points per year. From a panel of 12 eurozone countries, Checherita and Rother (2010) found that the negative growth effect of high debt starts from the levels of approximately 70% to 80% of GDP.

V. Empirical Model of Aging-Macroeconomy Nexus

A. Model and Data

In this section, we perform an empirical analysis of the link between population aging and some key aspects of the Korean economy. The purpose of this analysis is twofold: first, we aim at quantifying the effects of population aging on the macroeconomy discussed in the previous sections. Second, the results of the current analysis are expected to serve as a guideline for extending toward other full-fledged model for aging–macroeconomy nexus.

Following many previous studies, we adopt a VAR approach to examine the macroeconomic effects of aging in Korea[7]. As discussed in the preceding sections, aging and other macroeconomic variables have a high tendency to be closely related and to share common long-term trends, apart from exhibiting short-term fluctuations around those trends. On this ground, we construct a Vector Error Correction Model (VECM) for the Korean economy, allowing for the relationship among the variables at both the long- and short-term time horizons.

The model we estimate is of the form

$$\Delta Y_t = \Sigma_{i=1}^{K} \Upsilon_i \Delta Y_{t-i} + \alpha\beta' Y_{t-1} + \Psi + \varepsilon_t,$$

where Y_t is a (p×1) vector of system variables, $\alpha\beta' Y_{t-1}$: a lagged error correction term, and Ψ denotes deterministic components comprising an intercept and dummies for the periods of economic crisis during 1997–1998 and 2008–2009.

[7] As an anonymous referee has pointed out, the implications of population aging or demographic changes are better addressed by cross-country analysis than time-series analysis, considering that these changes exhibit long-term effects rather than short-term dynamics. Notwithstanding, quite a few existing studies adopt the VAR approach to investigate the macroeconomic effect of aging. Lopreite and Mauro (2017) investigated the impact of demographic changes on health expenditure in Italy. Doran (2012) examined the effects of fertility rates and increases in the old-age dependency ratio on labor effort and production in Ireland. Ferraro and Fiori (2020) assessed the effects of demographic structure of labor force in the US on the responses of unemployment rate to marginal tax rates.

Table 2
Variables used for VECM estimation

Variable	Description	Transformation	Raw Series
AGING	People aged 65 and over as a ratio of the total population.	n.a.	Share of 65 and over—elderly
PROD	GDP divided by total work hours	log	Real GDP per hours worked
GDP	Real GDP per capita	log	GDP per Head of Population (nominal) GDP Deflator (2015 = 100)
TAX	Real Taxes per capita	log	Total Taxes Collected (nominal) Population (all age groups) GDP Deflator (2015 = 100)
MEDEX	Real Current Expenditure on Health per capita	log	Current Expenditure on Health (nominal) GDP Deflator (2015 = 100) Population (all age groups)

Our model is estimated with annual data over the period 1970–2018 with lag length of 4. Five variables are in the VECM specification used: the share of the population over 65 years old (AGING)[8], labor productivity measured by per capita real GDP divided by total hours worked (PROD), per capital real GDP (RGDP), real per capita total tax revenues (TAX), and per capita real medical expenditure (MEDEX). All data series are obtained from the *OECD Data Warehouse*, except that the series of total nominal taxes collected is obtained from *NABOSTAT*, the database of the National Assembly of Budget Office. Table 2 provides further details for the sources, construction, and transformation of data series, and Figure 15 plots the five data series thus constructed.

[8] Regarding the measure of population aging, alternative indicators such as the old dependency ratio or life expectancy are also available. Our choice is guided by the discussion in Yoon *et al.* (2014) that such alternative measures are likely to contain the changes in demographic structure caused by forces other than the pure aging trend. By using the elderly share among the population, we attempt to isolate demographic shifts brought about by the trend of physical aging only.

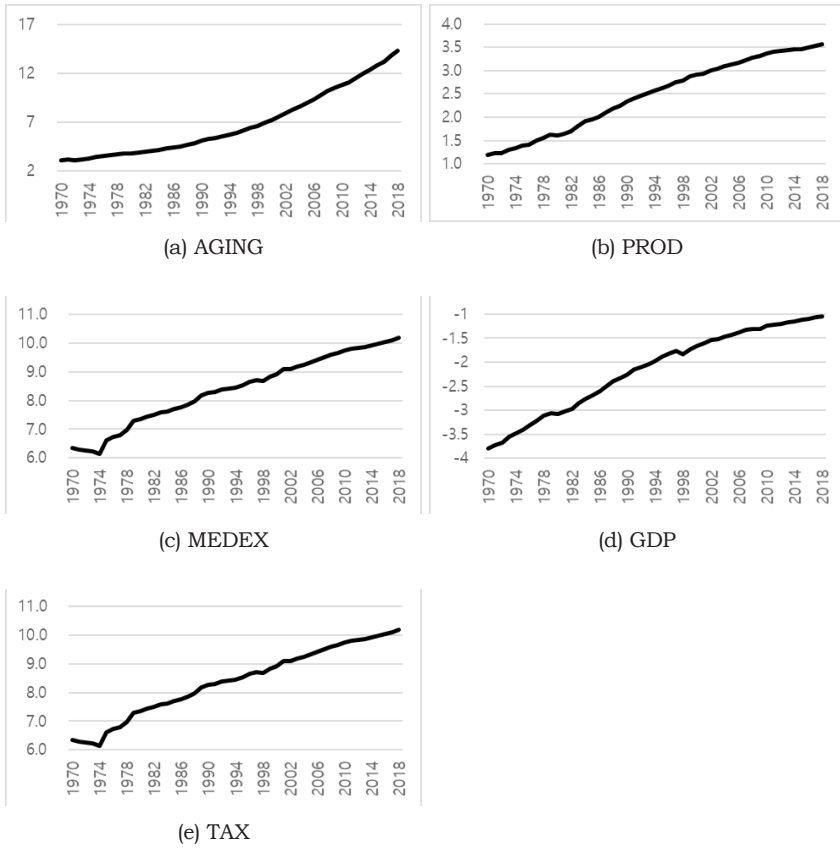


FIGURE 15
PLOTS OF DATA SERIES

The precondition for fitting a VECM to data is the presence of unit roots in individual series and cointegration among them. We first run the ADF and KPSS tests for unit roots. Table 3 presents the results. As foreseen in Figure 6, both tests support that all series are nonstationary in levels and stationary in first differences.[9]

[9] A possible exception is RGDP, for which the KPSS test rejects the null of stationarity in its difference at the 5% significance level. However, the test fails to reject the null at the 1% significance level. Thus, we treat RGDP as a difference stationary series.

Table 3
Results of ADF and KPSS Unit Root Test

variable	Levels		Differences	
	ADF	KPSS	ADF	KPSS
	Ho: Unit Roots	Ho: Stationary	Ho: Unit Roots	Ho: Stationary
AGING	1.694	0.244**	-5.864**	0.129
PROD	0.398	0.195*	-5.981**	0.164*
MEDEX	-1.703	0.321*	-6.480**	0.047
GDP	0.202	0.323**	-6.503**	0.097
TAX	-0.847	0.184*	-8.606**	0.235

Note: * and ** denote the rejection of the null hypothesis at the 5% and 1% significance levels, respectively.

We then apply the Johansen cointegration test to confirm whether a cointegration relation exists in the four data series. The results for trace statistic and maximum eigen value statistics in Table 4 support the null hypothesis that two cointegrating relations exist among the five variables, based on which we use the VECM rather than the ordinary VAR for the empirical analysis.

Table 4
Results of the Johansen Cointegration Test

Ho: No. of CI	Trace Test		Max Eigenvalue Test	
	Test Statistic	p-value	Test Statistic	p-value
0**	112.360	0.0000	42.819	0.0072
Up to 1**	69.544	0.0013	39.212	0.0023
Up to 2	30.329	0.1489	19.592	0.1911
Up to 3	10.737	0.4195	10.314	0.3758
Up to 4	0.423	0.5155	0.423	0.5155

Note: Lag order of 3 is determined by the BIC run for the unrestricted VAR. ** denotes rejection of the null at the 1% significance level.

B. Impulse Responses

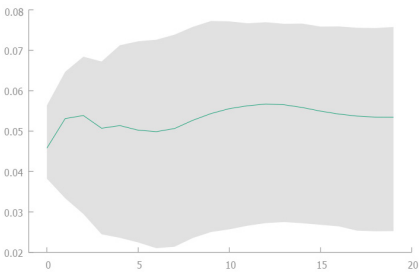
This section provides econometric evidence on the macroeconomic effects of population aging for Korea using an estimated VECM.[10] We

[10] Based on the results of preliminary checks in Table 3, we use 3 lags and

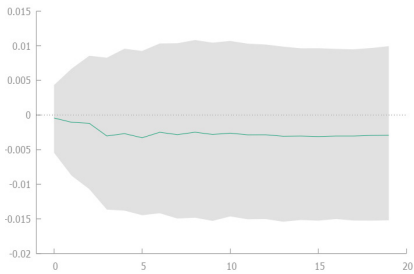
identify population aging shocks by assuming a recursive ordering, with the order of the variables in Table 3 above. Our rationale for putting the aging variable at the top of the causal ordering is that the aging trend is primarily a consequence of decreasing birth rates and extending life expectancy, which are in turn driven by sociocultural factors such as industrialization and medical technologies. Therefore, population aging is unlikely to react contemporaneously to shocks to other macroeconomic variables in the system. We put productivity and medical expenses next to aging on the assumption that the first-hand effect of aging falls on the overall quality and health of labor force. The two latter variables then affect the level of output and then the amount of taxes collected.

Figure 16 shows the impulse responses to a one standard-deviation increase in the elderly share aging shock identified from our estimated VECM. In each panel, the solid line denotes the point estimates of responses over the horizon of 20 years. The shaded area represents the 90% confidence band obtained from a bootstrap procedure with 2,000 replications. Following its own shock, the responses of the elderly share are significantly above zero throughout the two subsequent decades. Panel (b) exhibits that the aging shock is associated with continued decreases in labor productivity, although the negative response of productivity is statistically insignificant. By contrast, the effect of a rise in the elderly share manifests itself in the response of medical expenditure as shown in panel (c). A positive aging shock results in a significant increase in the per capita medical spending, even up to 20 years of horizon. Translated into tangible numbers, for example, if the share of the elderly population increases to 14.3 percent as of 2018 to 15 percent, the extra amounts an average Korean is expected to pay over the following 10 years sum up to 8.5 percent of that paid in 2018. The responses of GDP in panel (d) are weak and insignificant, in that the negative impact of aging shock on GDP is reversed in years 10 to 13 after the shock and then turns back to the correct sign. Still, the cumulative effects of the aging shock on GDP remain negative throughout the forecasting horizon. Finally, panel (e) shows the following: the adverse effect of aging is probably most conspicuous in the responses of tax revenues, which remain significantly below

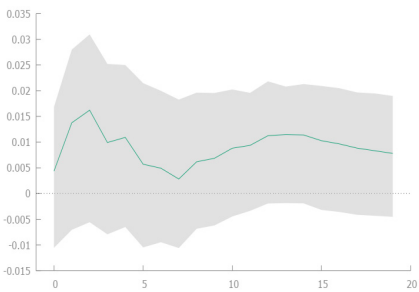
cointegration rank of 2.



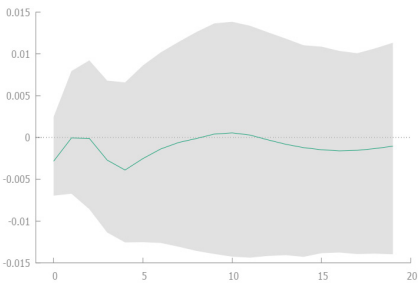
(a) Responses of AGE



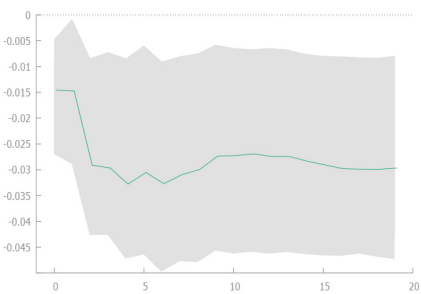
(b) Responses of PROD



(c) Responses of MEDEX



(d) Responses of GDP



(e) Responses of TAX

FIGURE 16

RESPONSES TO ONE S.D SHOCK IN THE ELDERLY SHARE

zero and from year 1 onwards. In summary, our VECM results are consistent with and underscore the concerns about the adverse ramifications of ongoing population aging in Korea: aggravation in labor productivity, decrease in per capita income, increasing burden of

healthcare expenditures,[11] and decreasing tax revenues.

VI. Concluding Remarks

As Korean population reaches old age, seniors are covering an increasingly large share of the population, whereas the portion of people in their working age is consequently decreasing. Consequently, labor force participation is widely expected to decline, by which economic growth and the foundation of collecting tax revenues are imperiled. Concurrently, the government is faced with the need to provide health care and other welfare programs to an increasing number of seniors. For example, the total healthcare expenditures for those aged over 65 in 2060 are expected to increase up to 281.4 trillion won, tantamount to 5.84 percent of GDP. In addition, the overall spending on senior welfare benefits is projected to increase to 680 trillion or so by the same year, representing approximately 45 percent of the total government income projection. Assuming that the details of government expenditure are maintained as in the budget bill for 2019, this increase in spending will contribute to a significant fiscal deficit amounting to 7.1 percent of GDP or 237.1 trillion won (using the 2019 actual GDP figures). At this pace of the looming fiscal imbalance, net government debt as a percentage of GDP is predicted to be over 85 percent by 2050. In sum, the impending demographic changes will profoundly affect government spending and its ability to raise revenues, imperiling government finances over the foreseeable future. The results of a VECM exercise are mostly in line with these predictions from previous studies.

The Korean government must make a tough choice. It can simply borrow their way through the problem and pass the buck to the next generations, at its own risk of fiscal and sovereign debt crisis. Otherwise, it can respond to the pressures by reforming public finance on one hand and improving economic growth and productivity on the other hand. The latter should aim at raising labor force participation

[11] As an anonymous referee has pointed out, the expansion in welfare program initiated in 2008 may have an impact on medical expenditure for the elderly. Owing to the short data span, however, formally introducing a break in sample period is not very plausible. We also believe that explicitly addressing such a policy reform in our empirical work will produce even graver prediction of the fiscal sustainability in the forecast periods.

of the elderly and females and encouraging investment in human capital and R&D. Regarding the former, many countries are now taking measures such as deferring old age pensions and encouraging enrollment in private pension by providing tax benefits or subsidies.

As found in Lee at al. (2013) from the panel of 80 countries, responses to population aging occur in the form of high retirement savings, high labor force participation, and increased immigration of workers from developing countries. Thus, a room still exists for appropriate policies that help mitigate the adverse consequences of population changes. At any rate, recognizing the current juncture of the looming demographic problems affecting the government finances is the first step in search of the right solutions.

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