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Demographic change, human capital, and economic growth in Korea

Jong-Suk Han[a], Jong-Wha Lee[b,*]

[a] Fellow, Korea Institute of Public Finance, Republic of Korea
[b] Economics Department, Korea University, 145 Anam-ro, Seongbuk-gu, Seoul, 02841, Republic of Korea

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ABSTRACT

We construct a measure of human capital using micro datasets on labor composition of age, gender, education, and wage rate and analyze its role in economic growth for the Korean economy. Over the past three decades, human capital has grown steadily at about 1% per year, contrasting to a continuously declining trend of total work-hours. This growth has been driven by the rise of better-educated baby-boom cohorts. A growth accounting exercise shows that human capital contributes significantly to economic growth; it accounted for 0.5% points of annual GDP growth over the period. Human capital is projected to remain a major growth factor over the next two decades as the increase in educational attainment continues. Increased employment rate of elderly or female workers reduces the aggregate human capital growth while increasing the available labor. Polices to improve human capital of female or elderly workers help to increase aggregate human capital growth.

1. Introduction

The Republic of Korea (henceforth, Korea) is known for its economic accomplishments. It grew at an average rate of 7.6% each year from 1965 to 2015,[1] making it one of the fastest growing economies in the world. Numerous studies on the backdrop of Korea's economic achievement have pointed out the improvement in human resources, alongside higher savings and investment ratios, greater trade openness, and improvements in rule of law, as significant factors for this growth (Lee, 2016).

The expansion and upgradation of the workforce have played a critical role in helping Korea catch up with the economic development of advanced economies. In the early stages, Korea enjoyed a large demographic dividend as large baby boom cohorts reached working age, boosting the nations productive capacity. The nation has also accumulated a stock of educated workforce at an unprecedented rate, backed by a strong household demand for higher education, and high public investment in the education sector. The abundant supply of well-educated labor force has allowed Korea to improve the competitiveness of its industries, transforming the economy into one of the worlds' top exporters.

In this paper, we present a measure of aggregate human capital stock in Korea and evaluate the contribution of human capital to GDP growth rate from 1986 to 2017. In addition to analyzing the past human capital development, we construct projections of human capital growth over 2020–2040, considering changes in population structure, educational attainment, and main labor market variables, such as employment and wage rate, with diff ;erent sets of scenarios.

The importance of human capital accumulation for economic growth is well-established in the literature (Lucas, 1988; Mankiw et al., 1992; Barro and Sala-i-Martin, 2003). Many researchers have constructed a measure for country-level human capital (Barro and Lee, 1994; Cohen and Soto, 2007; Lee and Lee, 2016). One strand of literature has constructed a quality-adjusted index of labor input, as a measure of the aggregate human capital stock, with the relative wage rate or relative productivity of labor inputs from diff ;erent characteristics, such as age and education level (Jorgenson et al., 1987; Bureau of Labor Statistics (BLS, 1993; Aaronson and Sullivan, 2001; Jorgenson et al., 2016).

In the U.S., it is well established to estimate human capital by constructing a quality-adjusted index of labor input. The methodology was pioneered by Jorgenson et al. (1987) and has continuously been developed by many others including BLS (1993); Aaronson and Sullivan (2001), and Bosler et al. (2017). This method, however, requires an extensive level of micro dataset, such as the Current Population Survey. Due to the data requirements, evidence for countries other than the U.S.

* Corresponding author.
E-mail addresses: hanjs@kipf.re.kr (J.-S. Han), jongwha@korea.ac.kr (J.-W. Lee).

[1] Real GDP growth rates are based on World Development Indicators from the World Bank database (World Bank, 2019).

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is less extensive. Schwerdt and Turunen (2007) estimate the human capital indexes for euro area as a whole by combining European Community Household Panel and the European Labor Force Survey. Other researches provide the estimates for specific European countries, such as Schwerdt and Turunen (2010) for Germany, Lacuesta et al. (2011) for Spain, Bolli and Zurlinden (2012) for Switzerland, etc. Similar situation also appears in Korea. There exists limited literature that measures human capital in Korea. To the best to our knowledge, this is the first study to estimate the quality-adjusted index of human capital in Korea using extensive micro data sets, and analyze the source of human capital growth and its contribution on economic growth. Furthermore, we provide projections of labor-quantity and human capital growth, with various hypothetical assumptions over the period from 2020 to 2040 and explore some policy implication to deal with demographic change in the future.

The remainder of this paper is organized as follows. Section 2 documents some features on demographic structures and labor market from 1986 to 2017 in Korea. Section 3 discusses the methodology to estimate human capital growth and investigate the sources of human capital growth. In section 4, we examine the contribution of human capital to economic growth in Korea. Section 5 presents projections of human capital growth from 2020 to 2040. The baseline projection uses the official demographic projection in Korea but fixes worked hours, employment rates, and wage rates in 2017. We then consider alternative scenarios commonly proposed to cope with the demographic change in Korea; enhancing female or elderly labor supply. We also compare these cases with two other scenarios which improve human capital of female or elderly workers. Finally, section 6 presents the concluding remarks.

2. Some facts on demographics and labor market in Korea

Before we estimate the human capital growth and examine its contribution to economic growth, we overview the evolution of demographic structure and some important labor market features in Korea since 1986. The facts that are documented below are based on the same data set used for estimating labor quantity and human capital indexes in section 3. In Korea, there is no unified data set that contains employment and wage rates like the CPS in the US. Therefore, we collect labor quantity variables and wage rates from two diff ;erent data set. Labor quantity variables, such as the number of employed workers and hours worked, are taken from the Annual Report on the Economic Active Population Survey (EAPS) collected by the National Statistics Office (NSO). These datasets contain underlying micro data based on employment status information collected from approximately 32,000 households every year and are used by the Korean government to estimate official labor market indicators such as the unemployment rate. EAPS has collected employment status data since 1986 and wage rate data since 2001. In order to consider a longer wage series, we combine two other micro datasets, namely the Basic Survey on Wage Structure (BSWS) from 1980 to 2007, and the Survey on Work Status by Employment Type (WSET) from 2008 to 2017. To obtain real wage rate, nominal wage rate is divided by consumer price index in 2015. The advantage of the BSWS and WSET datasets is that the wage rates are directly collected from establishments and, therefore, are less exposed to measurement error than EAPS' household survey data. Due to the limited coverage of EAPS data, our estimation of human capital covers the period from 1986 to 2017. These data set are used to document some facts on Korean labor market in following subsection, and also used in the section 3 to construct labor quantity and human capital growth rates.

2.1. Demographic structure

We document the population structure changes from 1985 to 2040 using the actual population growth rates and age structure of the population until 2017 and the projected values by the National Statistics Office after 2018.

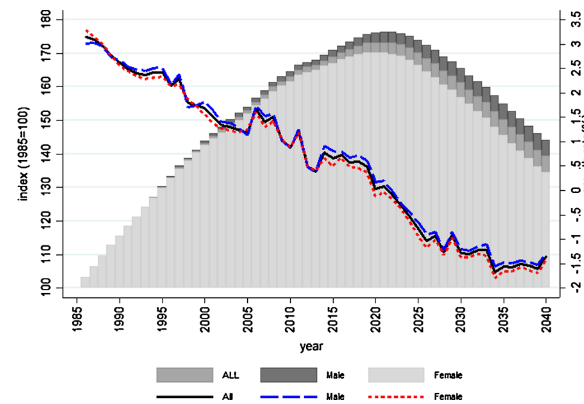

Fig. 1. Population growth rate.1985–2040.

Fig. 1 shows that the annual growth rates of the population aged between 25 and 64 years have declined continuously over time, from about 3% in the late 1980s, to below 1% in the 2010s. The growth rates of the population aged 25–64 are forecasted as negative, and consequently, the size of the population aged 25–64 is expected to decline in the coming decades owing to fertility decline and population aging. Due to this fact, the shrinking working-age population is a major concern for long-term growth in Korea.

Fig. 2 shows the change in the age structure of the population in selected years—1985, 2000, 2015, 2030, and 2040. There were continuous increases in the percentage of the working-age population from 1985 to 2015 due to the Korean baby boom in late 1950s, and early 1960s. However, the projected values for 2030 and 2040 show that the share of the population over the age of 60 will rise rapidly in the coming decades due to low fertility rates and longer life expectancy.

2.2. Labor market features

Now, we discuss some labor market features since 1986. The evolution of worked hours, employment rates, and wage rates are examined.

Fig. 3 presents the employment rate trend from 1986 to 2017 at the aggregate level and by gender. The aggregate employment rates had increased in the 1980s and 1990s. These rates, however, suff ;ered a severe drop during the Asian financial crisis in 1997–1998, and they have shown a mild recovery since then. The increase in overall employment rates after the crisis is mostly driven by the steady rise in female employment rates. They have exceeded the pre-crisis level, whereas the male employment rates have barely been restored to their pre-crisis levels. Nevertheless, the employment rates for males remain

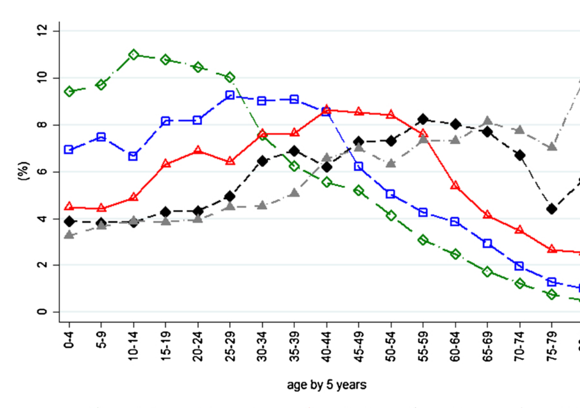

Fig. 2. Life-cycle population structure.

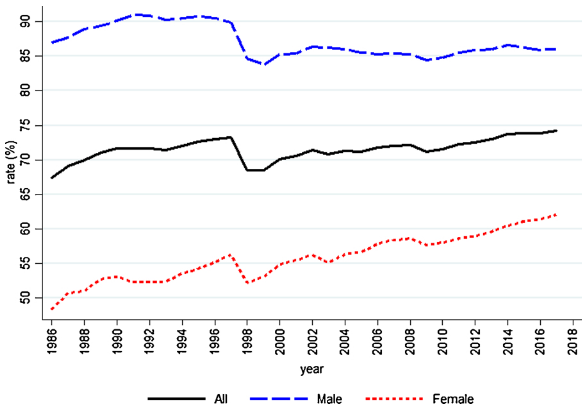

Fig. 3. Employment rate.1986–2017.

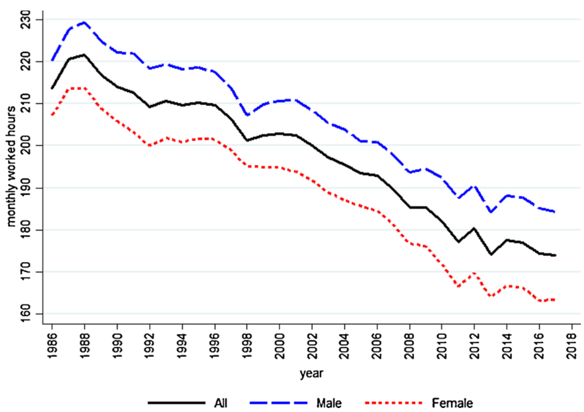

Fig. 4. Worked hours.1986–2017.

far higher than females. Korean females are primarily responsible for household aff ;airs and child rearing, and correspondingly, participate less in the labor market. Compared to the employment rates, the average monthly hours worked are also displayed in Fig. 4. These hours are only computed for employed workers at aggregate and by gender only. The males' hours are higher than the females throughout the periods, but the hours for both males and females have declined since late 1980s with significant drops during the Asian financial crisis.

We also examine the life-cycle patterns of employment rates and working hours for selected years—1986, 1996, 2006, and 2016. Fig. 5 presents the life-cycle employment rate by gender in selected years. For males, the standard life-cycle patterns, inverted U-shapes, are observed in employment rates, but they rotate around mid-40 s since 1986. The employment rates for over 50 years gets significantly higher in 2016 than in the earlier years. In contrast, these rates in the males ages 20–29 in 2016 are relatively lower than in the earlier years. These phenomena reflect the increased labor market participation of old-aged people but a relatively high youth unemployment in recent years. Female employment rates, however, display diff ;erent life-cycle patterns compared to the males' ones. Instead of inverted U-shapes, the females' rate depicts a M-shaped pattern due to a significant drop in their 30 s, attributed to career interruptions after marriage or childbirth, but a rise during their 40 s and 50 s. This pattern is more prominent in recent data, as employment rates for females in their 20 s and 40 s are much higher than for those in their 30 s.

The life-cycle patterns of average worked hours are similar to the employment rates' profiles in Fig. 6. The patterns show mildly inverted-U shaped curves for males, and M-shaped curves for females. The work hours for females are less than those for males across all ages. Unlike the employment profiles, the hours profiles move downwards from 1986 for both males and females. These features are consistent with the decreasing patterns of average monthly worked hours in Fig. 4.

So far, we provide some labor market features from the quantity side. Now, we document some facts on the price in the labor market, wages. As before, we examine the life-cycle wage profiles for males and females. Beside the wage profiles by gender, we also investigate the wage profiles across education group—high school graduates versus college graduates. It is worthwhile to look into the wage diff ;erence between education groups because Korea is well known of the fast growth of educational attainments.

The typical estimates of the return on age using Mincer wage regressions show that earnings grow as a concave function of age, implying that the productivity of prime-age workers (35–54 years) is high relative to young-age workers (25–35 years) or old-aged workers (55–64 years). As can be seen in Fig. 7, the cross-sectional age-wage profiles for males confirm this pattern. For the females, however, the wage begins declining in their late 30 s, reflecting a career interruption after marriage and child birth, and re-entry to lower-wage jobs in older ages. Noting that the cross-sectional Korean labor census data compare diff ;erent people born in diff ;erent years at diff ;erent points of their life cycles, the cross-sectional profile does not distinguish between age eff ;ects—the direct results from growing older, and cohort eff ;ects—the results from being born at diff ;erent times. Hence, the cross-sectional age-wage profiles can understate the life cycle earnings growth when there is growth in average wages.

The age-wage profiles also depend on education, work experience, job characteristics, or other factors that influence the productivity of older workers relative to younger workers. Identifying the "pure" biological eff ;ect of age requires excluding the eff ;ects of any other characteristics conflated with age. The age-productivity profiles of Korean workers reflect the significant diff ;erences in educational attainment across age groups. The higher educational attainment of younger workers compared to older workers contributed significantly

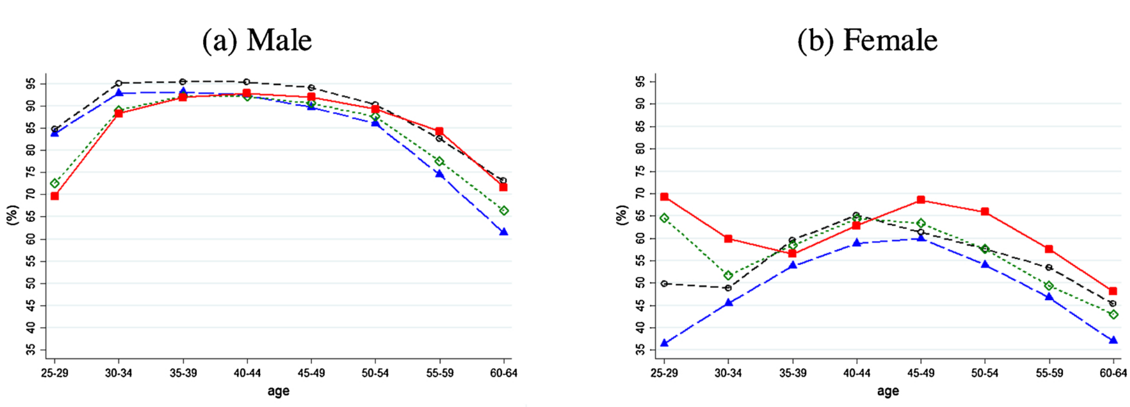

Fig. 5. Life-cycle employment rate profiles, selected year.

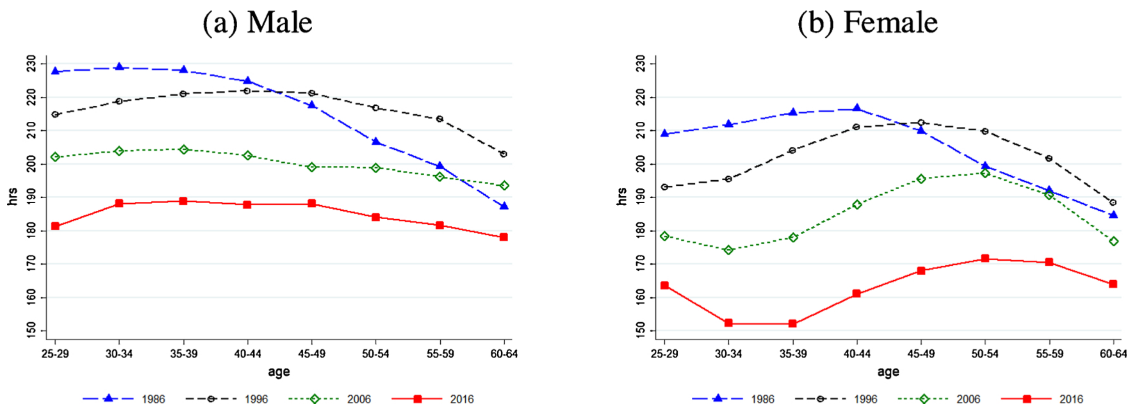

Fig. 6. Life-cycle worked hours profiles, selected years.

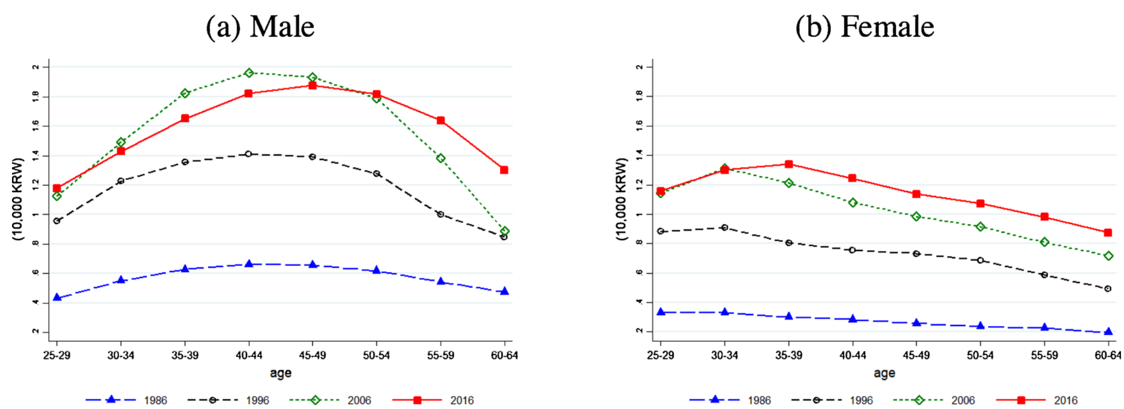

Fig. 7. Life-cycle wage profiles, selected years.

to the productivity gap between old-age and young-age workers. As completion of higher-level education among adults as well as old-aged people has risen over time, the age-productivity profile shifted upwards and changed the shape of the profile by making the average wage of old-aged workers decline gradually.

Fig. 8 presents the cross-sectional age-wage profiles by education level for the certain years as before. We observe wide wage gaps in terms of level between high-school and college graduates. The age-wage profiles for high-school graduates show the mildly inverted-U curve, as the wage of old-age workers is lower than that of prime-age workers. In contrast, the college graduates age-wage profiles show strong upward trends as wages continue to rise until the peak at 50–54 years and then begin to decline throughout the selected years, except in 1986. This may reflect higher productivity of college graduates, especially those who stay employed despite their old age. Nonetheless, this continuously upward sloping profile may also indicate the rigidity of the Korean labor markets, especially for the college educated workers. The lifetime employment, seniority-based wages, and promotion system allow little flexibility to adjust wages in line with observed productivity (Lee and Wie, 2017).

3. Estimates of human capital growth

In this section, we estimate the labor quantity and human capital growth rates from 1986 to 2017. In order to identify the driving forces of each growth, we perform several counterfactual analyses by holding worked hours, employment rates, and population structure constant at its 1986 level. For the human capital, we take one step further and use several counterfactual wage series to understand the main driving sources.

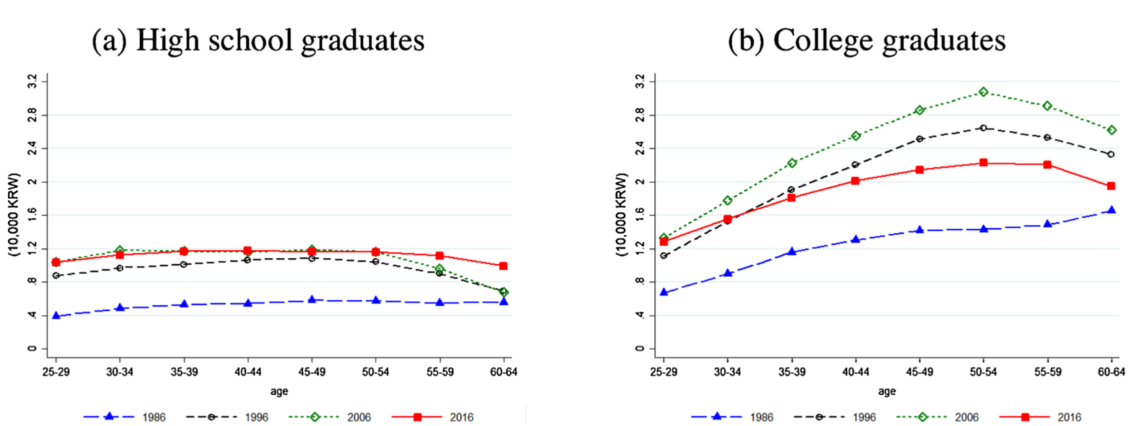

Fig. 8. Life-cycle wage profiles by education, selected years.

3.1. Methodology

We define the overall labor input as an aggregate of labor inputs from diff ;erent categories classified by gender, schooling, and age. The overall labor input (H) incorporates both the quantity and quality of the labor force.

$$H = L \cdot h \tag{1}$$

where labor quantity (L) is measured by the number of total work hours, and labor quality (h) is related to the average productivity of worker developed through education, job training, and age. We use the labor quality as a measure of human capital stock (per worker) in the economy. The growth rate of aggregate labor input is expressed as the share-weighted aggregate of the components where the weight is determined by the relative productivity or relative wage (Jorgenson et al., 2000).

$$\Delta \ln H = \sum_g v_g \Delta \ln L_g \tag{2}$$

where L_g indicates the quantity of the labor input in category g. The weight is the share of labor income attributed to each labor input in category g:

$$v_g = \frac{W_g \times L_g}{\sum_g W_g \times L_g} \tag{3}$$

where W_g is the wage rate of labor input in category g. Eqs. (2) and (3) reflect substitution among heterogeneous types of labor in each category with different marginal products.

The growth of human capital is defined as:

$$\Delta \ln h = \Delta \ln H - \Delta \ln L = \sum_g v_g \Delta \ln L_g - \Delta \ln L \tag{4}$$

As can be shown in Eq. (4), we can define the growth in human capital or labor quality as the difference between the weighted growth, and the unweighted growth of work hours, wherein the weights are the shares of labor income.[2] The unweighted growth of work hours ($\Delta \ln L$) indicates the growth in labor quantity. In Eq. (4), human capital growth is determined by changes in the composition of total work hours and wage rates among the different categories. For a given total of work hours, human capital improves when the employment of more-productive, higher-wage workers increases, and are substituted in place of less-productive, lower-wage workers in production.[3]

Labor quantity, i.e., total work hours, L is the sum of hours worked by workers in each type g, L_g, which is the product of (i) average work hours per month of workers of this type, μ_g, (ii) the employment rate of workers of this type, E_g, and (iii) the population of these workers, P_g. This can be expressed as:

$$L = \sum_g L_g = \sum_g \mu_g E_g P_g \tag{5}$$

In order to estimate the labor quantity and human capital growth rates, we need to construct some subgroups for each period. The subgroups are classified in Table 1. Labor quantity is calculated by the number of monthly hours worked by employed individuals between ages 25 and 64.[4] The human capital index is estimated by utilizing data on the composition of workers, as well as their wage rates, which are cross-classified by sexes (2), educational levels (4), and age (experience) groups (8), and end up with 64 (= 2 × 4×8) types of workers. Data on work hours, employment rate, population, and wage are computed for each category. Once the worker type is defined, we construct the human capital index using the weighted sum of total work hours across individuals in each of the 64 categories, using Eq. (4).

The choice of worker type can be further disaggregated by incorporating other characteristics of workers. If diff ;erent categories of labor inputs cannot be distinguished from the data, the labor input is measured using the aggregate labor input weighted by the overall labor share. This can underestimate the true contribution of labor inputs if the composition of labor shifts over time toward types of high quality.

Table 1
The classification of groups.

Group	Num. of Groups	Description	
sex	2	male, female	
education	4	secondary school drops	(< 12, HSD)
		secondary school graduates	(= 12, HSC)
		college dropouts	(13-15, SMC)
		college graduates	(≥16, CLC)
age	8	25-64 years, by 5-year intervals	

3.2. Labor quantity growth

We first construct our benchmark labor quantity index based on Eq. (5). It is plotted as a black solid line in Fig. 9. The average annual growth rate of labor quantity (i.e. total hours worked) from 1986 to 2017 was 1.30% (see Table 2). Labor quantity by this measure grew rapidly in the earlier period, at about 3.28% per year from 1986 to 1995. It experienced a severe drop to 0.13% during the 1997–1998 financial crisis and then showed a mild recovery. Over the recent years, from 2011 to 2017, its average growth rate was at 0.55% per year. Fig. 9 also presents the growth rates of labor quantity for three counterfactual cases. Using Eq. (5), we can generate three diff ;erent counterfactuals by holding one of the three factors, i.e., work hours, employment rate, or population across workers' types, fixed at its 1986 level. As can be observed from the green-dotted line (CF1) in Fig. 9, the labor quantity index which was constructed based on the counterfactual assumption that the average work hours across workers' types did not change since 1986, grew much faster compared to the baseline. As observed in Fig. 4, the average work hours have decreased since 1986 for all age groups. When we adjust the average work hours in 1986, the negative impact of average work hours on the total work hours is eliminated, and the labor quantity grows faster than in the benchmark case. The second counterfactual index (CF2), denoted by the red-dotted line, shows that labor quantity would have improved at a slower pace if employment rates had not changed since 1986. This is based on the fact that employment rates have continuously increased over the sample period except during the Asian financial crisis (Fig. 3). Hence, once the employment rates are replaced with the 1986 values, the labor-quantity growth rates are lower than the benchmark rates. The last counterfactual (CF3) demonstrates that labor quantity would have decreased significantly if the population across worker type had been fixed at the 1986 level. This indicates that the population structure change with the rise of baby boom cohorts was a major contributing factor of labor quantity growth during the past three decades.

[2] A drawback of this approach is that the labor income share can increase for reasons other than changes in labor productivity.

[3] In this framework, the substitutability between different types of workers is important for human capital growth, as it affects the changes in the share of labor income attributed to each input in equation (4). The factor substitutability can be estimated from the production function (or factor demand function) under several assumptions. We consider such estimation is beyond the scope of this paper. We discuss the relative wage rates (skill premium) between high-school graduates (unskilled labor) and college graduates (skilled labor) in section 3.4.

[4] The workers in this analysis include those who are self-employed and family workers, as well as temporary employees. We assume the wage rates for these workers are equal to those of the wage workers in each category.

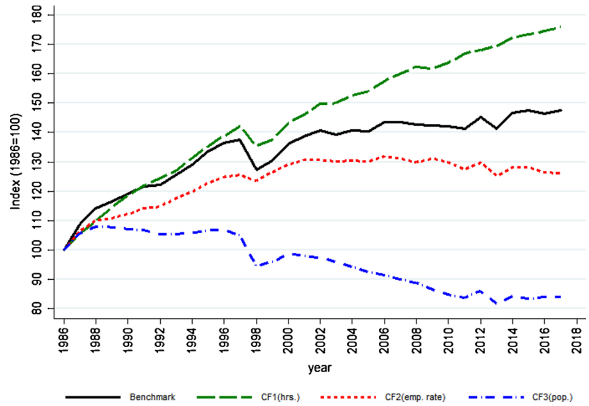

Fig. 9. Labor quantity index (1986 = 100) with counterfactuals.

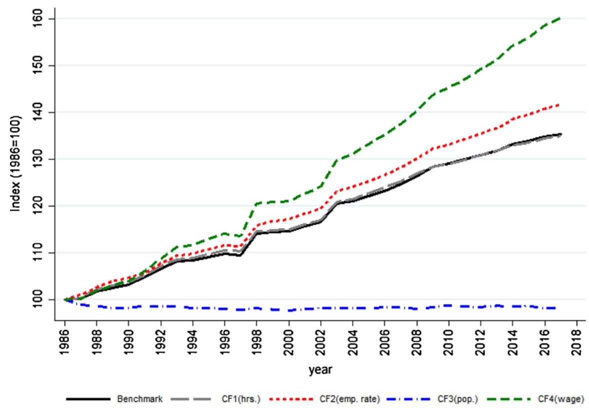

Fig. 10. Human capital index (1986 = 100) with counterfactuals.

3.3. Human capital growth

Our benchmark human capital estimates are constructed based on Eq. (4) and presented as a black solid line in Fig. 10. The index for human capital showed steady growth over the sample period. The average annual growth rate of human capital from 1986 to 2017 was 0.95% (see Table 2). Human capital grew at about 0.88% per year from 1986 to 1995, and at 0.68% per year from 2011 to 2017. It showed faster growth during the 1996–2010 period, at over 1.13% per year.

We construct four diff ;erent counterfactuals by holding one of the four factors, i.e. μ_g, E_g, P_g, and W_g, constant at its 1986 level. As indicated by Eqs. (4) and (5), the changes in the structure of average work hours, employment rate, and population across worker type, and their corresponding wage share values are important for the estimation of human capital index. Note that the growth rates of worked hours, employment rate, and population at the aggregate level do not have any impact on these counterfactual indices for human capital, while they aff ;ect those for labor quantity.

The four counterfactual indices for human capital are also displayed in Fig. 10. The first counterfactual (CF1) assumes no change in the structure of average work hours across worker type at the 1986 level. As observed in the figure, the change in average work hours has almost no eff ;ect on human capital. This result implies that the compositional change by work hours are not large enough to change the human capital growth. Next, we fix the employment structure across workers in 1986 (CF2). It has a small but positive eff ;ect on human capital. Note that the employment increases are mainly driven by the female employment increases (see Fig. 3). Therefore, if the employment rate is fixed in 1986, human capital may grow faster than the benchmark because it eliminates the increases of less-productive or lower-paid female workers. Human capital growth, however, would have decreased significantly, if no change had occurred to population structure across

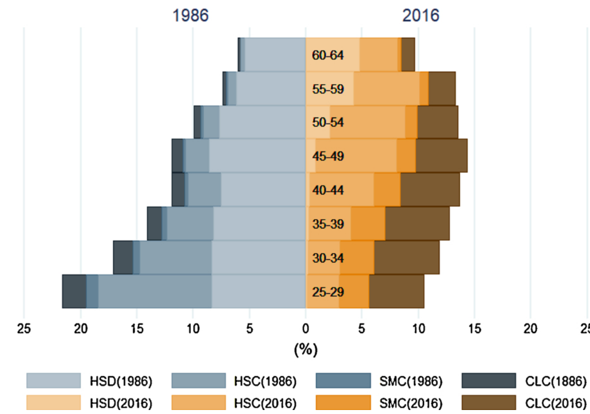

Fig. 11. Share of education level by age groups: 1986 vs. 2016.

workers types (CF3). The continued accumulation of a more-productive baby boom generation was a main contributing factor to human capital growth in Korea since 1986. Lastly, we apply a similar counterfactual analysis assuming that the wage rate for worker type is set at the 1986 level (CF4). The counterfactual human capital index is higher than the benchmark. This indicates that the wage rate has increased more for less-productive or lower-paid workers since 1986. Thus, if relative wage rates had not changed since 1986, human capital would have grown faster over the past three decades. We will investigate this issue in detail in the next sub-section.

3.4. Source of human capital growth

In our framework, a worker's average level of human capital stock is equal to the sum of the shares of workers, weighted by relative wage rates across workers, cross-classified by gender, education, and age, divided by total number of workers. Human capital, therefore, is determined by substitution among heterogeneous workers with diff ;erent marginal products or wage rates. When the share of worker types with higher-productivity increases, it promotes human capital growth.

Korea is well known for rapid improvement in educational attainment. Among the population aged 15 and above, the percentage of workers with at least some secondary schooling soared from 37% in 1970 to 87% in 2010. The proportion of college–educated persons has increased from 6% to 42% over the same period (Barro and Lee, 2013).

Fig. 11 displays the change in educational level by age group from EAPS data. There has been continuous growth in the shares of secondary and tertiary school graduates among workers, especially in the prime age group. The increase in population share of high-educated workers must not only reflect an increase in supply of high-educated workers, but also a demand for them. EAPS data shows that the employment rates for high-educated workers have been high, compared to low-educated workers.

Empirical investigation based on the Mincer-type wage regression shows that an additional year of schooling is associated with a significant increase in earnings or labor productivity. We estimate the Mincer-type wage equation by each year using Korean labor data from 1986 to 2017. The estimates, shown with a black line in Fig. 12, indicate that the premium of college education over secondary education ranged from 0.387 to 0.642. This implies that the marginal rate of return on college education was about 1.5–2 times higher than that on secondary education. Thus, the expansion of a college-educated workforce, combined with a relatively high wage rate, contributes to the strong human capital growth in Korea.[5] An expansion in the supply of high-educated workers lowers relative wage rate, and subsequently

[5] Although rapid expansion in higher education has contributed to improvement in workers' productivity, over-education and education-job mismatch are pressing issues in Korea. See discussions, for example, in Lee et al. (2016).

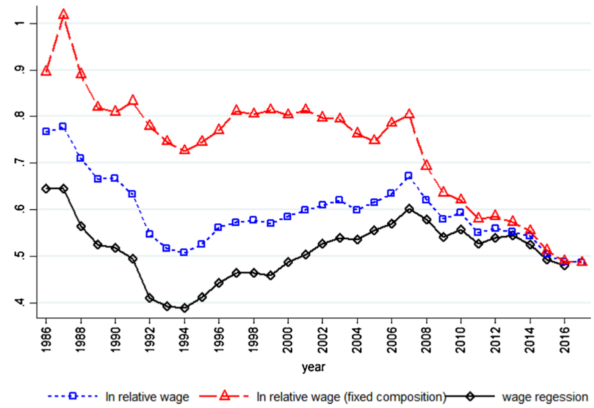

Fig. 12. Change of college premium:1986–2017.

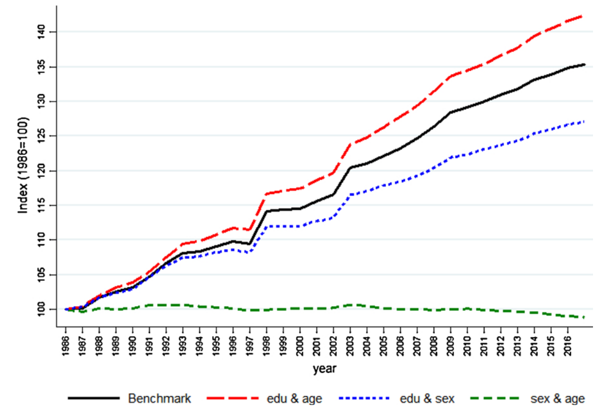

Fig. 13. Human capital indices with alternative wage series.

increases the demand for high-educated workers, leading to the equilibrium in the labor market. When the elasticity of substitution between high-educated and low-educated workers is greater than one, this raises the wage share of high-educated workers (Acemoglu, 2008). The increase in the supply of higher-educated workers leads to human capital growth, as long as their labor income share does not decline proportionally more.

Fig. 12 also presents the ratio of average wages between college graduates and secondary graduates, measured in the logarithmic scale. The values on blue line show that the relative wage rates have moved closely with the college premium estimates from the Mincer equation. The change in the relative wage by educational attainment is influenced by the change in the composition of labor force by sex and age. Keeping the sex and age composition fixed at the 1986 level, we calculate the relative wage rates, and present them using the red line. These adjusted values have also shown movements that are broadly similar to other estimates. However, the adjusted relative wage rates are much higher than the college premium estimates (in black), or the unadjusted relative adjusted wage rates (in blue) until 2007. They also showed little change over the period of 1997–2003 in contrast to the rising trend of the other estimates. The diff ;erences are possibly due to the changes in the supply of female college graduates, and in the age composition of college educated workers as well as shift in demand towards more educated, high-skilled employments. As shown in Figs. 7 and 8, the wage gap between the genders has been large, and the age-wage profiles have varied a lot by educational attainment.[6]

In order to assess the eff ;ect of change in educational attainment, sex and age among workers on human capital, we construct three alternative wage series by cross-classifying wage in broader categories; i.e. (1) across sexes and age groups, (2) across education and age groups, and (3) across sexes and education. We compute the average wages for each broader cross group and match them to the labor input cross-classified in the benchmark. Comparing these human capital indices with the benchmark, constructed from the benchmark wage series using cross-classification by sex, education, and age-group, we can identify the independent eff ;ect on human capital due to changes in composition of labor inputs across gender, education, or age-groups.

Fig. 13 presents the alternative human capital indices, together with the benchmark. The two alternative human capital indices classified by education and age group, and by education and sex, are not very diff ;erent from the benchmark. The index that is constructed using an alternative wage series with a broader classification of education and age is placed slightly above the original index. This implies that the alternative index, under the counterfactual that female wage rates are the same as male wage rates, underestimates the decline in productivity due to substitution of males with females. When an alternative wage series without the age variation is used, the human capital index is placed slightly below the original index. This is because the former underestimates wage increases caused by substitution of low-wage young workers with high-wage and more experienced workers, especially for males. This result indicates that a part of the human capital improvement is attributed to a pure age-eff ;ect, caused by the shift in employment toward higher-productive age groups.

As anticipated, the alternative human capital index, where education variation is excluded, deviates largely from the benchmark. This index displays almost no growth throughout the sample period. Therefore, the improvement in labor quality in Korea since 1986 was driven almost entirely by the substitution of less-educated, lower-productive workers with more-educated, higher-productive workers in employment. In the previous section, we find that the highly productive baby boom generation was a main contributing factor to human capital growth in Korea since 1986. Viewed in light of the findings in this section, this suggests that the higher productivity of the baby boom generation is majorly attributed to the growth in educational attainment.

4. The contribution of human capital on economic growth

This section appraises the contribution of human capital to output growth by adopting the growth accounting method of Solow (1957). The basic proposition of this approach is that human capital contributes to output through improvement of overall labor productivity, controlling for other contributing factors, such as physical capital stock, and technological advances.

Let us assume a standard production function:

$$Y = F(K, H, A) = F(K, L \cdot h, A), \tag{6}$$

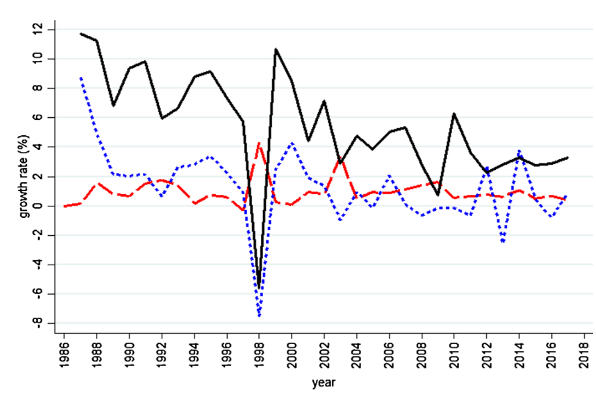

Fig. 14. Human capital, labor quantity and GDP growth rates:1986–2017.

[6] Han et al. (2019) investigate the source of change in skill premium in Korea.

Table 2
Annual growth rates of labor quantity, labor quality and GDP:1986–2017.
Source: GDP data are from the Bank of Korea and authors' calculations of other data.

	1986 – 2017	1986 – 1995	1996 – 2005	2006 – 2010	2011 – 2017
Real GDP growth rate	5.50%	8.84%	4.98%	4.03%	2.99%
Labor-quantity growth	1.30%	3.28%	0.56%	0.25%	0.55%
Contribution to GDP growth	0.72%	1.84%	0.30%	0.13%	0.28%
	(13.02%)	(20.83%)	(5.92%)	(3.35%)	(9.53%)
Human capital growth	0.95%	0.88%	1.14%	1.11%	0.68%
Contribution to GDP growth	0.51%	0.50%	0.59%	0.57%	0.35%
	(9.21%)	(5.65%)	(11.87%)	(14.21%)	(11.62%)

Notes: The labor quality is constructed by the weighted sum of work hours across workers aged 25–64 that are cross-classifi ed by gender, educational attainment and 5-year age-groups. The weights are relative productivity, measured by the share of labor income for each worker type. The labor quantity is total hours worked by all worker types. The contribution to GDP growth by labor quantity or quality is measured using the growth accounting formula. Data on labor income share are from Penn World Table ver. 9.1(PWT9.1).

where *Y* is the output (real GDP), *K* is the physical capital stock, and *A* measures the level of technology, or "total factor productivity (TFP)."

The growth accounting method appraises the contribution of labor resources—labor quantity and human capital—to output growth by decomposing the growth rate of aggregate output into contributions from the growth of *Y,* into each of the three productive inputs, *K, H* and *A*, as shown in Eq. (7):

$$\Delta \ln Y = \frac{F_K \bullet K}{Y} \bullet \Delta \ln K + \frac{F_H \bullet H}{Y} \bullet \Delta \ln H + \Delta \ln A, \tag{7}$$

where Δ lnX represents the change in the logarithm of the variable *X* between time *t* and *t + 1*, and F_K and F_H are the marginal products of capital and labor respectively. When the marginal products can be measured by factor prices, we rewrite Eq. (2) using the labor share, v_H, and the capital share, v_K [7], as follows:

$$\Delta \ln Y = v_K \bullet \Delta \ln K + v_H \bullet \Delta \ln H + \Delta \ln A = v_K \bullet \Delta \ln K + v_H \bullet \Delta \ln L + v_H \bullet \Delta \ln h + \Delta \ln A \tag{8}$$

The second term on the right-hand side (RHS) of the equation measures the contribution of labor inputs to output growth. An increase in human capital contributes to output, alongside labor quantity, physical capital, and technology.

Fig. 14 displays the growth rates of human capital and labor quantity with the real GDP growth rates from 1986 to 2017. All series are filtered with three-year moving averages to smooth out business cycle fluctuations. The real GDP and labor quantity growth rates have steadily decreased over the sample periods. Human capital growth rates, however, have been stable throughout the period. Labor quantity and human capital growth rates show opposite movements in their cyclical patterns. During the Asian financial crisis, labor quantity dropped drastically, owing to the declines in employment rates and average work hours. In contrast, the human capital growth rate rose during the crisis. The counter-cyclical property of the human capital growth – in contrast to the pro-cyclical movement of the labor quantity – also showed up clearly during other recession periods such as in 2003 (bubble burst), and 2008–2009 (global financial crisis). This feature confirms the cleansing eff ;ect of recession (Caballero and Hammour, 1994; Davis et al., 1998). Due to this compositional change over the business cycle, the average productivity increases during the recession.

Table 2 summarizes the growth rates of human capital and quantity over the sample periods. The real GDP growth rate is also included for comparison. The Korean economy had experienced high GDP growth rates until 1997, when it was hit by the Asian financial crisis. The average annual GDP growth rate was 8.84% from 1986 to 1995. Both labor quantity and human capital growth contributed to GDP growth during this period, but the contribution made by labor quantity was larger than that by human capital. The annual labor-quantity growth rate was 3.28%, on an average, but the human capital growth rate was only around 0.88% during that period. During the crisis, labor quantity dropped drastically, owing to the declines in employment rates and average work hours. In contrast, the human capital growth rate rose during the crisis. From 1996 to 2005, the human capital growth rate was at 1.14% per year, compared to 0.56% for labor quantity.

Korea’s average GDP growth rates have continuously declined after the Asian financial crisis, averaging 4.03% from 2006 to 2010, and 2.99% from 2011 to 2017. The GDP growth slowdown was accompanied by a significant decline in labor quantity. The total work hours had continuously declined from about 5.5% in late 1980s to 0.19% in mid 2010s. It grew only at 0.25% from 2006 to 2010, and 0.55% from 2011 to 2017. In contrast, the persistent growth of human capital has supported economic growth in the recent decades; the average human capital growth rates were at 1.11% from 2006 to 2010, and 0.68% from 2011 to 2017.

In growth accounting terms, the contribution of human capital to GDP growth was significant. According to Eq. (8), using the aggregate labor income share from the Penn World Table version 9.1 (PWT9.1)[8], human capital growth contributed 0.5% points of annual GDP growth over 1986–2016. Human capitals contribution to economic growth increased significantly in the recent decade. The share of GDP growth explained by human capital rose from about 5.7% in 1986–1995, to about 11.6% in 2006–2017. In contrast, the contribution of labor quantity to GDP growth dropped from about 20.8% in 1986–1995, to about 6.4% in 2006–2017.

5. Projections of human capital growth, 2020–2040

In this section, we consider the projections of labor quantity and human capital growth up to 2040. As discussed in the previous section, the change in labor quantity over the past three decades was driven by increases in population and employment rates across worker-types. However, the population aged between 25 and 64 is projected to decline until 2040 (Fig. 1). Hence, unless employment rates rise fast and off ;set the decline in working-age population size in the coming decades, the labor quantity is expected to decline continuously. The decrease in work hours is also expected to contribute to decreasing labor quantity. On the other hand, the change in human capital was largely driven by an increase in more-educated cohorts over time. As more

[7] $v_k = F_K \times (K/Y) = r(K/Y)$, and $v_H = F_H \times (H/Y) = w(H/Y)$, where *r* is the rental price of capital, and *w* is the wage rate. In practice, the factor share is measured by an average of the shares in time t and t+1.

[8] The baseline labor share measured by PWT is the share of labor compensation of employees excluding self-employed income. PWT adjusts the baseline labor share by incorporating self-employed labor income by country. In case of Korea, PWT adds the entire value added in agriculture to labor compensation.

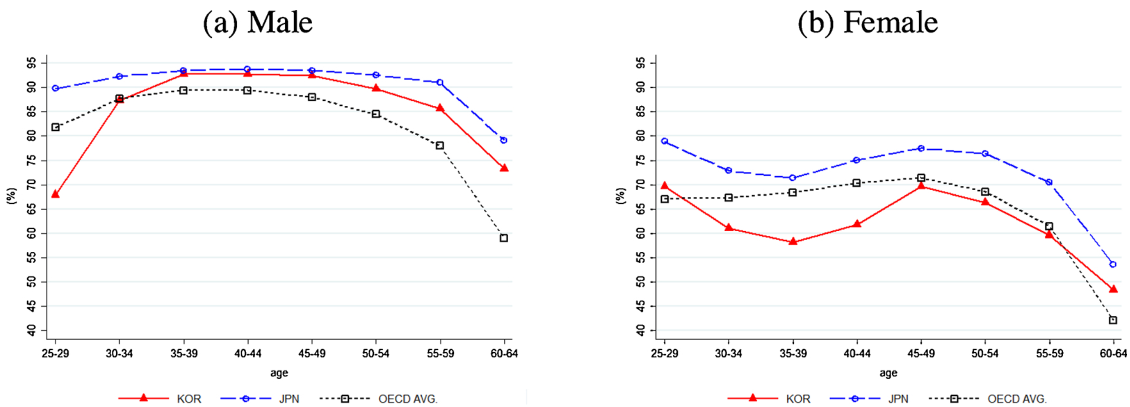

Fig. 15. Life-cycle employment rate profiles in 2017: Korea, Japan, and OECD average.

educated cohorts join the working-age population, human capital will increase.

We build our projections of demographic structure by age and gender using National Statistics Office (NSO)'s Population Projection 2016 ("middle"). In order to obtain projections of population by education, we use the educational attainment data from Barro and Lee (2015). Their projections provide the education level of the population group by five-year age group and by gender up to 2040. Since the education attainment projection is provided at 5 years intervals, we interpolate it to obtain annual series. We then combine the education attainment projection with the NSO's projection to construct population projection by age, gender and education. We set other variables except the population structure at the 2017 level in the baseline scenario. Besides the baseline scenario, we consider two sets of alternative scenarios; the first targets at increasing labor quantity and the second focuses on improving the human capital. Detail scenarios are discussed in following subsections.

In the projection, one critical assumption is the production technology remains as same as the current one. Due to rapid developments of automation technology and robotics, the production technology can change considerably in the future. For instance, automation intelligence (AI) can make high-skilled workers more substitutable with capital. New technologies can generate new jobs that require more non-cognitive and non-routine capabilities of workers, while reducing routine jobs. In order to incorporate this feature in the projection, we need to project technological development and human capital achievement in the future, including the change in the substitutability between physical and human capital. These are beyond the scope of this study, so we leave them as our future work.

5.1. Increasing labor quantity scenarios

In order to mitigate the negative impact of the decline in the population size, international organizations such as OECD or the IMF, commonly suggest policies to boost up the female or elderly employment rate (OECD, 2016; IMF, 2016). The following scenarios are designed based on these recommendations.

The employment rates of old-age workers, between 55 and 64, and of female workers have been rising in the recent decade in Korea (Fig. 3). Considering the fact that Korea has followed Japan's demographic changes with a lag of about 20 years, Japan is a good benchmark for gauging the future employment rates in Korea. OECD statistics show that the employment rates for all age groups and for both sexes in Japan are higher than those in Korea (OECD, 2019). Fig. 15 shows that the employment rates in Japan, for example, were 91.0% and 79.1% for male ages 55–59 and 60–64, respectively in 2017, while the corresponding rates in Korea were 85.7% and 73.3% in the same year. For females, Japan's employment rates are higher by 8–13% points than the Koreas corresponding rates in each 5-year age group of 25–64 years old. Based on these facts, we consider following two alternative scenarios:

(i) the employment rates of elderly workers of both sexes, aged between 55 and 64 years, increase gradually to Japan's 2017 level until 2040

(ii) the employment rates of female workers across all age groups increase gradually to Japan's 2017 level up to 2040.

The employment rates for all worker types are assumed to increase proportionally. In addition, we assume that the increases in employment rates of old-age or female workers occur exogenously without changing their 2017 levels.

Fig. 16 (a) shows the baseline projection of the labor quantity index for the 2020–2040 period, with two alternative employment rate assumptions. In the baseline scenario, the annual labor-quantity growth rates are projected to be -0.2% in 2020 and fall dramatically to -1.5% in 2040, with no change in the employment rate. The other two scenarios also show rapid decline in the trends. While the increasing employment rates can off ;set the decrease in working age population to a certain extent, the decline in labor quantity is an inevitable process, which will have a significantly negative impact on Korea's economic growth in the future.

In contrast, the projections for the human capital index in Fig. 16b show that Korea can maintain significant growth in human capital over the next two decades owing to the continuous increase of better-educated workers.[9] The annual human capital growth rates are projected to decline slowly from 0.52% in 2020 to 0.12% in 2040, with no change in the employment rate. Hence, the contribution of human capital to GDP growth will remain positive and significant, though declining, over the next decades, in contrast to the negative contribution of labor quantity. The two alternative scenarios show that increases in employment rates result in slower human capital growth paths. This reflects the increasing share of less productive demographic groups in total employment. An increase in the availability of old-aged or female workers reduces the average wage or productivity growth rates of workers in the economy because the average productivity for the old-aged or female workers is lower than that of the average worker. Hence, a notable feature of the projections is that they show the opposite eff ;ect of employment increase in old-aged and female workers on labor quantity and human capital. Note that we do not consider the labor market participation of

[9] This result can be sensitive to several assumptions in the projection, such as the constant income share of high-educated workers at the 2017 level up to 2040. As discussed in the section 3.1 and footnote 6, the substitutability between inputs in the production determines the change of relative income share when relative supply changes. When the supply of high-educated, high-skilled workers increases continuously, unskilled workers may become more important and more complementary with high-skilled workers for the production in certain industries or certain tasks. The role of skilled and unskilled workers in the age of rapidly changing technology and industry demand must be critical to the productivity of workers in the future, which is beyond the scope of this paper.

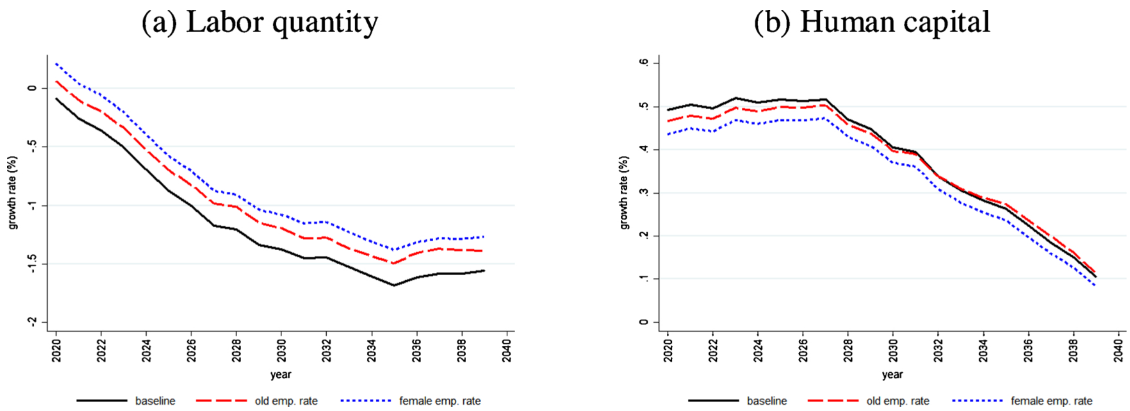

Fig. 16. Labor quantity and human capital growth projection:2020–2040.

groups over the age of 65. Considering that the share of people aged 65 and above is expected to increase rapidly until 2040, the increased employment of the elderly will increase the country's workforce but reduce human capital growth. In addition, the scenarios assume no change in average work hours based on the worker type, which is set at the 2017 level. If the average work-hours decrease, the labor quantity will decline faster, while its eff ;ect on human capital will be unclear, depending on the changes across worker types.

5.2. Improving human capital scenarios

Increasing old-aged or female workers' employment rate helps to off ;set the declining trends of labor quantity growth. Human capital growth, however, will be slow down because the labor force composition moves towards less productive workers. To resolve this trade-off ;, we consider another set of scenarios which improves the human capital growth by increasing females' or old-aged workers' productivity or wage.

Fig. 17 displays the gender wage gap for Korea (red line), Japan (blue line), and OECD average (black line) until 2017. The data are from OECD (2019).The gender wage gap is measured by the diff ;erence between male and female median wages divided by the male median wages. As observed in the figure, the wage gap tends to shrink over the period. Nevertheless, the wage gap in Korea is still considerably larger than Japan or OECD average. Without closing this gap, increasing female employment rate will have a limited eff ;ect on negative economic growth. The first scenario, therefore, focuses on improving female wage to reduce the gender wage gap. Korean government can strengthen policies to improve working-life balance and child-care facilities, so that females can continue their career without interruptions and enhance productivity. Like the scenarios in the previous subsection, we use the Japanese case as the benchmark; the gender wage gap decreases to that of Japan in 2017 until 2040. Since males' wages are set at 2017 level, we apply female wage growth to reduce the wage gap.

Similar situation occurs for the elderly employment rate. As seen from the life-cycle wage profile (Fig. 7), when the old-wage employment rate increases, the human capital growth falls because old-age workers' productivity measured by wages are lower than the that of prime-age workers. Old workers tend to be less productive than young workers as physical and cognitive capacities of an individual declines with age. However, older workers (especially those ages 50–64 in our framework) have longer work experience and might be able to offset negative aging effect on productivity through training participation and proper skills acquisition as discussed in Chomik and Piggot (2019). Lee et al. (2019) empirically shows that the job training after the formal education has positive impacts on workers' productivity. Moreover, this impact is larger for elderly workers. They use the Program for the International Assessment of Adults Competencies (PIAAC) survey developed by OECD (2013) and estimate the Mincer regression with job

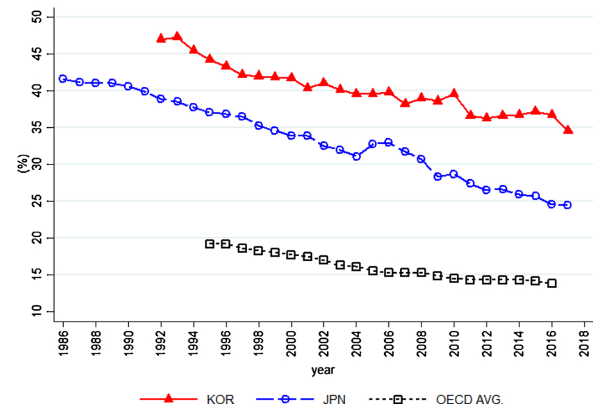

Fig. 17. Gender wage gap trend from 1986 to 2017.

training indicator for Korea. While estimating the job training eff ;ect on log wage, they also control unobserved ability with PIAAC score, which may potentially cause an omitted variable bias, with other control variables such as education, age, occupation, and industries. They find the positive impact of job training on wage; 1% increase of job training increases 0.108% of wage rate. Using the interaction terms between job training indicator and 10-years age group dummies, they also document that the job training eff ;ect on wage is large for age 56–65 workers compared to younger aged workers; 1% increase of job training for age 56–65 workers increases the wage rate by 0.33%.

Despite the positive eff ;ect of job training on productivity, most elderly workers have barely experienced job training. Fig. 18 provides the share of workers, who have been engaged in job training during the 12 months preceding the PIAAC survey, by 5-years age groups. We clearly observe that the share of job trained workers declines with the age. Among the worker aged 25–29, 54% experiences the job training, but only 15% of 60–64 aged workers is engaged in the training. The second scenario for human capital growth is based on these two facts; the job training has a positive impact on labor productivity measured by wage especially for the old-aged workers, but the share of job trained workers is low compared to young workers. In this scenario, we increase the portion of 55–59 and 60–64 aged workers' job training to that of 25–29 aged workers until 2040. Using the estimate of Lee et al. (2019), we escalate the wage for 55–50 and 60–64 aged workers along with the change of job training share.

In sum, we implement the following two scenarios to improve human capital growth[10] :

[10] In addition to policies improving productivity of human capital of female and elderly workers, new technologies can be more friendly to these demographic groups and help them to become more productive.

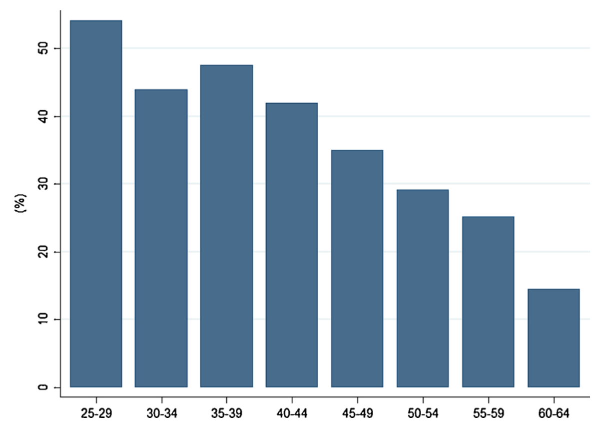

Fig. 18. Share of participating job training by 5-year age in Korea.

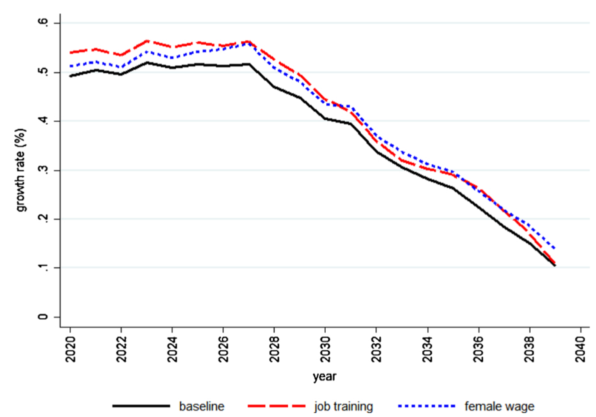

Fig. 19. Human capital growth projection with policies improving human capital:2020–2040.

(i) policies are adopted to increase female wage gradually until reducing the gender wage gap to Japan's 2017 level until 2040

(ii) the share of job trained workers for aged 55–59 and 60–64 gradually increases to that for aged 25–29 in Korea's 2017 level until 2040.

In the previous subsection, we observe that the human capital growth rate gradually decreases from 0.52% in 2020 to 0.12% in 2040 in the baseline, while these rates decline faster than the baseline when the employment rates for females or elderly workers are assumed to increase in the future. In contrast, the human capital growth rates are higher than the baseline when their wages are assumed to improve. Fig. 19 displays the projection for human capital index for two scenarios for improving human capital. The projection lines by both scenarios locate above the baseline from 2020 to 2040.

Table 3 summarizes the average growth rates of the labor quantity and human capital for each scenario considered in previous and this subsection. The average growth rate for labor quantity and human capital are -1.16% and 0.38% from 2020 to 2040, respectively. As discussed before, the negative growth of labor quantity is mitigated when the female or elderly employment rates are raised through 2040. Human capital growth rate, however, decreases by -0.007% point or -0.038% point when the employment rate for those workers are increased because their labor productivity is relatively lower than the average workers. Because of this trade-off ; between labor quantity and human capital, the increasing employment rates for low productivity workers have limited impacts on economic growth.

The second set of scenarios concentrates on upgrading human capital directly. Since the educational attainment in Korea is the highest around the world, investing on the formal education may not improve the human capital dramatically. These scenarios focus on the human capital

Table 3
Projected annual growth rates of labor quantity and human capital:2020–2040.

	2020 -2040	2020 -2024	2025 -2029	2030 -2034	2035 -2040
Labor quantity growth					
Baseline	−1.16%	−0.40%	−1.11%	−1.51%	−1.61%
Increase old employment rate	−0.98%	−0.23%	−0.93%	−1.34%	−1.41%
Increase female employment rate	−0.86%	−0.10%	−0.82%	−1.20%	−1.31%
Human capital growth					
Baseline	0.38%	0.51%	0.49%	0.35%	0.19%
Increase old employment rate	0.38%	0.48%	0.47%	0.35%	0.20%
Increase female employment rate	0.35%	0.45%	0.44%	0.32%	0.16%
Decrease gender wage gap	0.41%	0.52%	0.52%	0.39%	0.22%
Provide job training for the elderly	0.42%	0.55%	0.53%	0.37%	0.22%

improvements beyond the formal education. In case of female workers, if they can continue their careers without any interruption, their productivity or wage may grow and reduce the wage gap with male workers. For old workers, their productivity may enhance through job training, provided better opportunities to engage the training. The human capital growth for these two scenarios are quite substantial. 0.413% and 0.418% are the average annual growth rates for gender wage gap and job training scenarios, respectively. The growth rates for each case are 0.03% point and 0.035% point higher than the baseline growth rate. These diff ;erences are substantial enough to overcome the drops of human capital growth rate from increasing labor quantity scenarios discussed previously. Therefore, it is important to implement some policies to improve human capital for less productive workers, such as female and elderly workers, when the labor quantity for these workers expands.

6. Conclusion

We estimated Korea's human capital growth by using extensive micro datasets on labor composition in terms of age, sex, education, and wage rates. The labor quantity growth rate has continuously declined from about 5.5% per year in the late 1980s to -0.77% in 2016. Human capital growth, however, has persisted at around 0.8% − 1% throughout the sample period with counter-cyclical patterns. The main source of human capital growth in Korea was consistent improvement of educational attainment among workers. The better-educated and more productive workforce has contributed significantly to economic growth. In the recent decades, the contribution of human capital to GDP growth has become more important than that of labor quantity.

Korea is projected to maintain its human capital growth over the next two decades while experiencing a dramatic decline in labor quantity. The annual human capital growth rates are projected to decline slowly from 0.7% in 2017 to 0.1% in 2040, given a constant employment rate in 2016. An increase in the number of aged or female workers is expected to reduce the growth rates of aggregate human capital. Thus, Korea needs to respond to declining labor quantity by improving labor quality continuously. Because the educational attainments are already very high in Korea, providing higher education does not seems to work well in the future.[11] Improving the quality of higher

[11] One important consideration is whether human capital accumulation at the college is already above the optimal level in Korea. While many Koreans may continuously benefit from a high rate of return to investment in college education, even after considering its high costs, private and social rates to return to the educational investment have already been declining. There has been a rising concern about skills mismatches of college educated workers in the Korean labor markets (Lee et al., 2016).

education, opportunities expanding life-long training and providing better environments for females, however, can help increase human capital growth. Our estimates show that increased productivity of female and elderly workers can help improve aggregate human capital significantly over the next two decades.

Our human capital estimates are subject to measurement errors. We had to merge several household and labor market survey datasets to measure the changes in the labor market over the past three decades, but these datasets may not be completely consistent. In assessing the role of human capital on economic growth, we adopt the growth accounting method. As the method is just a mechanical decomposition of the output growth into components associated with productive inputs, it is limited to consider the interactions among these factors. An abundant human capital stock can have a positive eff ;ect on technological progress. Conversely, technological change can raise the relative demand for more-educated and skilled workers, thus promoting human capital accumulation. We will need a structural model to identify the independent impact of human capital on output growth in the economy. Future studies can improve the human capital measure and further investigate the relationship between human capital accumulation and economic growth in the Korean economy.

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