Korea Institute for Health and Social Affairs

Working Paper 2015-01

Analysis of the Impact of Decreasing Labor and Growing Income Polarization on Economic Growth

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ISBN: 978-89-6827-242-4 93330

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Background

1 Background

Korea's changing demographic structure is expected to exert diverse and far-reaching ripple effects throughout the country's society and economy. This study analyzes how these demographic structural changes will likely affect Korea's economic growth using a growth accounting model, which shows that multiple factors impact on economic growth, including labor, capital, and technological progress. A great number of studies argue that a decrease in the growing of the economically active population or in its absolute size slows economic growth. This argument appears to make sense on an intuitive level. The economically active population is itself a factor of growth, and therefore its decline will necessarily slow down or even stop economic growth altogether. The growth accounting model is usually divided between quantitative analyses and qualitative ones. The latter take into account not only the absolute size of a given economically active population, but also the quality of the given human capital. Qualitative analyses therefore involve how the increasing educational and wage levels of workers also affect economic growth. The purpose of this study is to determine how Korea's declining birth rate and the increasing aging population affect the quantity of its economically active population and how the qualitative improvement in the country's human capital can help offset the decreasing quantity of labor. Much of the existing literature on this topic approaches such questions by analyzing the different wage levels of workers in different industries and occupations. This study takes a different approach, analyzing the income level of each income quantile and the rate at which it increases, thus forecasting the future income levels for all income quantiles in Korea. We examined how the changes in the demographic structure and the growing polarization in income levels interact with each other and affect economic growth. The analysis offered here proves that the declining birth rate of a society, such as Korea, can also lead to an improvement in the quality of its workforce.

Chapter 2

Literature Review: Theories of Economic Growth

2 Literature Review: Theories of Economic Growth

1. Solow's growth model

This study applies a growth accounting model in order to determine how the declining birth rate in Korea affects the country's economic growth. Much of the literature in this regard assumes that the economic growth of societies with decreasing birth rates occurs as a result of the technical substitution between capital and labor. Since the emergence of Robert Solow's neo-classical growth model (1956), numerous theorists have applied growth accounting models, from diverse perspectives, to their own studies. However, it was not until Jorgenson et al. (1972) that the term "growth accounting" began to be used somewhat generically. The concept is predicated on a number of assumptions, including those of linear homogeneous production functions and a perfectly competitive market. The significance of the perfect competition assumption lies in that it is, as is the assumption of constant returns to scale, a condition in which total factor production growth can be eqated to technological progress.

Growth accounting, in other words, assumes that the economy of a given society continues to grow on the basis of continuous increases in the total output level, particularly as a result of increases in production factors (i.e., capital [K] and labor [L]) and advances in technology. The growth accounting models formulated so far in the literature all share certain basic characteristics. Notwithstanding their purposive and technical differences, they all assume that economic growth reflects not only changes in such quantitative factors as capital and labor, but also changes in qualitative factors, i.e., technological progress.

As growth accounting involves the respective contributions of different production factors to a given economic growth rate, we need to develop an economic growth model. The Solow model, by far the most popular model used in this accounting process, assumes that economic growth takes place in the form of increasing output thanks to the interaction between the two production factors—capital and labor—and technology. In the Solow model, economic growth does not occur unless the amount of capital increases, the size of labor increases, or technology improves. The model also assumes an constant returns to scale. Therefore, an N-fold increase in one of the production factors is assumed to lead to a proportional increase in the output. The production function in this model takes on a concave form, assuming that the level of marginal output gradually decreases after reaching a peak. The function that meets this requirement, known as the Cobb-Douglas production function, is expressed as follows:

$$Y_t = K_t^{\alpha}(A_t L_t)^{1-\alpha} \qquad (1)$$

(Y_t: output at time t, K_t: capital at time t, A_t: TFP,

L_t: population size at time t, α: share of capital,

$1-\alpha$: labor's relative share)

Growth accounting expresses economic growth as a function of the TFP, which refers to the combined productivity of all the given production factors, including labor, capital, and technology (Jang 2013). The concept implies that there can be multiple factors, aside from capital and labor, that also affect the productivity of capital and labor (Jeong et al. 2009). Thus, technological progress is a central component of growth accounting, as it encompasses multiple factors other than capital and labor that may contribute to economic growth. The Solow growth model expresses changes in technology or productivity as changes in the TFP (A_t). The TFP, representing the combined effect of all factors, other than quantitative factors that contribute to production, and it indicates qualitative improvements in human capital and capital goods. Because TFP is a concept that is not directly observable or measurable on national accounts, it is estimated by subtracting the total economic growth rate from the potential economic growth reflecting the rates of increases in labor and capital. That is why TFP is also called

Solow residual.

We can identify the respective shares of the economic growth factors in a given economic growth rate by taking a logarithm of Equation (1) and its derivative with respect to time t:

$$\hat{Y} = \hat{A} + \alpha\hat{K} + (1-\alpha)\hat{L} \qquad (2)$$

2. Estimating TFP

The TFP is a component of the Solow growth model that is particularly difficult to measure and estimate, as the name “Solow residual” suggests. Jorgenson (1967) was the first to attempt to measure, in exact detail, the size of Solow residual, as opposed to assuming TFP as simply the difference between the total output and the contributions of labor and capital to the total output. Jorgenson started from the assumption that the total output, as expressed by the national income account, represents the sum of the cost of each production factor. He then derived two correlated equations for the quantitative and qualitative decompositions of economic growth. Hence, the difference between an economic growth rate and the shares that capital and labor have in it became known as the primal approach of the Solow residual, while the difference between an economic growth rate and the rates of increase in the interest rate and wage is known as the dual approach of the Solow residual. According to the law of equivalence of the national income account, total output is the sum of the costs of all production factors, so Hsieh (2002) expresses total output as the sum of the costs of capital and labor, as follows:

$$Y = rK + wL \tag{3}$$

Here r represents the effective rental cost of capital, i.e., the real interest rate, while w represents the real wage. Take the derivatives of both sides with respect to time t, and we get Equation (4):

$$Y\hat{Y} = rK\hat{r} + rK\hat{K} + wL\hat{w} + wL\hat{L} \tag{4}$$

Divide both sides of Equation (4) by Y and we get Equation (5):

$$\hat{Y} = \frac{rK(\hat{r} + \hat{K})}{Y} + \frac{wL(\hat{w} + \hat{L})}{Y} \tag{5}$$

Express the share of capital income and the relative share of labor income as $rK/Y = S_K$ and $wL/Y = S_L$, respectively, and we get Equation (6):

$$\hat{Y} = S_K(\hat{r} + \hat{K}) + S_L(\hat{w} + \hat{L}) \tag{6}$$

Move the quantitative aspect of growth to the left side of Equation (6) and we get Equation (7):

$$\hat{Y} - s_K\hat{K} - s_L\hat{L} = s_K\hat{r} + s_L\hat{w} \tag{7}$$

Hsieh (2002) thus estimates the Solow residual by quantitatively decomposing the shares of capital and labor in the total economic growth rate, as expressed by the left-hand side of Equation (7). Hsieh then calls this equation for measuring the Solow residual, using quantitative decomposition, as the Solow residual (primal), i.e., SR_{primal}. The two sides of Equation (7) are identical to each other, and therefore, the right side naturally becomes the Solow residual, i.e., the Solow residual (dual) or SR_{dual}. The primal and the dual are in a spontaneous relationship of duality, which is why their use is called a dual approach.

$$SR_{primal} = \hat{Y} - s_K \hat{K} - s_L \hat{L} \qquad (8)$$

$$SR_{dual} = s_K \hat{r} + s_L \widehat{W} \qquad (9)$$

Equation (8) is sometimes referred to as the numerical method for measuring the Solow residual, while Equation (9) is referred to as the price method.

3. Literature on economic growth in Korea

The literature on Korea's TFP and economic growth can be largely divided between studies adopting the primal approach and others adopting the dual approach. A leading study on the economic growth rate in Korea using the dual approach is Han and Shin (2008). Jang (2013) is another interesting study employing the method originally formulated in Hall (1988), relaxed the assumption of perfect competition.

A. Han and Shin (2008)

In their study of the causes of the slowdown in Korea's economic growth rate after the Asian Financial Crisis of 1997, Han and Shin performed a growth accounting analysis using numerical and price variables. In using numerical variables, the authors presupposed a certain production function akin to the Cobb-Douglass production function or translog function, and determined each factor's respective growth share based on the elasticity of production to capital and labor. The authors thus argue that, assuming capital and labor are rewarded according to the marginal production curve on a perfectly competitive market, the production elasticity of a factor is the share of income from that factor. If we presuppose the Cobb-Douglas production function for this model, we get the first of the two equations shown in (10) below. Convert it into a logarithmic form and take its derivative with respect to time t and we get the second equation, which helps us identify each factor's share in income. This equation takes a form identical to that of the general growth accounting model.

$$
\begin{aligned}
&Y(t) = A(t)K(t)^{\alpha}L(t)^{1-\alpha}, \qquad (10) \\
&\hat{Y}(t) = \hat{A}(t) + \alpha\hat{K}(t) + (1-\alpha)\hat{L}(t)
\end{aligned}
$$

The growth accounting model using price variables rests on the assumption that the total output of a given year's national income account is the sum of the real capital input—obtained by multiplying the capital input of the given year $K(t)$ by the real rental cost of capital $r(t)$—and the real labor input—obtained by multiplying the labor input $L(t)$ by the real wage $w(t)$. As in the numerical model, we take the derivative of each side with respect to time t and divide it by total output (Y) to identify the relationship between numerical variables and price variables.

$$Y(t) = r(t)K(t) + w(t)L(t), \tag{11}$$
$$\hat{Y}(t) = \theta_K(\hat{r}(t) + \hat{K}(t)) + \theta_L(\hat{w}(t) + \hat{L}(t))$$
$$\hat{Y}(t) - \theta_K\hat{K}(t) - \theta_L\hat{w}(t) = \theta_K\hat{r}(t) + \theta_L\hat{w}(t)$$

The left-hand side of the third equation in (11) represents the estimated rate of increase in TFP using numerical variables, while the right-hand side represents the estimated rate of increase using price variables. Han and Shin thus show that the main culprit of the radical slowdown in Korea's economic growth after the Asian Financial Crisis was the slowdown in the amount of capital accumulation per capita.

〈Table 1〉 Primal Growth Accounting Analysis Results (Han and Shin 2008)

(Unit: %)

Term	$\hat{Y}$	$\hat{L}$	$\hat{K}$	TFP
1981-1985	7.5	2.7	9.5	2.5
1986-1990	9.2	4.0	12.3	2.3
1991-1995	7.5	4.2	11.6	0.8
1996-2000	4.3	1.6	6.6	1.0
2001-2005	4.5	1.3	4.7	2.0

Source: Han and Shin (2008)

〈Table 2〉 Dual Growth Accounting Analysis Results (Han and Shin 2008)

(Unit: %)

Term	$\hat{Y}$	Real wage	Real rental cost of capital	Dual TFP
1981-1985	7.5	3.2	.9	2.4
1986-1990	9.2	4.6	-4.3	1.5
1991-1995	7.5	2.6	-2.8	0.8
1996-2000	4.3	0.3	.1	0.2
2001-2005	4.5	3.5	-2.9	1.3

Source: Han and Shin (2008)

B. Choi et al. (2007) and the Bank of Korea

Choi et al. (2007) provides an empirical analysis of the role that human capital has played in Korea's economic growth. Assuming that workers in Korea are rewarded at varying rates in proportion to their marginal productivity, the authors measured the labor input in terms of man-hours and the quality of labor. Their study is noteworthy in that it takes into account the differences in sex, educational attainment, and occupational types among workers in considering that the quality of labor differs by individual and occupational/industrial idiosyncrasies. The authors then developed the total labor input index, taking into account both the quantitative and qualitative aspects of labor input, and applied it to all industries first and separately to the manufacturing and service sectors. Next, the authors analyzed the respective shares of production factors (capital, labor and TFP) in the economic growth in Korea from 1985 to 2005. Their growth accounting model does not differ from the basic one we looked at earlier:

$$Y(t) = A(t)K(t)^{\alpha}L(t)^{\beta},\ L(t) = Q(t) \cdot H(t) \qquad (12)$$

α = share of capital income, β = labor's relative share.

As this second equation shows, the authors express the quality of labor input in terms of the amount of human capital (Q) and the quantity of labor input in terms of multiples of man-hours (H). While the level of contribution from TFP to economic growth during the period from 1985 and 2005 was generally low, it was relatively high in the manufacturing sector, while the contribution from labor was high in the service sector.

〈Table 3〉 Growth Accounting Analysis Results (Choi et al., 2007)

(Unit: %)

Term	$\hat{Y}$	$\hat{L}$	$\hat{K}$	TFP
1985-1995	8.3	2.8	3.5	2.0
1995-2005	4.4	1.1	2.0	1.4
1985-1990	9.2	3.0	3.4	2.9
1991-1997	6.5	2.0	3.3	1.2
2000-2005	4.6	1.6	1.7	1.3

Source: Choi et al. (2007)

C. Korea Productivity Center (2010)

The Korea Productivity Center (2010) provides a growth accounting analysis of not only Korea, but also other major member states of the Organization for Economic Cooperation and Development (OECD) using the EU KLEMS data. EU KLEMS refers to a comprehensive database that provides the entire range of information needed for growth accounting analyses and wide-ranging considerations of economic growth and TFP (KPC, 2010; Jang, 2013). The database provides basic data on 72 industries found in the 25 EU member states for the period from 1970 to 2007. In order to use these data for an empirical analysis of Korea, however, KPC needed to modify the KLEMS industrial classification system. KPC (2012) thus applied 66 of the 72 industrial categories of the EU KLEMS to Korea, except for six categories: namely, (5) crude oil and gas exploration, (6) uranium and thorium mining, (33) other precision machinery, (39) materials for recycling, (56) imputed rent, and (72) international and foreign businesses.

The EU KLEMS data also provide information not only on quantitative aspects of labor input, such as the number of workers and the number of man-hours, but also on qualitative aspects, such as the sexes, age and educational attainments of workers, assuming that the labor of workers of different sexes, age groups, and educational backgrounds differs in quality.

The standard KLEMS method involves analyzing the productivity of each sector (e.g., manufacturing, mining, service), rather than that of an entire economy, by dividing a given output by the amounts of capital (K), labor (L), energy (E), and intermediate goods (M) required. Other analyses involve additional items of input, such as imported goods and services. While much of the literature based on the KLEMS data is confined to manufacturing and other specific sectors, KPC's studies apply the KLEMS method to all sectors of the Korean and other OECD member state economies for a more far-reaching international comparison.

KPC's analyses show a markedly reduced role of TFP in economic growth than do other studies. This is because KPC does not include factors other than capital and labor in the concept of TFP, and it opts instead to retain individual concepts for energy, raw materials, service, and so forth. KPC's international comparison shows that the role of TFP in economic growth is much lower in Korea than elsewhere, such as in Japan and the United States. KPC thus classifies Korea as a factor input-oriented economy and not a TFP-oriented one.

〈Table 4〉 Growth Accounting Analysis Results (KPC, 2012)

(Unit: %)

Term	$\hat{Y}$	Labor	Capital	Energy	Raw materials	Service	TFP
1981-1990	10.03	0.87	2.54	0.63	4.17	1.69	0.11
1991-2000	7.04	0.58	1.79	0.42	2.58	1.30	0.37
2001-2005	5.38	0.49	0.93	0.28	2.23	1.15	0.31
1981-2005	7.90	0.68	1.92	0.48	3.14	1.43	0.26
2001-2008	5.15	0.36	0.90	0.34	2.05	1.19	0.30
1981-2008	7.57	0.62	1.80	0.48	3.00	1.41	0.26

Source: KPC (2012).

D. Jang and the National Assembly Budget Office (2013)

Jang (2013) compares major studies in and outside of Korea on the topic of TFP and points out the unrealistic nature of the two core assumptions—perfect competition and constant returns to scale—that researchers use to assume the identity of TFP and technological progress. Once we abandon these assumptions, neither the primal TFP nor the dual TFP corresponds to actual technological progress. Hall's (1988) solution to this dilemma was to relax the perfect competition assumption and introduce the minimal cost requirement in estimating TFP. Jang (2013) therefore, in his analysis of TFP, uses Hall's model which relaxed the assumption of perfect competition.

As with Solow (1957, p. 312), Hall equates TFP to the difference between the multiple of the rate of increase ($\triangle q_i$) in the output/capital ratio ($\triangle \log(Q/K)$) and labor's relative share (α), on the one hand, and the multiple of the rate of increase in the labor/capital ratio ($\triangle n_t$) and labor's relative share (α), on the other. The equation therefore can be expressed as follows:

$$\triangle q_t - \alpha_t \triangle n_t = \theta_t \tag{13}$$

If we assume perfect competition and constant returns to scale, the share of labor input will be identical to the elasticity of the production function. However, since he had relaxed the perfect competition requirement, Hall decided to resort to the concept of the markup ratio (i.e., price/marginal cost) as an indicator of market competitiveness.

First, he obtained the marginal cost (mc) by dividing the change in the labor input ($\triangle N$), multiplied by the wage (w), by the corresponding change in the output, as follows:

$$mc = \frac{w \triangle N}{\triangle Q} \tag{14}$$

Convert this into an equation of the rate of change and we get Equation (14). The equation expresses the output growth rate as multiples of changes in production factors.

$$\frac{\triangle Q}{Q} = \frac{wN}{xQ} \frac{\triangle N}{N} \tag{15}$$

The markup ratio of μ represents the price divided by the marginal cost. The rate of increase in the output-to-capital ratio therefore can be expressed as the markup ratio multiplied by labor's relative share and by the rate of increase in the capital-to-labor ratio, as follows:

$$\triangle q_t = \mu_t \alpha_t \triangle n_t \qquad (16)$$

All these equations, however, assume that all the variables involved remain constant over time. If, however, technological progress occurs along with changes in the capital stock, the marginal cost should be modified and expressed as $mc = \dfrac{w\triangle N + r\triangle K}{\triangle Q - \theta Q}$. This is obtained by subtracting and adding the multiples of the real cost of new capital (r) from the denominator (containing the compensating coefficient of -θQ) and to the numerator of the equation (expressing the reduction in capital stock $\triangle K$), respectively. In this way, the output can continue to increase without additional capital and labor inputs when hicks-neutral technological progress is occurring at a rate of θ. Then, we apply the constant returns to scale assumption by using $\dfrac{wN}{xQ}$ and $\dfrac{rK}{xQ}$ to represent the respective rates of the shares of labor and capital and income, the sum of which amounts to one. We can now rewrite the marginal cost equation, which bears resemblance to the standard growth accounting equation we have been using, as follows:

$$\frac{\triangle Q}{Q} = \frac{wN}{xQ}\frac{\triangle N}{N} + \frac{rK}{xQ}\frac{\triangle K}{K} + \theta \qquad (17)$$

$$\hat{Y} = (1-\alpha)\hat{L} + \alpha\hat{K} + \hat{A}$$

Hall has thus newly defined TFP by relaxing the perfect competition assumption using the minimal cost requirement. According to Jang (2013), OECD (2012) employs Hall's method, but fails to take into account a number of other important factors, such as the quality of the labor input, the tax on the rental cost of capital, or the variations in the interest rate over time. Jang tries to overcome this shortcoming by basing his analysis on the KIP data from KPC and the estimates on the cost to capital users in Pyo et al. (2009). The findings of Jang's analysis are summarized in the table below.

〈Table 5〉 Growth Accounting Analysis Results (Jang, 2013)

(Unit: %)

Term	$\hat{Y}$	Labor	Capital	TFP
1971-1980	8.5	3.8	4.3	0.4
1981-1990	9.3	2.5	5.7	1.1
1991-2000	6.0	1.5	3.8	0.7
2001-2010	3.7	1.6	2.0	0.1

Source: Jang (2013).

The manufacturing sector shows little difference in terms of TFP whether the primal approach or the Hal approach is used. This indicates that monopoly profit is relatively less in manufacturing. The greater gap in the results when applying the two different approaches to the service sector therefore indicates that monopoly profit is relatively greater in service.

All these studies involve different scopes of time and therefore defy direct comparisons. However, the rates of change in

TFP shown by their growth accounting analyses range from 0.3 percent to 2.9 percent.

E. Growth accounting method of this study

This study applies a modified version of the dual approach originally used by Hsieh (2002). The major difference between Hsieh's method and ours is that we use weighted average wages of different income quantiles instead of the weighted average wages of different industries, with the purpose of determining the correlation between income polarization and the quantitative decrease in the labor input.

Chapter 3

Input Factors for Economic Growth Rate Decomposition

3 Input Factors for Economic Growth Rate Decomposition

1. Gross domestic product (GDP)

Using the available data on the various input variables used in the growth accounting model, we decomposed the respective shares of these variables in the past economic growth rates of Korea. For the gross domestic product for Korea (Y), we used Bank of Korea records, which are updated on an annual basis. The nominal GDP multiplied rapidly from KRW 191.3 trillion in 1990 to KRW 1,173 trillion in 2010. Yet the real economic growth rate has been steadily declining, from 6.61 percent in the early 1990s to 3.36 percent in the late 1990s, to 3.31 percent by the early 2000s, and to 2.65 percent in the late 2000s.

2. Quantitative input factors

Two core quantitative factors that determine GDP are capital stock and number of employees.

〈Table 6〉 Nominal GDP and Real Economic Growth Rates by Year (1990-2010)

(Units: KRW 100 million, %)

Year	Nominal GDP	Real economic growth rate	Year	Nominal GDP	Real economic growth rate
1990	1,913,828				
1991	2,314,282	6.61	2001	6,514,153	3.13
1992	2,639,932		2002	7,205,390	
1993	2,987,616		2003	7,671,137	
1994	3,499,726		2004	8,268,927	
1995	4,096,536		2005	8,652,409	
1996	4,609,526	3.36	2006	9,087,438	2.65
1997	5,063,136		2007	9,750,130	
1998	5,010,272		2008	10,264,518	
1999	5,490,050		2009	10,650,368	
2000	6,032,360		2010	11,732,749	

Source: Annual economic statistics from the Bank of Korea.

A. Capital stock

For capital stock, we used the Bank of Korea's data on the status of real production capital stock, as of the end of each year, for each category of economic activities enumerated in the National Account. The Bank of Korea keeps records of the changes in the production capital stock for 31 industries in total, including agriculture/forestry/fishery, mining, service, and construction. Like the real economic growth rate, the real growth rate of the capital stock has been declining, from 4.85 percent in the early 1990s to 3.1 percent in the late 1990s, to 2.3 percent in the early 2000s, and to 1.90 percent in the late 2000s.

B. Number of employees (labor input)

We tracked the number of employees on the basis of the December publications of Statistics Korea's monthly employment trend data concerning Korea's economically active population. Statistics Korea's surveys on this population include data on the numbers of persons, over given periods of time, who have worked for at least one hour to earn a wage; who have worked without pay for at least 18 hours a week to help support family-run farms or businesses; and who have temporarily stopped working either at their jobs or own businesses, due to such causes as illnesses and injuries, annual leaves, education and training, and labor disputes. The number of employees counted as such decreased radically by 1.3 million from 1997 to 1998 and by 70,000 from 2008 to 2009. However, it steadily increased in other years. The radical drops in the number of employees coincide with major economic and financial crises that hit Korea.

〈Table 7〉 Capital Stock Trends (1990-2010)

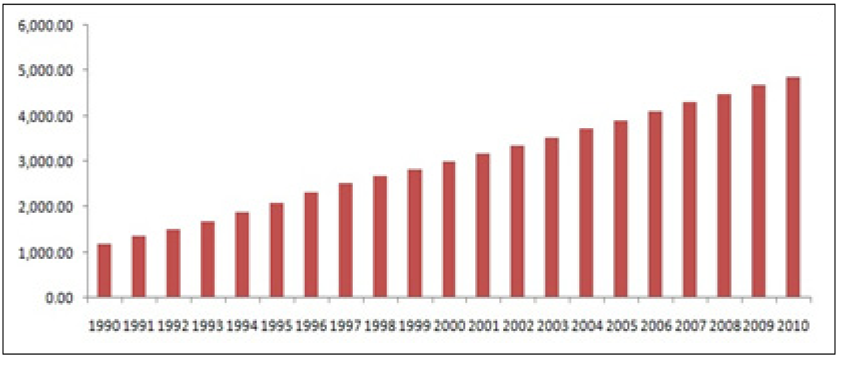
(Units: KRW 1 trillion, %)

Year	Capital stock	Rate of increase	Year	Capital stock	Rate of increase
1990	1,200.95				
1991	1,365.04	4.85	2001	3,170.05	2.30
1992	1,524.92	4.85	2002	3,350.63	2.30
1993	1,694.41	4.85	2003	3,538.08	2.30
1994	1,884.74	4.85	2004	3,727.37	2.30
1995	2,099.09	4.85	2005	3,915.61	2.30
1996	2,329.87	3.10	2006	4,107.89	1.90
1997	2,546.49	3.10	2007	4,309.54	1.90
1998	2,681.45	3.10	2008	4,499.84	1.90
1999	2,828.60	3.10	2009	4,682.45	1.90
2000	3,002.09	3.10	2010	4,876.37	1.90

Source: National Income Account, annually kept by the Bank of Korea.

[Figure 1] Annual Capital Stock Trends (1990-2010)

(Unit: KRW 1 trillion)



〈Table 8〉 Number of Employees by Year (1990-2010)

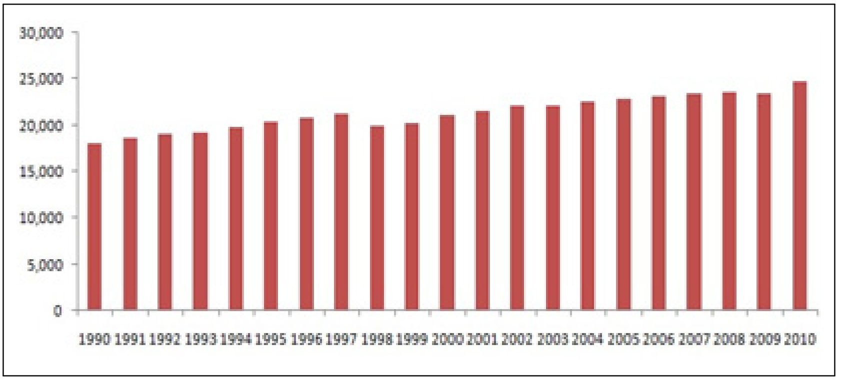
(Units: 1,000 persons, %)

Year	Number	Rate of increase	Year	Number	Rate of increase
1990	18,085				
1991	18,648	1.058	2001	21,572	0.677
1992	19,009	1.058	2002	22,169	0.677
1993	19,234	1.058	2003	22,139	0.677
1994	19,848	1.058	2004	22,557	0.677
1995	20,414	1.058	2005	22,856	0.677
1996	20,853	0.315	2006	23,150	0.709
1997	21,213	0.315	2007	23,432	0.709
1998	19,937	0.315	2008	23,577	0.709
1999	20,291	0.315	2009	23,505	0.709
2000	21,155	0.315	2010	24,802	0.709

Source: National Statistics Portal, annually updated by Statistics Korea

[Figure 2] Trend in the Number of Employees by Year (1990-2010)

(Unit: 1,000 persons)



3. Qualitative input factors

As this study takes a dual (price) approach for analysis, we need to measure the respective contributions to economic growth of qualitative factors forming TFP. The qualitative input factors included in our analysis are the real wage level (w) and the economic rent of capital (r).

A. Real wage level

The real gross wage is obtained by multiplying by 12 the average monthly wage of full-time workers at businesses hiring five full-time workers or more, and then by adding the annual special benefits and the like to the multiple. The resulting estimate thus represents the annual salary of an average worker in Korea. In order to convert that into real wage, we used the Consumer Price Index (CPI) of 2010. This showed that the average real wage level increased by 5.75 percent a year during the first half of the 1990s and by 1.25 percent a year in the latter half. The rate spiked back up to 4.47 percent in the early 2000s but rapidly dropped to -0.22 percent in the late 2000s.

〈Table 9〉 Average Real Wage Level by Year (1990-2010)

(Unit: KRW)

Year	Average real wage	Year	Average real wage
1990	17,813,299	2001	27,567,593
1991	19,375,843	2002	28,860,203
1992	20,827,327	2003	30,226,041

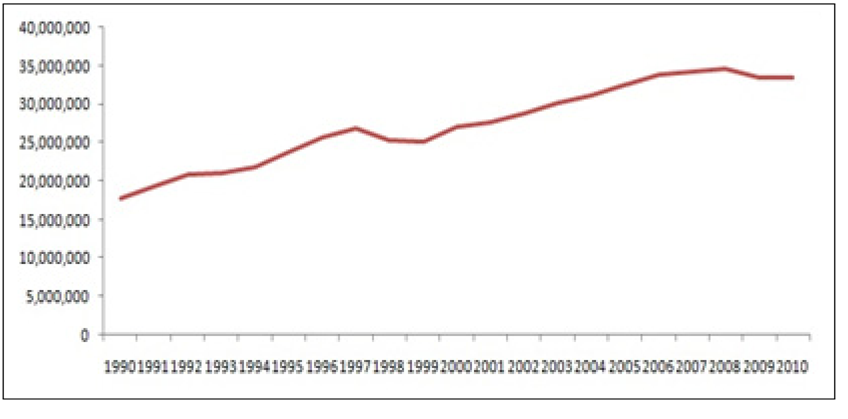
Year	Average real wage	Year	Average real wage
1993	21,177,585	2004	31,140,988
1994	21,826,412	2005	32,497,335
1995	23,838,582	2006	33,722,484
1996	25,683,504	2007	34,233,798
1997	26,810,405	2008	34,560,178
1998	25,280,768	2009	33,500,068
1999	25,096,627	2010	33,420,390
2000	26,975,836		

Note: The real wage was estimated by taking into account the inflation rate, as estimated on the basis of the CPI of 2010 (Bank of Korea).
Source: Survey on the Real Status of Employment by Employment Type, each year.

The reason the real gross wage appears to be in decline in recent years is that, while the total amount of the average monthly wage has been increasing, the amount of performance bonuses and other such annual special benefits has been decreasing.

[Figure 3] Trend in Real Gross Wage by Year (1990-2010)

(Unit: KRW)



As in Hsieh (2002), the analysis of growth rates in general involves the substitution of the weighted industrial average for the real wage level. However, as our purpose is to identify and analyze the substitution effect between the qualitative factor of human capital (as expressed by income polarization) and the quantitative factor of human capital (as represented by the number of employees), this study appropriates the weighted average wage of each income quantile rather than of each industry.

To this end, we gathered the raw data used for the annual *Surveys of the Real Status of Employment by Employment Type* (formerly known as the *Wage Structure Surveys*) and divided the real gross wage data into 10 quantiles or deciles. Then the weight of wage in each decile was multiplied by the average wage of the given decile.

As the weight of the real gross wage for the uppermost decile increased for the most part from 1990 to 2010, except for a brief decline, while the pattern for the bottommost decile has been the opposite—that is, a steady decline after a brief spike. The weighted average of the real gross wage for all deciles kept increasing consistently, before beginning to decline in 2010. This reflects the sizable decrease in the amount of annual special benefits.

B. Dividend ratios of the manufacturing sector (economic rent of capital)

The dual approach this study takes requires an indicator that represents the economic rent of capital. We need to measure this rent in order to estimate the share of technological progress, which is part of the TFP, in the increase in the economic growth rate. Well-known indicators of the return on capital as a measure of technological progress include the return on asset (ROA) rate, the return on equity (ROE) rate, and the net income (or loss) rate. However, data on these measures in Korea are only available from 2003 onwards. Moreover, the time series of the data for the manufacturing sector is particularly unstable, inhibiting researchers from estimating these indicators on the basis of the rates of increase or decrease in certain measures during specific periods of time. We therefore decided to appropriate the dividend ratio of the manufacturing sector, as published in the Bank of Korea's annual *Business Management Analyses*. According to the annotations on the accounts and analysis indicators provided by the Bank of Korea, the dividend ratio refers to "the ratio at which the amounts of dividends are to be paid with respect to the total amount of shares (i.e., paid-in capital) of a given business." The ratio indicates the level of dividends paid to investors and represents a rate of return on investment. Investors thus consider this ratio to be an important factor when making investment decisions.

As no data on the dividend ratios of all industries and sectors in Korea can be found concerning years prior to 2003, we decided to refer only to the dividend ratios of the manufacturing sector, as these data are available from 1990 onwards.

Hsieh (2002), it should be noted, used the real interest rate as an indicator of the economic rent of capital. We cannot do the same, as the interest rate has been declining considerably in Korea over the last two decades. Because the purpose of this study is to determine how much the return on capital has increased thanks to technological progress, we decided to use the less volatile dividend ratios of the manufacturing sector instead of the interest rate. Considering the abrupt increase in the rate of return on technology-intensive industries, such as information technology, in Korea since 2000, the interest rate is still too volatile an indicator of the economic rent of capital resulting from technological progress.

〈Table 10〉 Dividend Ratios of the Manufacturing Sector by Year (1990-2010)

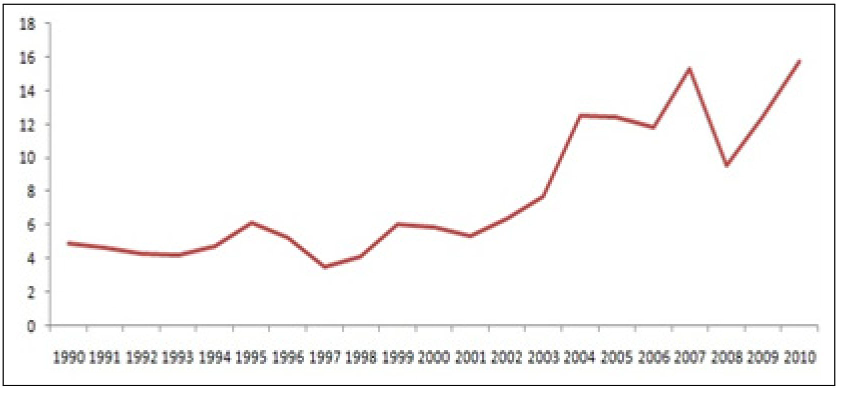
(Unit: %)

Year	Ratio	Year	Ratio
1990	4.93	2001	5.38
1991	4.65	2002	6.43
1992	4.34	2003	7.72
1993	4.21	2004	12.51
1994	4.73	2005	12.44
1995	6.15	2006	11.87
1996	5.26	2007	15.31
1997	3.52	2008	9.54
1998	4.14	2009	12.44
1999	6.07	2010	15.78
2000	5.89		

Source: Bank of Korea, *Business Management Analysis*, each year.

[Figure 4] Dividend Ratios of the Manufacturing Sector (1990-2010)

(Unit: %)



4. Factor income share ratios

The factor income share ratios may not be directly included in the growth function, but they exert a decisive influence on the total output. These ratios determine the respective shares to be contributed by capital and labor to a given production function. Once labor's relative share is determined, the capital income share is automatically determined as well. As for labor's relative share $(1-\alpha)$, this study uses the data provided by the Bank of Korea's National Account.

⟨Table 11⟩ Factor Income Share Ratios: Labor vs. Capital (1990-2010)

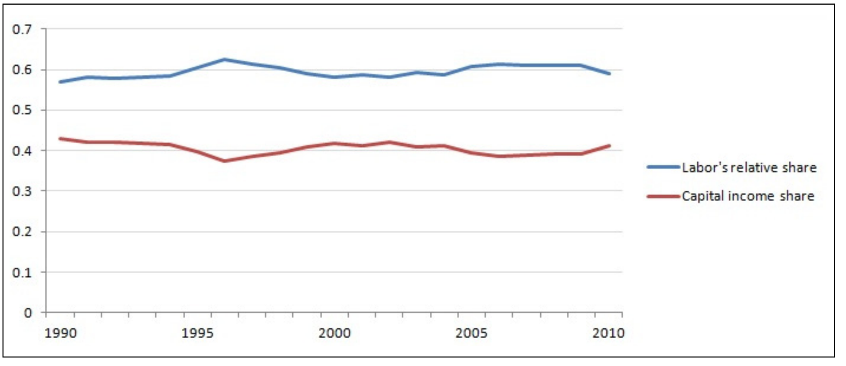
(Unit: %)

Year	Labor's relative share	Capital income share
1990	0.570	0.430
1995	0.604	0.396
2000	0.581	0.419
2005	0.607	0.393
2010	0.589	0.411

Source: National Account, annually updated by the Bank of Korea.

[Figure 5] Trends in the Capital Income Share and Labor's Relative Share (1990-2010)

(Unit: %)



Resource: Statistics Korea

Chapter 4

Decomposition of Economic Growth, 1990–2010

4 Decomposition of Economic Growth, 1990–2010

1. Primal decomposition

The primal decomposition method takes TFP as the difference between the real economic growth rate and the respective shares of capital and labor of that growth rate. Using this method, we multiplied the capital stock and the number of employees of each year by the given factor income share ratios and subtracted the multiples from the economic growth rates of the years from 1990 to 2010. See Table 3-12 for the results of decomposing Korea's past economic growth rates using these estimates on the yearly capital stock and number of employees. The table shows that the economic growth rate and the rate of increase in capital input steadily declined in Korea, thus inducing a consistent decline in SR_{primal}. Notwithstanding the steady declines in the primal SR and the rate of increase in the capital stock, the rate of increase in labor dropped sharply then steadily decreased.

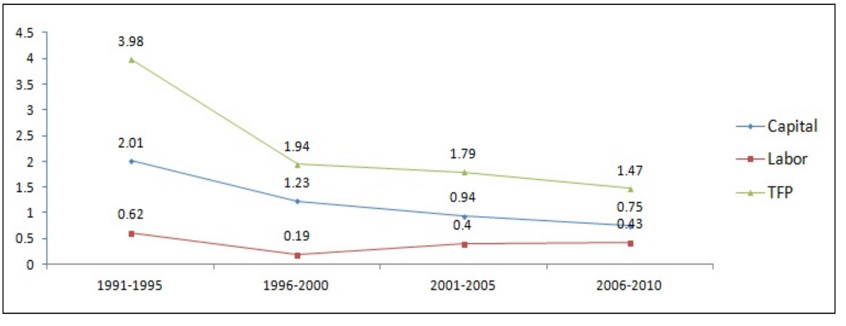
〈Table 12〉 Decomposition of Growth Factors (1990-2010)

(Unit: %)

Term	Economic growth rate (Y)	Capital input (a)	Avg. capital income share ratio (b)	Capital's contribution (c = a x b)	Labor (d)	Avg. labor's relative share (e)	Labor's contribution (f = d x e)	SR_{primal} (Y-c-f)
1991-1995	6.61	4.853	0.4142	2.01	1.058	0.5858	0.62	3.98
1996-2000	3.36	3.101	0.3966	1.23	0.315	0.6034	0.19	1.94
2001-2005	3.13	2.297	0.4092	0.94	0.677	0.5908	0.40	1.79
2006-2010	2.65	1.905	0.3936	0.75	0.709	0.6064	0.43	1.47

[Figure 6] Trends in the Rates of Increase in Growth Factors (1990-2010)

(Unit: %)



2. Dual decomposition

The dual decomposition method involves directly estimating TFP, which is left residual and merely guessed at in the Solow model. To this end, we used the dividend ratios and the average wage level of each income quantile as indicators of the TFP of capital and labor, respectively, and added to them the weights determined by the factor income share ratios. The resulting dual

Solow residual slightly decreased in the early part of our subject period, before growing and again decreasing in the later years. The drop in the rate of increase in TFP was particularly more noticeable for the years 2001 to 2005 than other years because the sum of the weights of the different income quantiles' wages showed a negative growth, thus diminishing it in absolute size.

Hsieh (2002) holds that the resulting Solow residuals of the dual and primal methods must be identical in theory. Even so, he points out, the exact residual may be elusive if the different types of data and statistics used for the two different methods are not consistent.

〈Table 13〉 TFP Decomposition (1990-2010)

(Unit: %)

Term	Dividend ratio of manufacturing sector (A)	Avg. capital income share ratio (B)	TFP's contribution to growth as technological progress (C = A x B)	Rate of increase in each income quantile's weighted average income (D)	Avg. labor's relative share (E)	TFP's contribution to growth as improvement in human capital (F = D x E)	SR_{dual} (C+F)
1991-1995	0.24	41.42	0.10	3.08	58.58	1.80	1.90
1996-2000	-0.05	39.66	-0.02	1.86	60.34	1.12	1.10
2001-2005	1.31	40.92	0.54	1.97	59.08	1.16	1.70
2006-2010	0.67	39.36	0.26	-0.40	60.64	-0.24	0.02

The resulting primal and dual Solow residuals differ from each other quite significantly. The size of the difference also varies from term to term, appearing to be at its largest with respect to the term from 2006 to 2010. Hsieh (2002) also suggests that the results of the two methods may differ due to other factors involved in growth accounting. The size of the gap between the primal and dual Solow residuals, resulting from the presence of these other growth-contributing factors, can be expressed as π.

$$SR_{dual} = s_K \hat{r} + s_L \hat{w} + \pi \qquad (18)$$

〈Table 14〉 Differences in TFP's Contributions to Growth: Primal vs. Dual

(Unit: %)

Term	SR_{primal}	SR_{dual}
1991-1995	3.98	1.90
1996-2000	1.94	1.10
2001-2005	1.79	1.70
2006-2010	1.47	0.02

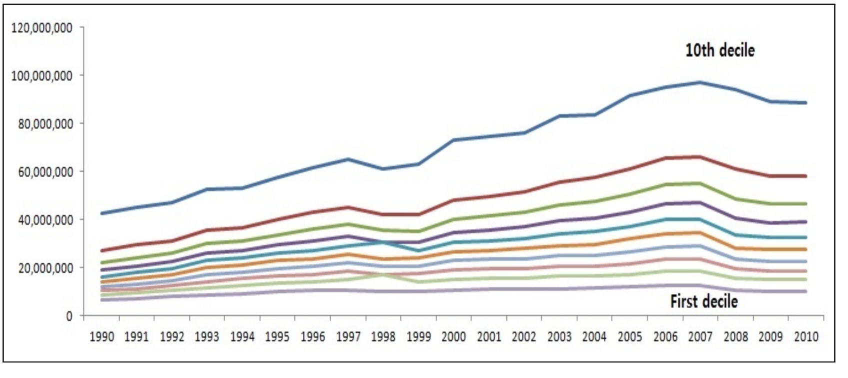
3. Different education spending of income quantiles and wage polarization

A. Overview

Appendix Table 2-1 shows the distribution of total amounts of wage by income quantiles. We can see that the weight of the 10th decile's income was the highest of all income quantiles, ranging from 23.82 percent in 1990 to 25.13 percent in 2008, before dropping slightly to 24.66 percent in 2010. The fifth decile's income weight was the lowest, ranging from 9.13 percent in 1990 to 9.01 percent in 2008, before rising slightly to 9.12 percent in 2010. The weight of the first decile's income was also the lowest, ranging from 3.67 percent in 1990 to 2.82 percent in 2008, and further dropping to 2.81 percent in 2010. The distribution of income weights indicates income polarization of a growing intensity afoot in Korea. It is not far-fetched to hypothesize that much of this income polarization reflects the varying amounts of different income quantiles' spending on education. Therefore, we need to determine how the polarization of spending on education leads to income polarization in Korea.

[Figure 7] Real Average Income Trends for 10 Deciles (1990-2010)

(Unit: KRW)



Based on the Wage Structure Survey of each year from 1990 to 2010, we can see income polarization increases over time, as shown in Figure 7. We can capture this change in income distribution as a probability density function. Assuming that real gross wages follow the pattern of a log-normal distribution (μ,

σ), its probability density function ($f(x)$: pdf) can be expressed as the equation shown below Table 15. Table 15 lists distributions of real gross wages across the deciles every five years, from 1990 to 2010.

〈Table 15〉 Log-Normal Distributions of Real Gross Wages (1990, 1995, 2000, 2005, and 2010)

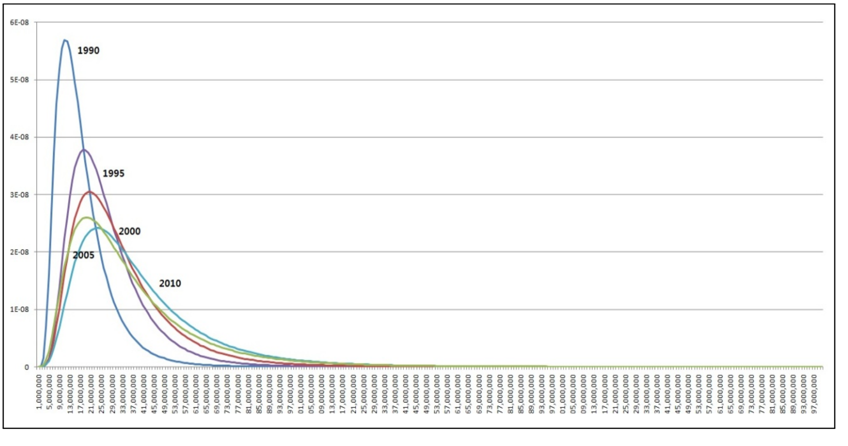
Income/year	1990	1995	2000	2005	2010
1,000,000	2.14E-15	7.26E-15	8.97E-14	4.1E-13	5.49E-13
2,000,000	7.77E-11	3.42E-12	9.03E-12	1.47E-11	4.64E-11
3,000,000	1.6E-09	6.86E-11	1.01E-10	1.09E-10	3.62E-10
4,000,000	6.95E-09	4.17E-10	4.57E-10	4.02E-10	1.22E-09
5,000,000	1.61E-08	1.39E-09	1.28E-09	1E-09	2.71E-09
6,000,000	2.69E-08	3.24E-09	2.71E-09	1.97E-09	4.78E-09
7,000,000	3.73E-08	6.03E-09	4.72E-09	3.3E-09	7.23E-09
8,000,000	4.58E-08	9.62E-09	7.24E-09	4.94E-09	9.88E-09
9,000,000	5.18E-08	1.37E-08	1.01E-08	6.81E-09	1.25E-08
10,000,000	5.54E-08	1.81E-08	1.31E-08	8.81E-09	1.51E-08
(Omitted)					
290,000,000	1.59E-15	1.07E-14	2.23E-13	2.36E-12	3.59E-12
291,000,000	1.53E-15	1.03E-14	2.16E-13	2.3E-12	3.51E-12
292,000,000	1.48E-15	9.96E-15	2.1E-13	2.25E-12	3.43E-12
293,000,000	1.43E-15	9.59E-15	2.03E-13	2.19E-12	3.35E-12
294,000,000	1.38E-15	9.24E-15	1.97E-13	2.14E-12	3.28E-12
295,000,000	1.33E-15	8.9E-15	1.91E-13	2.08E-12	3.21E-12
296,000,000	1.28E-15	8.57E-15	1.86E-13	2.03E-12	3.13E-12
297,000,000	1.24E-15	8.26E-15	1.8E-13	1.98E-12	3.06E-12
298,000,000	1.19E-15	7.95E-15	1.75E-13	1.93E-12	3E-12
299,000,000	1.15E-15	7.66E-15	1.69E-13	1.88E-12	2.93E-12
300,000,000	1.11E-15	7.38E-15	1.64E-13	1.84E-12	2.87E-12

$$f_x(x) = \frac{1}{\sigma x\sqrt{2\pi}} exp - \frac{1}{2}(\frac{\ln x - \mu}{\sigma})^2 \qquad (19)$$

Now we need to determine how large the fat-tails are and how they change on the probability density function. Table 15 shows the distribution of wage level probabilities across income deciles every five years (1990, 1995, 2000, 2005 and 2010) based on Equation (17). For example, we can add up the probabilities of the real wages—ranging from KRW 1 million to KRW 300 million—in 1990 to obtain a log-normal distribution of the real gross wages of 1990.

Figure 8 expresses the distributions listed in Table 3-15 in the form of graphs. Here we can see that the size of the fat-tail in the distribution of wages continues to grow larger over time.

[Figure 8] Distribution of Real Gross Wages by Income Quantile: Assuming Log-Normal Distribution (1990-2010)



〈Table 16〉 Actual Statistics on the Real Average Wages and Log-Normal Distribution Estimates

(Unit: KRW)

Year	Actual statistics (A)	Log-normal distribution estimates (B)
1990	17,813,350	17,717,261
1991	19,375,826	19,297,162
1992	20,827,387	20,739,916
1993	23,860,753	23,849,364
1994	24,797,515	24,824,605
1995	26,947,325	26,968,457
1996	28,558,162	28,599,536
1997	30,247,345	30,275,393
1998	28,914,757	28,244,904
1999	28,409,278	28,380,445
2000	32,091,256	32,086,800
2001	32,900,257	32,897,874
2002	33,824,334	33,856,365
2003	36,079,404	36,115,554
2004	36,802,225	36,893,206
2005	39,213,391	39,298,358
2006	41,970,882	42,103,045
2007	42,416,581	42,499,595
2008	37,483,724	37,485,006
2009	35,880,722	36,013,220
2010	35,846,086	36,067,488

Table 16 shows that the actual statistics on real average wages and the log-normal distribution estimates do not differ significantly.

The weight of the 10th decile in the real gross wage has been increasing steadily over time, while the weight of the first decile has been declining. Hypothesizing that this growing phenomenon of income polarization is attributable to the different amounts of investment each income quantile makes in education, we need to determine the relative differences from quantile to quantile in terms of education spending each year.

Chapter 5

Long-term Growth Projections Using the Dual Method (2011 to 2050)

5 Long-term Growth Projections Using the Dual Method (2011 to 2050)

The purpose of this study is to determine whether and how much the qualitative improvement of the workforce in Korea, as indicated by the rising wage level, could offset the possible loss of productivity in the workforce due to a decreasing birth rate leading to a gradual decline not only in the number of employees, but also in the absolute size of the economically active population.

Using the same method that we used for the decomposition and analysis of the different factors' contributions to economic growth, we sought to project the respective shares of quantitative and qualitative factors contributing to the long-term economic growth of Korea.

To this end, we surveyed the data on the physical capital growth rate and on the rate of increase in the number of employees, provided by the Third Long-term Projections for the National Pension (LTPNP). The Third LTPNP uses the primal rather than the dual (price) approach for the analysis of economic growth rates. This study therefore had to perform its own time series estimations on the likely rates of increases in wage and capital income required for the dual method.

1. LTPNP's rates of increase in economic growth and TFP

Table 17 lists the projected rates of increases in economic growth and TFP based on the LTPNP's scenario for the "optimistic projection of the intermediate level." According to this scenario, the slowdown in the rates of increases in physical capital and in the number of employees will serve to slow down the long-term economic growth rate of Korea. Nevertheless, the rate will remain positive because TFP will remain intact without significantly decreasing.

〈Table 17〉 Economic Growth Rate Scenario for Optimistic Projections of the Intermediate Level

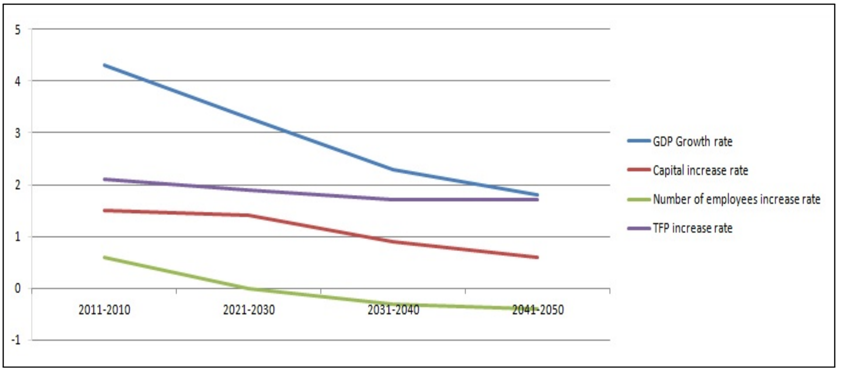
(Unit: %)

Term	GDP growth rate ($\hat{Y}$= A+B+C)	Physical capital increase rate (A)	Number of employees increase rate (B)	TFP increase rate (C)
2011-2020	4.3	1.5	0.6	2.1
2021-2030	3.3	1.4	0.0	1.9
2031-2040	2.3	0.9	-0.3	1.7
2041-2050	1.8	0.6	-0.4	1.7

Source: Fiscal Projections Committee (2013), *Long-term Fiscal Projections for the National Pension: Suggestions for the Improvement of the National Pension System and Fund Administration*, p. 93.

[Figure 9] Real Economic Growth Rate Projections Based on the Optimistic Projections Scenario (FPC)

(Unit: %)



Source: Fiscal Projections Committee (2013), *Long-term Fiscal Projections for the National Pension: Suggestions for the Improvement of the National Pension System and Fund Administration*, p. 93.

2. Long-term TFP projections using the dual method

A. Economic rent of capital

In our earlier analysis of growth rates, we substituted the dividend ratio of the manufacturing sector for the rate of economic rent of capital. In our long-term projections, we similarly estimate and use the dividend ratios of the manufacturing sector for different points in time. We use the SAS forecast procedure to this end, applying a confidence level of 95 percent to our estimates of changing ratios.

〈Table 18〉 Projections on the Dividend Ratios of the Manufacturing Sector

(Unit: %)

Term	Projection	Avg. rate of change	Term	Projection	Avg. rate of change
2015	19.96	0.72	2035	28.82	0.31
2020	23.01	0.72	2040	29.13	0.31
2025	25.28	0.42	2045	31.68	0.26
2030	27.17	0.42	2050	32.94	0.26

Notes: 1) Based on the SAS 9.3 forecast procedure, with a confidence level of 95 percent.
2) The average rate of change refers to the rate of change in the projections from 2011 to 2020, 2021 to 2030, 2031 to 2040, and 2041 to 2050.

B. Wage per income quantile

Rather than analyzing and projecting the rates of increase in wage by industry, this study uses the weighted average wage of each income quantile to project the future rate of increase. However, if we only use the rate of increase in the average income of each income quantile, the difference in the gross wage amount from quantile to quantile will cause a bias in each quantile's contribution to economic growth. Therefore, we need to estimate the weight of the gross wage of each quantile and project the likely trend of change in each quantile's average wage. We combine the two to obtain the weighted average growth of the real wage.

Real wage growth rate = weighted gross wage growth rate of each income quantile
X weighted average wage growth rate of each income quantile (18)

We used the raw data for the annual Surveys on the Real Status of Employment by Employment Type in order to identify the real gross wage of households and divide households into 10 quantiles according to their wage level. To produce projections regarding the weight of the gross wage and the average wage of each quantile from 2011 to 2050, we performed a trend analysis using a model offering the greatest explicatory power for past records. Assuming that the real wages will follow the pattern of a log-normal distribution in each quantile, we also compared the average wages of different quantiles.

(1) Estimating the weight of the gross wage per quantile

A polynomial projection model offers the greatest explicatory power for the weight of gross wages of income quantiles. In the function for each quantile, x stands for time (t), and y for the weight of the real gross wage. The functions are therefore based on the trend in the weights of real gross wages of different income quantiles from 1990 to 2010. As our trend analysis begins with the year 2011, the year 2011 is converted into one (1) and the year 2012 into two (2), and so forth, in the place of x.

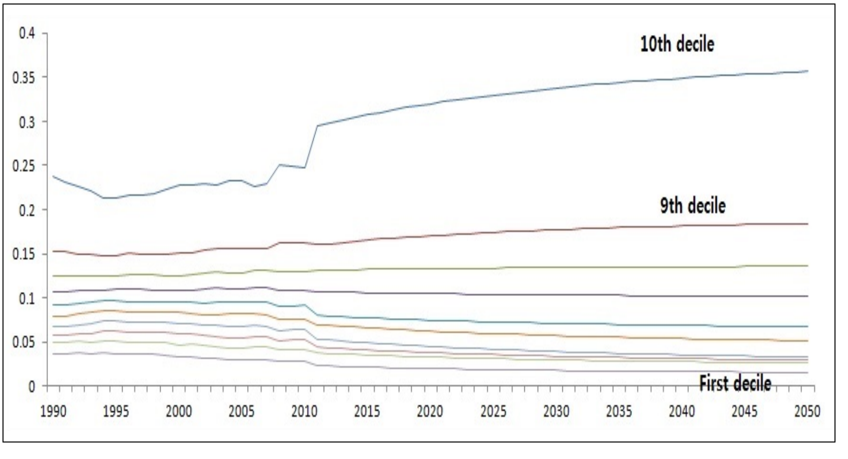
As Table 19 shows, the rate of increase in the real weighted average wage is the highest in the most-earning 10th decile, and turns negative starting with the 4th decile.

〈Table 19〉 Functions for the Real Weighted Gross Wage Projections

Income decile	Function	R^2
10	$y=2E+10x^2-6E+10x+2E+12$	0.956
9	$y=1E+10x^2+1E+10x+1E+12$	0.960
8	$y=7E+09x^2+1E+10x+1E+12$	0.961
7	$y=5E+09x^2+2E+10x+9E+11$	0.961
6	$y=3E+09x^2+3E+10x+7E+11$	0.960
5	$y=2E+09x^2+4E+10x+6E+11$	0.960
4	$y=1E+09x^2+4E+10x+5E+11$	0.962
3	$y=1E+09x^2+3E+10x+4E+11$	0.964
2	$y=1E+09x^2+2E+10x+4E+11$	0.965
1	$y=6E+08x^2+1E+10x+3E+11$	0.954

[Figure 10] Past Trends (1990–2010) and Future Projections for the Real Weighted Gross Wages of the 10 Deciles (2011–2050)

(Unit: %)



(2) Projecting average wages

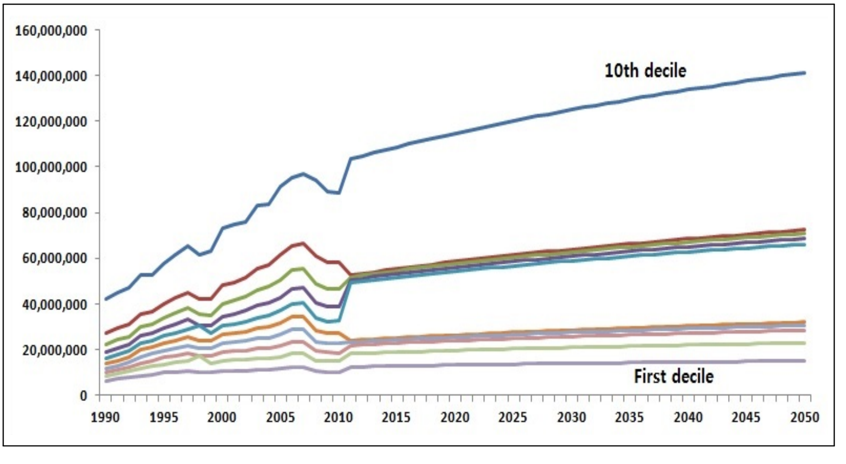
The involuntary function provides the greatest explicatory power and the most rational projections regarding the average real wages of different income quantiles. As in the case of the weighted real gross wages, we also based our projections of the weighted real average wages on our past trend analysis.

〈Table 20〉 Real Average Wage Trend Analysis and Functions

Income decile	Function	R^2
10	$y=4E+07x^{0.307}$	0.906
9	$y=2E+07x^{0.313}$	0.920
8	$y=2E+07x^{0.308}$	0.920
7	$y=2E+07x^{0.307}$	0.924
6	$y=2E+07x^{0.291}$	0.914
5	$y=1E+07x^{0.283}$	0.902
4	$y=1E+07x^{0.273}$	0.892
3	$y=1E+07x^{0.255}$	0.883
2	$y=9E+06x^{0.228}$	0.839
1	$y=7E+06x^{0.187}$	0.825

[Figure 11] Past Trends (1990-2010) and Future Projections for the Real Weighted Average Wages of the 10 Deciles (2011-2050)

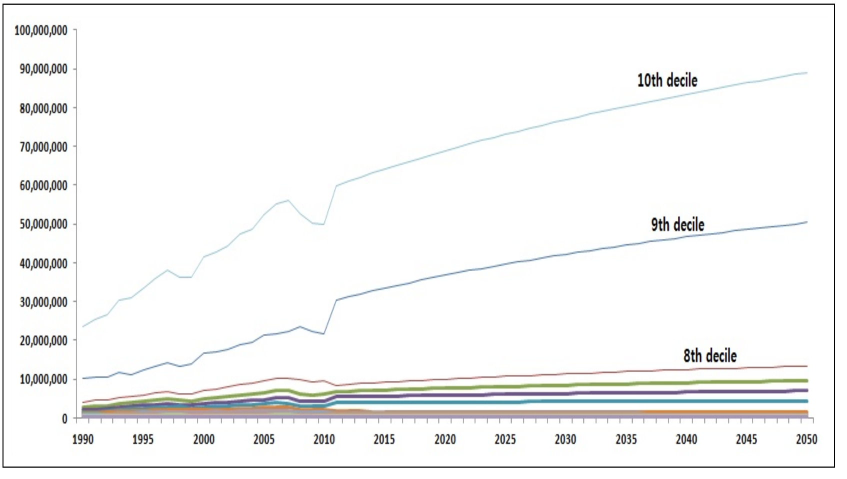
(Unit: KRW)



(3) Projecting the real average wage distributions

[Figure 12] Weighted Real Average Wage Distribution by Income Quantile Based on Trend Analysis (2011–2050)

(Unit: KRW)



〈Table 21〉 Rate of Increase in the Weighted Real Average Wage ($\hat{w}$)

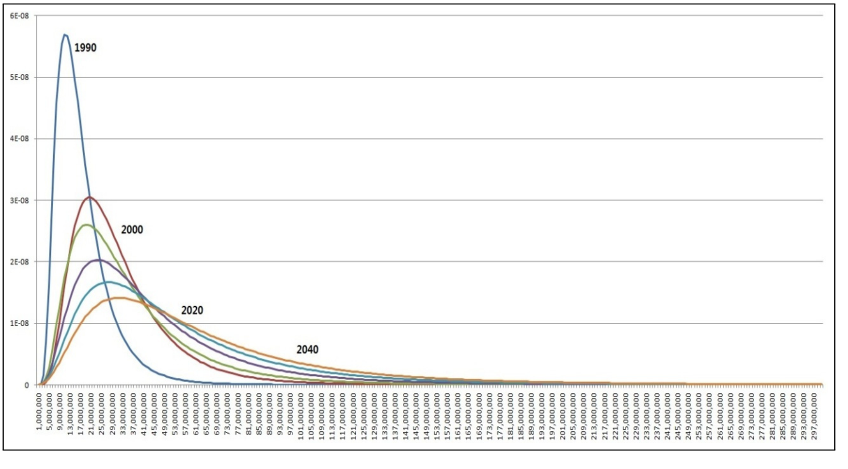
Decile	Rate of increase in the weight of real gross wage (A)				Rate of increase in the real average wage (B)				Rate of increase in the weighted real average wage (C = A x B)			
Terms[1)]	1	2	3	4	1	2	3	4	1	2	3	4
10	2.55	1.53	0.98	0.68	1.16	0.86	0.67	0.55	5.87	1.40	1.00	0.77
9	1.05	0.60	0.38	0.25	1.19	0.88	0.69	0.56	0.65	1.28	0.92	0.72
8	0.18	0.11	0.07	0.05	1.17	0.86	0.67	0.55	2.36	0.96	0.74	0.59
7	-0.24	-0.13	-0.08	-0.05	1.14	0.84	0.66	0.54	3.66	0.70	0.57	0.48
6	-0.54	-0.32	-0.20	-0.14	1.10	0.82	0.64	0.52	3.50	0.32	0.30	0.29
5	-0.74	-0.45	-0.30	-0.20	1.07	0.79	0.62	0.51	-2.15	-0.08	0.01	0.07
4	-0.83	-0.51	-0.33	-0.23	1.03	0.77	0.60	0.49	-2.21	-0.62	-0.41	-0.26
3	-0.60	-0.37	-0.24	-0.16	0.97	0.72	0.56	0.46	-0.58	-0.45	-0.28	-0.16
2	-0.49	-0.29	-0.18	-0.12	0.86	0.64	0.50	0.41	0.36	-0.40	-0.21	-0.10
1	-0.35	-0.19	-0.11	-0.07	0.71	0.52	0.41	0.34	-0.79	-0.62	-0.34	-0.19
Total									1.58	1.08	0.81	0.65

Note: Terms = 1: 2011-2020, 2: 2021-2030, 3: 2031-2040, 4: 2041-2050.

The 10th and 9th deciles show noticeably larger distributions of the weighted real average wages, pointing to a manifest phenomenon of income polarization.

Applying the theory of Kim et al. (2003),[1] we forecast the distribution of the gross wages and compared the results to the findings of our trend analysis. Based on the verification that taking a natural logarithm of each decile's wage results in a normal distribution of the gross wages, we performed a time series analysis of the yearly gross wage distributions from 1990 to 2010 based on the Wage Structure Survey data, and we used the distributions to project future wage distributions until 2050.

[Figure 13] Real Gross Wage Distributions Based on a Log-Normal Distribution Assumption: 1990-2010 vs. 2015-2050



1) J. Kim and M. Seong (2003), *Changes in the Sources of Income According to Projected Long-term Changes in the Workforce*, Korea Institute for Public Finance.

〈Table 22〉 Trend Analysis and Projections of the Real Average Wage and the Log-Normal Distribution Estimates

(Unit: KRW 1,000)

Year	Trend analysis projections (A)	Log-normal distribution estimates (B)
2011	49,167	37,000
2012	49,807	37,900
2013	50,428	38,900
2014	51,031	39,800
2015	51,616	40,600
2016	52,186	41,500
2017	52,742	42,600
2018	53,283	43,700
2019	53,811	44,400
2020	54,327	45,100
2021	54,831	46,000
2022	55,325	47,300
2023	55,807	47,800
2024	56,280	49,000
2025	56,743	49,900
2026	57,197	50,900
2027	57,643	51,600
2028	58,080	52,600
2029	58,510	53,500
2030	58,932	54,200
2031	59,347	55,400
2032	59,754	56,300
2033	60,155	57,300
2034	60,550	57,273
2035	60,939	58,063
2036	61,321	58,854
2037	61,698	59,644
2038	62,069	60,435
2039	62,435	61,226
2040	62,796	62,016
2041	63,152	62,807
2042	63,503	63,597
2043	63,849	64,388
2044	64,191	65,178
2045	64,529	65,969
2046	64,862	66,759
2047	65,191	67,550
2048	65,516	68,340
2049	65,837	69,131
2050	66,155	69,921

The wage projections show a heavy-tailed distribution, suggesting that the number and proportion of well-paid employees will continue to grow in the future. Assuming that this increase reflects an improved productivity of labor, we can surmise that the productivity of well-paid employees will grow at a faster pace than the productivity of employees in other deciles. As Appendix Table 7 shows, the trend analysis projections concerning the top 20 percent of wage earners were at least 10 percent higher than the log-normal distribution estimates. However, there is no significant difference between the trend analysis projections and log-normal distribution estimates on the real average wages in general.

3. Growth accounting predictions (2011–2050)

Because we used the Third LTPNP's long-term projections regarding quantitative input factors, our economic growth rate projections differ significantly from the results of our TFP decomposition (SR_{dual}). As the TFP of both capital and labor will decrease over time, SR_{dual}, a combination of the two, will also continue to decrease.

〈Table 23〉 TFP Decomposition and Projections (2011–2050)

(Unit: %)

Term	Dividend ratio (A)	Capital income share ratio (B)	Capital's contribution to growth (C = A x B)	Income by quantile (D)	Labor's relative share (E)	Labor's contribution to growth (F = D x E)	SR_{dual} (G=C+E)
1991-1995	0.24	0.4142	0.10	3.08	0.5858	1.80	1.90
1996-2000	-0.05	0.3966	-0.02	1.86	0.6034	1.12	1.10
2001-2005	1.31	0.4092	0.54	1.97	0.5908	1.16	1.70
2006-2010	0.67	0.3936	0.26	-0.40	0.6064	-0.24	0.02
2011-2020	0.72	0.417	0.30	1.58	0.584	0.92	1.22
2021-2030	0.42	0.417	0.18	1.08	0.584	0.63	0.81
2031-2040	0.31	0.417	0.13	0.81	0.584	0.47	0.60
2041-2050	0.26	0.417	0.11	0.65	0.584	0.38	0.49

Using the Fiscal Projection Committee (FPC)'s projections on the respective shares of physical capital and the number of employees—both quantitative factors—in economic growth and using the SR_{dual} estimates of our own, we reached the following projections on Korea's economic growth rates from 2011 to 2050.

〈Table 24〉 Economic Growth Rate Projections (2011–2050)

(Unit: %)

Term	Economic growth rate ($\hat{Y}$) ($\hat{K}+\hat{L}+SR_{dual}$)	Physical capital ($\hat{K}$)	Number of employees ($\hat{L}$)	SR_{dual}
2011-2020	3.32	1.5	0.6	1.22
2021-2030	2.21	1.4	0.0	0.81
2031-2040	1.20	0.9	-0.3	0.60
2041-2050	0.69	0.6	-0.4	0.49

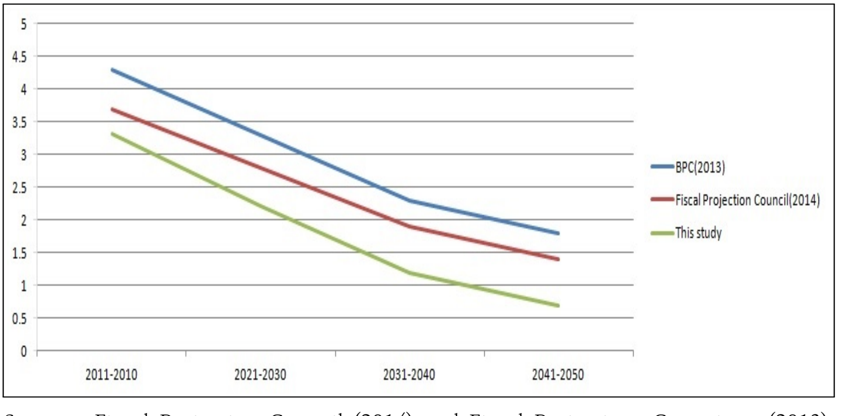
Note: See the FPC's projections regarding the rates of increases in capital stock and the number of employees.

Both the Budgetary Protection Committee for the National Pension Service (BPC, 2013) and the real GDP growth rate projections of this study predict that the growth rate will decline in the future, but at different absolute sizes.

The PBC's projections are based on a scenario of "optimistic projections of the intermediate level" and thus show the highest possible rates. The Ministry of Strategy and Finance's Fiscal Projection Council (2014), on the other hand, based its projections on a scenario of "neutral projections of the intermediate level." For this study, we based our projections on a scenario of pessimistic projections and therefore show the greatest margin of fall. As the TFP continues to decline and the absolute number of employees—standing for labor input—also begins to decline in 2031 and onwards, the rate of increase in physical capital will likely fall as well, lowering the economic growth rate in the long run.

[Figure 14] Comparisons of the Economic Growth Rate Projections (2011-2050)

(Unit: %)



Sources: Fiscal Projection Council (2014) and Fiscal Projections Committee (2013), *Long-term Fiscal Projections for the National Pension: Suggestions for the Improvement of the National Pension System and Fund Administration*, p. 93.

Note: Budgetary protection committee for the National Pension Service, BPC (2013, intermediate, optimistic) Fiscal Projection Council (2014, intermediate, neutral)

Labor is likely to make a greater contribution to TFP than capital at all times, suggesting that the real gross wage, used in this study as an indicator of labor input, will likely play a greater role in Korea's economic growth than other measures of capital. The reason the rate of increase in labor's contribution to TFP is projected to decrease slightly is that the rate of increase in the real average income will likely decrease as well.

Chapter 6

Conclusion: Substitution Effect of the Quality and Quantity of Labor

6 Conclusion: Substitution Effect of the Quality and Quantity of Labor

Human capital, the qualitative side of labor input, will increase its share in TFP in the long run, while the absolute quantity of labor input will eventually come to bear an inverse relation to economic growth rates. The objective of this study is to identify and forecast whether and how much the qualitative side of labor will offset the inevitable loss of the quantity of labor in Korea in the future. Our method involves determining how future increases in the real gross wage can help offset the eventual decrease in the number of employees over the long term.

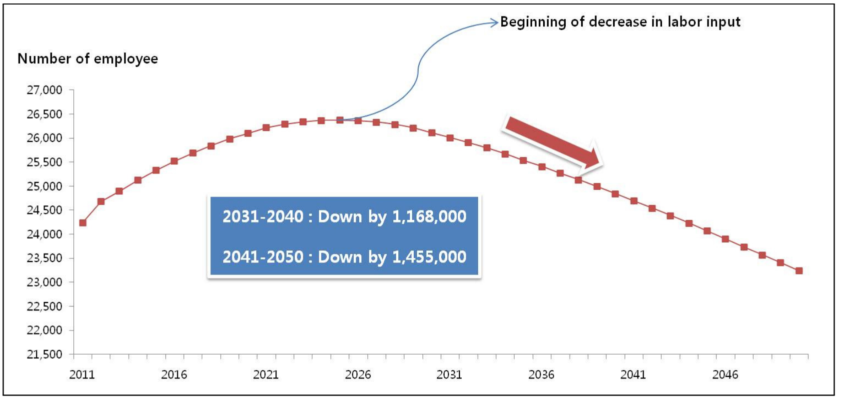
In the process of our analysis, we have found that the phenomenon of income polarization will grow worse in Korea, with the weight of the real gross wages of the 9th and 10th deciles increasing while the share of the 1st decile's real gross wage will decrease. Therefore, it will be the 9th and 10th deciles, with their greater productivity as indicated by their wages, that will help to offset the slowdown in Korea's economic growth rate resulting from the reduced number of employees. This finding of ours is significant as it provides empirical clues for the correlation between income polarization and economic growth.

Based on our analysis, we set out to estimate the economic growth rate at which the increase in the weighted real average wage can help offset the decrease in the number of employees as the absolute size of labor input in Korea begins to decline.

The LTPNP's projections on the rate of increase in labor input and our own projections on the increase in the weighted real average wage imply that, while the absolute size of labor input in the Korean economy will begin to decline in 2031, the real gross wage will continue to increase. More specifically, from 2031 to 2040, the number of employees is predicted to decrease by 1,168,000 from 26,013,000 to 24,845,000. From 2041 to 2050, the figure will further decrease by 1,455,000, from 24,695,000 to 23,240,000. The absolute size of labor input, in other words, is forecast to decline by 2,623,000 or so in total from 2013 to 2050. This leads to an average annual loss of 116,800 employees from 2031 to 2040 and an average annual loss of 145,500 employees from 2041 to 2050.

[Figure 15] Projected Trend in Labor Input (2011-2050)

(Unit: 1,000 persons)



Source: Fiscal Projections Council (2014).

In the meantime, the weighted real average wage is expected to grow by KRW 17,432,716 per capita from 2031 to 2050, thus offsetting the diminishing effect of the decrease in labor input on Korea's economic growth by the same amount.

More specifically, the weighted real average wage for the top 20 percent is predicted to increase by KRW 76,761,160 over the two decades, which is 4.4 times greater than the average for all income groups. Income polarization will therefore worsen, with the well-paid doing more to offset the absolute decrease in labor input than the poorly-paid. The fat-tail toward the right end of the wage distribution graphs we saw earlier suggests that the weighted real average wage for the top 20 percent will further increase from KRW 78,228,604 in 2031 to KRW 103,432,450 by 2050 in light of the worsening income polarization in Korea's human capital.

The weighted gross wage for all income quantiles will increase by 0.82 percent from 2031 to 2040, and the labor side of TFP will therefore increase by 0.48 percent, based on the average relative share of labor, which is 0.584. By applying these estimates to the rate of increase in the wage and economic growth contribution of each income decile, we obtain the following estimates.

As Table 25 shows, aside from the continued increase in the real gross wage at 0.82 percent and the increase in the labor's relative share of TFP at 0.48 percent, the total number of employees will decrease by 0.3 percent from 2031 to 2040. As the quantitative and qualitative aspects of labor input move in the opposing directions, we can infer that the increase in the real wage will help offset the loss of the absolute size of labor input. As the income for the top 10-percenters and 20-percenters will increase at 1.00 percent and 0.92 percent, respectively—each higher than the overall average of 0.82 percent—they will help offset the loss of labor input more than other income quantiles, whose real wages will either grow at a rate below the overall average or stop growing and begin decreasing.

〈Table 25〉 Offsetting Effect of Labor Input and the Rates of Increases in Real Wages (2031–2040)

(Unit: %)

Rates of increases in real wage ($\hat{w}$)				Rate of increase in labor input ($\hat{L}$)
Income decile	Rate of increase in real wage	Labor's relative share	Rate of increase in labor's relative share of TFP	Total
10	1.00	0.584	0.58	-0.3 (Down by 1,168,000 persons.)
9	0.92	0.584	0.54	
8	0.74	0.584	0.43	
7	0.57	0.584	0.33	
6	0.30	0.584	0.18	
5	0.01	0.584	0.01	
4	-0.41	0.584	-0.24	
3	-0.28	0.584	-0.16	
2	-0.21	0.584	-0.12	
1	-0.34	0.584	-0.20	
Overall	0.82	0.584	0.48	

Note: See the Ministry of Strategy and Finance's internal documents for the estimated loss of labor input (same for Table 26).

〈Table 26〉 Offsetting Effect of Labor Input and the Rates of Increases in Real Wages (2041–2050)

(Unit: %)

Rates of increases in real wage ($\hat{w}$)				Rate of increase in labor input ($\hat{L}$)
Income decile	Rate of increase in real wage	Labor's relative share	Rate of increase in labor's relative share of TFP	Total
10	0.77	0.584	0.45	-0.4 (Down by 1,455,000 persons.)
9	0.72	0.584	0.42	
8	0.59	0.584	0.34	
7	0.48	0.584	0.28	
6	0.29	0.584	0.17	
5	0.07	0.584	0.04	
4	-0.26	0.584	-0.15	
3	-0.16	0.584	-0.09	
2	-0.10	0.584	-0.06	
1	-0.19	0.584	-0.11	
Overall	0.65	0.584	0.38	

These estimates indicate that income polarization will ultimately help offset the negative effect of the inevitable loss of labor input—due to the decreasing birth rate and the aging of the population—on the Korean economy. In other words, we can offset the quantitative loss of human capital with its qualitative improvement. The higher one's income quantile, the less one's required additional contribution is needed to offset the effect of the loss of labor input on the Korean economy. The decreasing birth rate and income polarization, therefore, could be causally correlated. As technology-intensive industries grow at a faster rate than other industries, employees of these industries will inevitably earn greater wages than employees elsewhere. However, the fact that these technology-intensive industries require relatively few employees indicate that having fewer children will eventually help improve the quality of human capital in Korea in the long term.

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