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Research Report

The Evolution of Wage Inequality in Korea

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The Evolution of Wage Inequality in Korea

Youngsun Koh

KOREA DEVELOPMENT INSTITUTE

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The Evolution of Wage Inequality in Korea

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Preface

Increasing income inequality has received great public attention since the 1990s around the world. Academic works proliferated, while social tensions rose in many countries. This study examines the history of wage inequality in Korea in 1980-2016. During this period, wage inequality first declined (1980-1994), then rose (1995-2007), and then declined again (2008-2016).

This experience provides for an interesting case study that has both important theoretical and practical implications. Theoretically, it challenges the skill-biased technical change hypothesis, a widely accepted view in academia, as the latter cannot explain the increasing demand for *unskilled* labor as observed in Korea. In practical terms, the findings from this study offer guidance for policymakers on how to expand the job opportunities for disadvantaged workers, such as female workers, high school graduates, and other workers with low employability and weak labor market attachment.

This study benefited from the generosity of many people, including two anonymous referees, who provided valuable comments on earlier drafts. The author wants to thank them all. Most of all, Jiyoung Lee's excellent research assistance, with her devotion and technical skill, is deeply appreciated.

Jeong Pyo Choi
President of KDI

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Summary

Wage inequality in Korea has undergone several changes in 1980-2016. It fell in 1980-1994, rose in 1995-2007, and then fell again in 2008-2016. Different worker characteristics have had different impacts on wage inequality. In the early years, sex, age, and education were the three most important characteristics, but in later years, firm tenure became the most important one, followed by education and establishment size.

The impact of each worker characteristic can be decomposed into price effect (the sensitivity of wage inequality to a marginal change in worker characteristics) and distribution effect (the impact of changing distribution of worker characteristics across wage quintiles). In the cases of sex and age, both price and distribution played important roles in reducing inequality. In the case of education, price was the main driver in all periods, reducing inequality in the first period (1980-1994), increasing it in the second (1995-2007), and again reducing it in the third (2008-2016). In the cases of tenure and establishment size, distribution contributed significantly to increasing inequality.

Price is determined through the interaction between demand and supply. As for sex, the relative demand for male workers declined in all periods and particularly in the second and third periods, and accordingly their relative wage fell. As for age, the relative demand for older workers increased in all periods. But it was outpaced by the increase in supply, and as a result the relative wage fell for older workers. As for education, the relative demand for college graduates over high school graduates increased faster than the supply in the second period but not

in the first and third periods. The relative wage of college graduates rose in the second period but not in the other periods.

There have been suggested many explanations for the changes in demand. Among them, the endogenous technical change hypothesis posits that the increased supply of a particular group induces innovations that make more use of that group. According to this hypothesis, the increasing supplies of female workers and older workers increased the demand for these workers. Similarly, an increasing supply of high school graduates in the 1970s and 1980s led to the subsequent increase in the demand for them in the first period; an increasing supply of college graduates in the 1990s and early 2000s led to the subsequent increase in the demand for them in the second period; and the leveling off of their supply at the end of the 2000s led to the subsequent leveling off of the demand for them in the third period. On the other hand, the stories based on skill-biased technical change (SBTC) cannot provide explanations on the increases in the relative demand for some groups of unskilled workers—female workers (in the second and third periods), elderly workers (in the third period), and high school graduates (in the first period).

The rapid rise in the skill levels of female workers and younger workers appears to have added to the demand for them. On top of the endogenous technical change, this may explain the declining relative demand for male workers, and the slow increase in the relative demand for older workers (relative to the supply).

In addition to the price, the distribution of worker characteristics across wage quintiles have had important impact on wage inequality. In the case of sex, light manufacturing (most notably textiles, apparel, and leather products) had provided low-pay blue-collar jobs for the mass of female workers. Since the 1980s, however, the decline of this industry and the expansion of service industry and white-collar jobs provided female workers with the opportunity to move up the wage ladder and helped reduce the gap between sexes.

The average tenure has grown continuously, and so has the wage gap between long tenure and short tenure. This has increased the importance of tenure as a determinant of wage inequality. In the meantime, the group of workers with short tenure came to include not only younger

workers but also older ones who have entered the labor market at later ages or who have had to hop around unstable jobs during their career. All older workers are not necessarily earning high wages, and this makes age less important now as a predictor of wage inequality.

Over the decades, large establishments have increasingly relegated blue-collar jobs and low value-added activities to smaller establishments and focused instead on white-collar jobs and high value-added activities. Now a smaller number of workers are working in large establishments, and establishment size is more important than before in increasing wage inequality.

A look at the changes in employment and wage across occupations indicates that supply factors (i.e., workers migrating into high-paying occupations) were at work in the first period to reduce the gap between low-paying and high-paying occupations. In contrast, it is difficult to find a clear pattern in the second and third periods. Much the same story can be told of the changes in employment and wage across industries.

These findings have important policy implications. Efforts are needed to further upgrade women's skill levels. It is also necessary to strengthen the labor market attachment of disadvantaged workers (including older workers) and help them stay with an employer longer, for example by reducing the regulations on their employment. Priority should also be given to improving the quality of education at all levels of schooling (especially at the upper-secondary level) rather than expanding its quantity. Any impediments to SMEs' growing large should be eliminated and firms with stronger potential for job creation should be allowed to outcompete those with weaker potential. Lastly, flexibility should be increased in the labor market to accommodate rapid structural changes in the economy.

CHAPTER 1

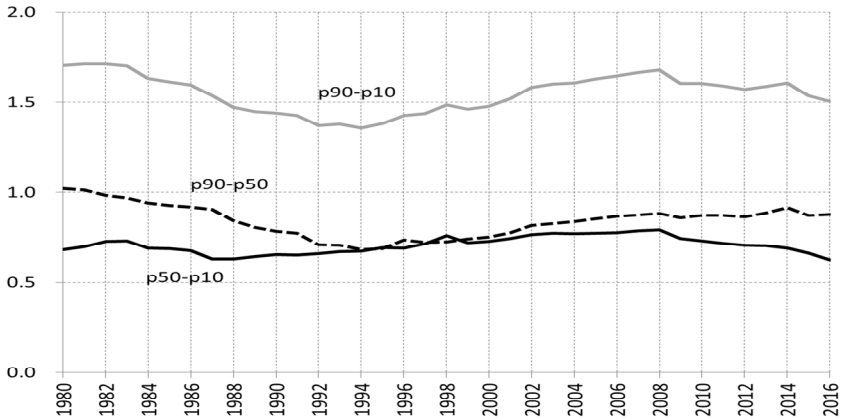
Introduction

Since the 1980s, many advanced countries have witnessed rising wage inequality among their workers (Katz and Autor, 1999, Table 9). This has been often attributed to skill-biased technical change (SBTC), which is claimed to increase the demand for high-skilled labor (Juhn, Murphy, and Pierce, 1993; Katz and Autor, 1999; Goldin and Katz, 2007). Alternative explanations resort to globalization (Wood, 1995; Feenstra and Hanson, 1996; 1997; 2001), changing institutional settings such as declining union densities and the falling real value of minimum wages, or endogenous technical change (Acemoglu, 2002). While the economics profession has come to accord greater importance to SBTC than to other lines of explanation, there exists less than a complete consensus on this issue.[1]

This paper studies the evolution of wage inequality in Korea since the 1980s as illustrated in Figure 1-1. Here we can discern three distinct periods. In the first period (1980-1994), wage inequality as measured by the p90-p10 gap fell quite dramatically. In the second period (1995-2007), the trend was reversed and wage inequality rose steadily. It reached a peak in 2007, and then declined again slowly throughout the third period (2008-2016).

1 For example, Acemoglu (2002, p.34) points out that the SBTC story is not compatible with the sluggish growth of total factor productivity (TFP) in the United States in 1970-1995 and that previous innovations (e.g., telegraph) may have been no less radical than recent innovations (e.g., computers).

Figure 1-1 Percentile Gaps in Log Hourly Wage



Note: p90, p50, and p10 refer to the 90th, 50th, and 10th percentile, respectively.
Source: Ministry of Employment and Labor, *Wage Structure Survey*, various years.

Korea's experience poses interesting theoretical questions. First, the improvement in wage distribution in the first period stands in sharp contrast to the deterioration observed in many developing countries (Wood, 1999; Robbins, 2003; Goldberg and Pavcnik, 2007, Table 1; Jaumotte *et al*., 2013). On the face of it, the improvement can be interpreted as supporting the Heckscher-Ohlin model. The latter predicts that international trade will boost the demand for input factors that are abundant in the economy, which was low-skilled labor in Korea at its early stage of export-driven economic growth. As will be explained later, however, this story does not fit with the fact that Korea was already moving away from labor-intensive toward more capital-intensive industries in the 1980s. We need other stories to explain the improvement in this period.

Second, while the deterioration in wage distribution in the second period might be attributed to SBTC, the latter cannot explain other important movements of wage inequality in Korea. For example, in the first period, the demand for high school graduates grew faster than that for college graduates, which implies that unskilled labor-biased technical change rather than SBTC was underway in this period. Similarly, female workers are generally believed to be less skilled than

male workers, but the demand for the former grew faster than the latter in all periods. Most important, wage inequality declined in the third period despite scant evidence that technical change slowed down in this period. We need other theoretical framework than SBTC to understand these episodes.

This paper studies wage inequality in Korea to understand the factors that have affected its evolution. For this purpose, a novel approach is proposed to decompose wage inequality into sex, age, education, and other worker characteristics. This approach has advantages over those proposed by others such as Juhn, Murphy, and Pierce (1993, JMP hereafter) and Fields (2003). Unlike the former, the order of decomposition does not matter. And unlike the latter which uses the variance measure and can analyze the total wage inequality only, this approach uses the quintile gap measure and allows an analysis of inequality between top, middle, and bottom quintiles. In addition, it allows a detailed examination of changing distributions of worker characteristics. Employing this approach, this paper finds significant changes in the roles played by various worker characteristics. In the early years, for example, sex, age, and education contributed to narrowing the wage gap, but in later years, firm tenure and establishment size came to widen it.

In the next step, the contribution of each worker characteristics to the wage gap is further decomposed into "price" and "distribution" effects. In the case of tenure, for example, the wage premium each additional year of service fetches is called the price of tenure. This is measured with the coefficient estimate on the tenure variable from a typical wage equation regression. The price effect refers to the change in wage inequality due to the change in price over time. But the price effect alone cannot explain all the changes in inequality. As the average tenure increased rapidly over the years, the tenure at the top wage quintile increased faster than that at the bottom, and worked to widen the wage gap. The distribution effect refers to the impact that such a changing distribution across wage quintiles has on wage inequality. While most of the previous studies (e.g., JMP) have focused their attention on the price effect (in fact, the *aggregate* price effect), this paper finds that distribution has also played an important role in Korea,

and that its consideration provides better understanding of wage inequality development.

The discussion on prices necessarily leads to the discussion on demand and supply. This paper follows the traditional approach (Katz and Murphy, 1992) to examine the change in relative demands for sex (male vs. female), age (older vs. younger), and education (college vs. high school). The exercise then leads us to interesting theoretical issues alluded to at the beginning.

There have been many studies on wage inequality in Korea. Unlike this paper that covers three and half decades (1980-2016) and examines the impact of many variables simultaneously, these studies have often focused on the 1990s (Kwon and Kim, 2001; Shin, 2007) or specific variables such as education (Park, 2014) and establishment size (Sun and Kim, 2013). In particular, the results from the studies on the 1990s tend to support the SBTC hypothesis, but this paper shows that this hypothesis cannot explain some important aspects of wage inequality development in Korea.

This paper consists of six chapters. Following the introduction, Chapter 2 decomposes the *level* of wage inequality into various worker characteristics, and then decomposes the *change* in wage equality into price and distribution effects. Chapter 3 examines price effect and Chapter 4 distribution effect. Chapter 5 discusses policy implications. Chapter 6 concludes the paper.

CHAPTER 2

Decomposition of Wage Inequality

This chapter proposes a new approach to decomposing the *level* of wage inequality into various worker characteristics and its *change* into price and distribution effects. The approach is then applied to the Korean data.

1. Data

The main source of data for this paper is the Wage Structure Survey (WSS) for 1980-2016. The WSS has been carried out each year by the Korean Ministry of Employment and Labor on a sample of establishments. It contains information on the workers' wage, hours worked, sex, age, final education completed, work experience, tenure with the current employer, occupation, industry, and the size of the establishment in which they work. As far as it relies on company documents for data collection, it is considered more reliable than household surveys that often depend on workers' memories.

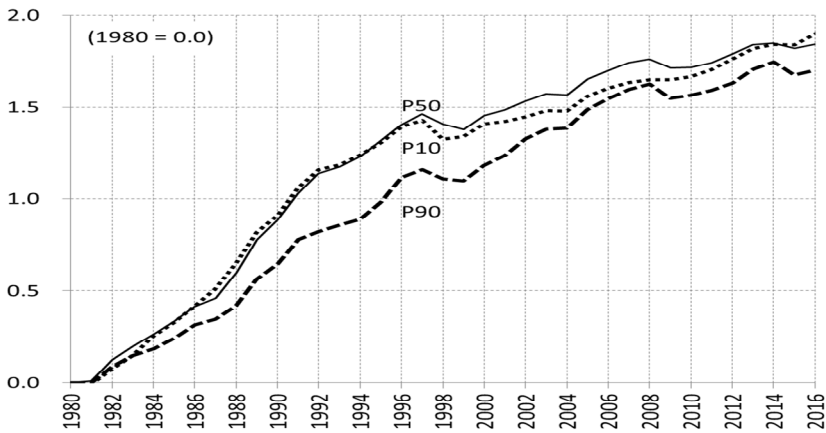
On the other hand, workers with no fixed workplace and workers in the agricultural and government sectors are excluded from the WSS. In addition, the size of establishments surveyed has changed from ten or more permanent employees (1980-1998) to five or more (1999-2005) and finally to one or more (2006-2016). For the sake of consistency, those establishments with less than ten employees are dropped from the

sample for 1999-2016 in the following analysis.[2,3] As there exist no other sources that cover the 1980s, the somewhat limited coverage of the WSS is deemed a price worth paying.

Following DiNardo, Fortin and Lemieux (1996), I use the hourly wage to measure wage inequality. The hourly wage is closer to the textbook concept of price of labor than monthly or yearly earnings, and better represents the quality of job. For example, a part-time job with higher hourly wage and lower yearly earnings might be of better quality than a full-time job with lower hourly wage and higher yearly earnings.

The nominal wage is deflated with the consumer price index (2015=100) to obtain the real wage. Figure 2-1 shows that the median real hourly wage (p50) registered a 6.5-fold growth (1.8-fold growth in in log terms) in 1980-2016. In the meantime, the growth of the 10th

Figure 2-1 Log Real Hourly Wage



Source: Ministry of Employment and Labor, *Wage Structure Survey*, various years.

2 In addition, minors aged less than 15 years, whose employment is prohibited by law, are dropped from the sample, as are the workers in such industries as agriculture, water supply, and communication, which have many missing years. This reduced the number of workers in the sample by less than two percent before 1999, by three to six percent in 1999-2005, and by five to nine percent in 2006-2016.

3 Appendix 1 compares the p90-p10 gaps before and after dropping the establishments with less than ten employees.

percentile wage (p10) kept pace with that of the median wage in the first period, lagged behind it in the second, but made up for the loss in the third. The growth of the 90th percentile (p90), on the other hand, was slower than those of p50 and p10 in the first period, but gained speed in the later periods.

Table 2-1 reports the dramatic change in worker characteristics between 1980 and 2016. The average age of workers rose from 28.6 to 41.2 years. The share of middle school graduates plummeted from

Table 2-1 Worker Characteristics

		1980	1990	2000	2010	2016
Sex	Male (%)	60.1	67.2	71.1	69.2	66.2
Age	Average no. of years	28.6	32.7	36.6	39.0	41.2
Highest education completed	Middle school (%)	59.8	33.1	17.6	6.1	3.8
	High school (%)	29.4	48.0	48.0	39.8	38.9
	Junior college (2-year) (%)	2.3	5.9	12.3	17.4	16.7
	College (4-year) (%)	8.6	13.0	22.2	36.6	40.6
Work experience	Less than 3 years (%)	57.7	39.2	28.7	31.4	32.3
	3-10 years (%)	34.1	40.6	38.7	36.5	33.9
	10 or more years (%)	8.2	20.2	32.6	32.1	33.9
Firm tenure	Average no. of years	2.8	3.8	5.4	6.8	7.1
Establishment size	10-299 employees (%)	54.8	63.1	75.8	76.0	78.3
	300 or more employees (%)	45.2	36.9	24.2	24.0	21.7
Occupation	Professional, technical, and managerial (%)	10.9	21.9	26.7	28.0	28.0
	Clerks (%)	16.2	16.3	22.1	25.1	25.6
	Services and sales (%)	6.0	7.2	4.4	7.9	9.6
	Craft workers and operators (%)	65.7	52.2	39.0	31.2	27.9
	Elementary occupations (%)	1.2	2.3	7.7	7.9	8.9
Industry	Light manufacturing (%)	35.4	27.5	14.8	8.6	7.8
	Heavy and chemical manufacturing (%)	35.1	36.4	32.3	29.5	28.3
	Industry exc. manufacturing (%)[1)]	5.9	4.6	5.8	5.9	5.6
	Services (%)	23.7	31.5	47.0	56.0	58.4

Note: 1) Industry excluding manufacturing is comprised of mining, utilities, and construction.
2) Hours worked were used as weights in the calculation.

Source: Ministry of Employment and Labor, *Wage Structure Survey*, various years.

59.8 to 3.8 percent while that of college (4-year) graduates jumped up from 8.6 to 40.6 percent. The workers with ten or more years of experience increased from 8.2 to 33.9 percent of the total, and the average firm tenure grew from 2.8 to 7.1 years. At the same time, workers in establishments with 300 or more employees declined from 45.2 to 21.7 percent of the total. The occupational mix also witnessed significant changes, with the share of professional, technical, and managerial jobs rising from 10.9 to 28.0 percent and that of craft workers and operators falling from 65.7 to 27.9 percent.[4] The industrial structure also changed substantially, with the service industry increasing its share from 23.7 to 58.4 percent at the expense of light manufacturing whose share fell from 35.4 to 7.8 percent.

2. Estimation of Wage Equations

As a first step in our investigation, a Mincerian wage equation is estimated separately for each year:

$$y_{it} = X_{it}\beta_t + \varepsilon_{it} \quad (1)$$

where y_{it} stands for the log hourly wage of individual i in year t and X_{it} includes sex, age, age squared, education, experience, firm tenure, firm tenure squared, establishment size, occupation, and industry. The regression result will be denoted by

$$y_{it} = X_{it}\hat{\beta}_t + \hat{\varepsilon}_{it}. \quad (2)$$

The results for 1980, 1990, 2000, 2010, and 2016 are reported in Table 2-2. All coefficient estimates have expected signs with high statistical significance.

Figure 2-2 plots the coefficient estimates. Panel A suggests a strong

4 The classifications of occupations and industries have each undergone several changes. For the purpose of this paper, new and time-invariant classifications were constructed as explained in Appendix 2. In reclassifying the occupations, an extensive reference was made to ILO (2012). Despite my best efforts, of course, the consistency of new classifications over time cannot be fully guaranteed.

Table 2-2 Regression of Log Hourly Wage

Year		1980	1990	2000	2010	2016
Sex	Male	0.350***	0.275***	0.202***	0.236***	0.193***
		(0.002)	(0.002)	(0.003)	(0.002)	(0.002)
Age		0.045***	0.025***	0.037***	0.041***	0.037***
		(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
Age squared × 10		-0.005***	-0.003***	-0.004***	-0.004***	-0.004***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Highest education completed	Middle school	-0.142***	-0.104***	-0.124***	-0.049***	-0.041***
		(0.002)	(0.002)	(0.003)	(0.004)	(0.003)
	Junior college	0.167***	0.064***	0.039***	0.092***	0.093***
		(0.006)	(0.003)	(0.003)	(0.003)	(0.002)
	College	0.435***	0.334***	0.235***	0.300***	0.263***
		(0.004)	(0.003)	(0.003)	(0.003)	(0.002)
Work experience	Less than 1 year	-0.184***	-0.225***	-0.223***	-0.171***	-0.104***
		(0.003)	(0.003)	(0.004)	(0.004)	(0.003)
	1-3 years	-0.061***	-0.063***	-0.082***	-0.062***	-0.042***
		(0.002)	(0.002)	(0.004)	(0.003)	(0.002)
	5-10 years	0.077***	0.047***	0.025***	0.050***	0.040***
		(0.003)	(0.002)	(0.003)	(0.003)	(0.002)
	More than 10 years	0.163***	0.129***	0.071***	0.135***	0.120***
		(0.004)	(0.003)	(0.004)	(0.004)	(0.003)
Firm tenure		0.035***	0.032***	0.036***	0.027***	0.027***
		(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
Firm tenure squared × 10		-0.008***	-0.005***	-0.005***	-0.001***	-0.001***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Establish-ment size (employees)	10-29	-0.109***	-0.099***	-0.114***	-0.121***	-0.110***
		(0.004)	(0.003)	(0.003)	(0.003)	(0.002)
	30-99	-0.074***	-0.069***	-0.082***	-0.059***	-0.065***
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
	300-499	0.017***	0.068***	0.111***	0.107***	0.084***
		(0.002)	(0.001)	(0.001)	(0.003)	(0.002)
	500 or more	0.047***	0.147***	0.116***	0.231***	0.264***
		(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
Occupation		O	O	O	O	O
Industry		O	O	O	O	O
Observations		404,120	473,785	475,472	628,027	674,100
R-squared		0.740	0.715	0.665	0.604	0.610

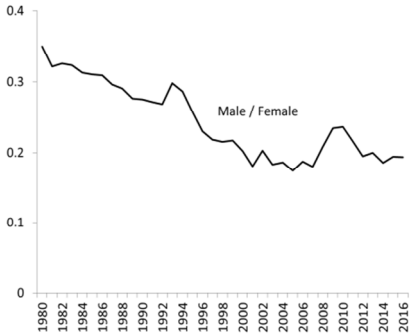
Note: 1) The coefficient estimates for the constant term and the occupation and industry dummies are not shown.

2) Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

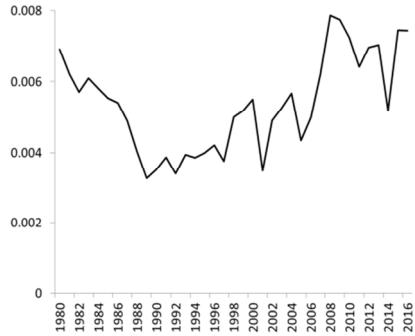
3) Observations on workers were weighted by the number of hours worked.

Figure 2-2 Coefficient Estimates

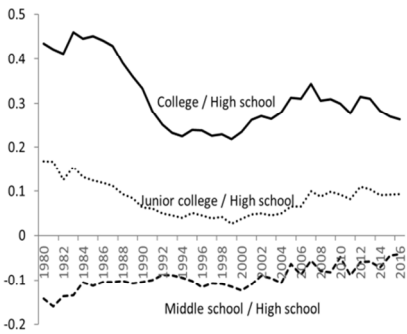
(Panel A) Sex



(Panel B) Age

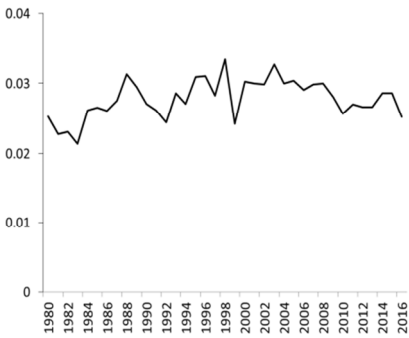


(Panel C) Education

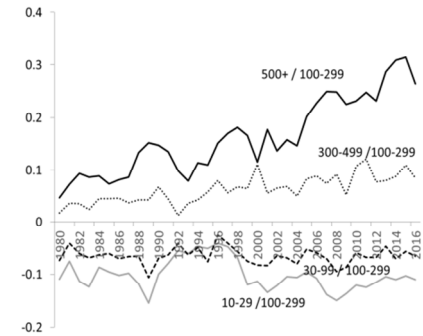


(Panel D) Work Experience

(Panel E) Firm Tenure



(Panel F) Establishment Size



Note: For age (B) and firm tenure (E), their average values over 1980-2016 were put into the square term.

downward trend in the premium for male workers in the first and second periods. In Panel B, the premium for older workers declined rapidly in the first period but then rose in the second and third. In Panel C, the premium on college education over high school education has alternated between decreases (in the first and third periods) and increases (in the second). A similar trend is observed for the premium of junior college education over high school education. The premium on work experience shown in Panel D also shares some of these features. In Panel E, the premium on firm tenure has undergone short-term ups and downs without a clear long-term trend. In Panel F, the premium on large establishments has grown continuously and significantly. The growth has been strongest in establishments with 500 or more employees.[5]

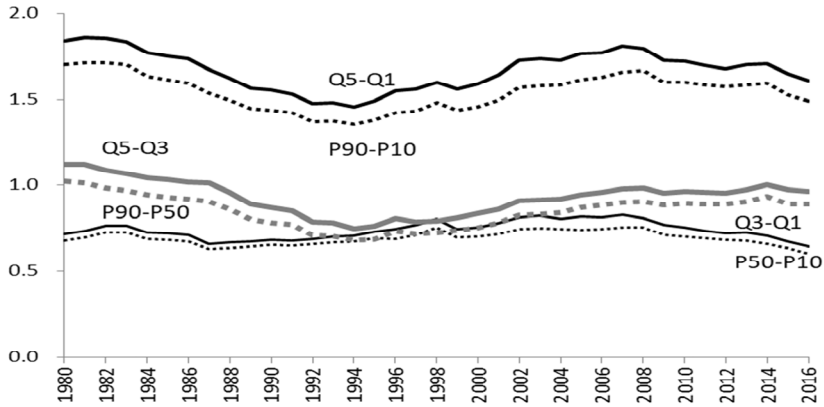
In what follows, these regression results will be utilized to decompose the overall wage inequality along various workers characteristics.

3. Approximation of Percentiles with Quintile Averages

We now suppress time subscripts in our notation for the moment and approximate the 10th, 50th, and 90th percentiles of log wage, y_i, by the averages over the bottom (1st), middle (3rd), and top (5th) quintiles, respectively. For example, the 10th percentile of y_i, y_{P10}, is approximated by $y_{\overline{Q1}} = \frac{1}{n_1}\sum_{i \in Q1} y_i$ so that $y_{P10} \approx y_{\overline{Q1}}$, where $Q1$ is the group of workers belonging to the bottom quintile and n_1 their number. Adopting similar notations for other percentiles and quintiles, we have $y_{P50} \approx y_{\overline{Q3}}$ and $y_{P90} \approx y_{\overline{Q5}}$. The percentile gaps are then approximated by quintile average gaps: $y_{P90} - y_{P10} \approx y_{\overline{Q5}} - y_{\overline{Q1}}$, $y_{P90} - y_{P50} \approx y_{\overline{Q5}} - y_{\overline{Q3}}$, and $y_{P50} - y_{P10} \approx y_{\overline{Q3}} - y_{\overline{Q1}}$. The right

5 Why there exists a premium on establishment size has been the subject of many studies. The proposed sources of premium—higher capital-labor ratio, higher monitoring cost, larger room for rent-sharing, etc. in larger establishments—can explain some but not all of the premium (Brown and Medoff, 1989; Troske, 1999; Oi and Idson, 1999). In this regard, the innate human desire for fairness, well-known in social psychology (Pinker, 2002, p.255; Haidt, 2012), may offer yet another source to be investigated.

Figure 2-3 Percentile Gaps and Quintile Average Gaps



hand sides (RHSs) of these semi-equalities will be called Q5-Q1 gap, Q5-Q3 gap, and Q3-Q1 gap, respectively.

Figure 2-3 shows that this produces fairly good approximations.

Now setting $X_{\overline{Q1}} = \frac{1}{n_1}\sum_{i\in Q1} X_i$ and $\hat{\varepsilon}_{\overline{Q1}} = \frac{1}{n_1}\sum_{i\in Q1} \hat{\varepsilon}_i$, and similarly for other quintiles, we have from eq. (2)

$$\begin{aligned} y_{\overline{Q1}} &= X_{\overline{Q1}}\hat{\beta} + \hat{\varepsilon}_{\overline{Q1}}, \\ y_{\overline{Q3}} &= X_{\overline{Q3}}\hat{\beta} + \hat{\varepsilon}_{\overline{Q3}}, \\ y_{\overline{Q5}} &= X_{\overline{Q5}}\hat{\beta} + \hat{\varepsilon}_{\overline{Q5}}, \end{aligned} \tag{3}$$

and therefore

$$\begin{aligned} y_{P90} - y_{P10} \approx y_{\overline{Q5}} - y_{\overline{Q1}} &= (X_{\overline{Q5}} - X_{\overline{Q1}})\hat{\beta} + (\hat{\varepsilon}_{\overline{Q5}} - \hat{\varepsilon}_{\overline{Q1}}), \\ y_{P90} - y_{P50} \approx y_{\overline{Q5}} - y_{\overline{Q3}} &= (X_{\overline{Q5}} - X_{\overline{Q3}})\hat{\beta} + (\hat{\varepsilon}_{\overline{Q5}} - \hat{\varepsilon}_{\overline{Q3}}), \\ y_{P50} - y_{P10} \approx y_{\overline{Q3}} - y_{\overline{Q1}} &= (X_{\overline{Q3}} - X_{\overline{Q1}})\hat{\beta} + (\hat{\varepsilon}_{\overline{Q3}} - \hat{\varepsilon}_{\overline{Q1}}). \end{aligned} \tag{4}$$

Each of the RHSs of eq. (4) has two components, the first measuring the contribution of observable worker characteristics (X) to wage inequality and the second being residual inequality. In the literature, the first component is often called “between-group” inequality and the second “within-group” inequality (Lemieux, 2006).

The between-group inequality can be further decomposed into individual characteristics in X. For example, consider the first three

variables in the regression—sex, age, and age squared—and denote them by x_1, x_2, and x_3, respectively. Also denote the coefficient estimates of these variables by $\hat{\beta}_1$, $\hat{\beta}_2$, and $\hat{\beta}_3$. Then the contribution of sex to the Q5-Q1 gap is given by $(x_{1,\overline{Q5}}-x_{1,\overline{Q1}})\hat{\beta}_1$, and that of age is given by $(x_{2,\overline{Q5}}-x_{2,\overline{Q1}})\hat{\beta}_2+(x_{3,\overline{Q5}}-x_{3,\overline{Q1}})\hat{\beta}_3$. Similarly, let x_4, x_5, and x_6 denote the three education dummies (middle school, junior college, and college) and $\hat{\beta}_4$, $\hat{\beta}_5$, and $\hat{\beta}_6$ their coefficient estimates. Then the contribution of education is given by $(x_{4,\overline{Q5}}-x_{4,\overline{Q1}})\hat{\beta}_4+(x_{5,\overline{Q5}}-x_{5,\overline{Q1}})\hat{\beta}_5+(x_{6,\overline{Q5}}-x_{6,\overline{Q1}})\hat{\beta}_6$. Interestingly, the choice of dummy (e.g., female rather than male) does not affect the result of computations.

There exist alternative approaches to decomposing wage inequality as suggested by JMP and Fields (2003). Appendix 3 compares them with this paper's approach emphasizes the latter's advantage.

4. Results of the Decomposition of Levels

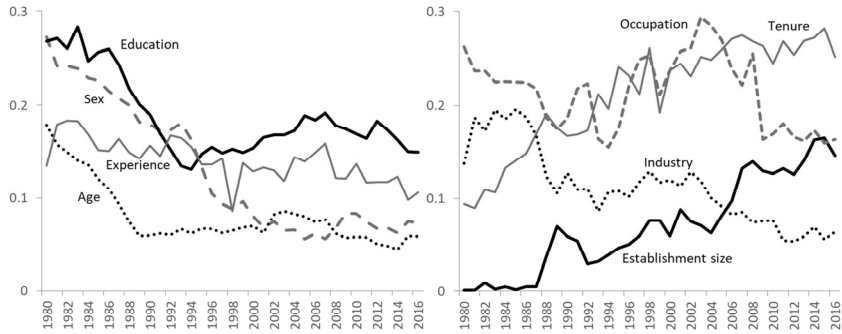
Figure 2-4 illustrates the results of decomposition using eq. (4). For the Q5-Q1 gap in Panel A, note that the contributions of education, sex, and age have fallen dramatically, while those of firm tenure and establishment size have risen substantially. Looking at Panels B and C, we can see that the falling contribution of education has occurred mostly in the upper part of the wage distribution (Q5-Q3), while those of sex and age have occurred in the lower part (Q3-Q1).

These changes have led to the changing relative contributions of worker characteristics (Table 2-3, Figure 2-5). In the early years, sex, age, and education played very important roles: In 1980, for example, sex explained 14.8 percent of the Q5-Q1 gap, age 9.7 percent, and education 14.6 percent. But now firm tenure is the most important factor, explaining 15.6 percent of the Q5-Q1 gap in 2016. It is followed by education (9.3 percent) and establishment size (9.1 percent).[6]

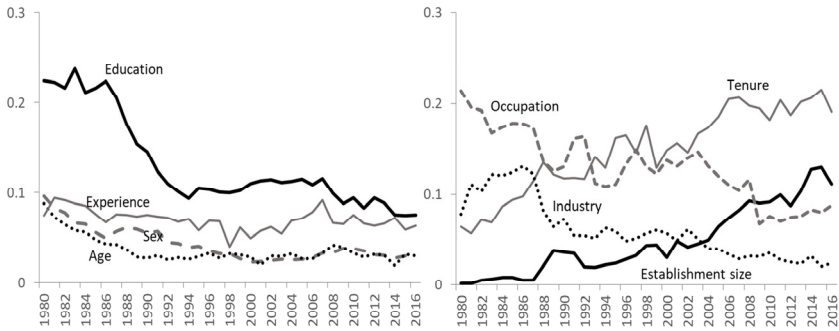
6 Occupation and industry were excluded from the discussion in this paragraph because of the uncertainty surrounding the consistency of reclassification over time. See footnote 4.

Figure 2-4 Contributions of Worker Characteristics to the Wage Gap

(Panel A) Q5-Q1 Gap



(Panel B) Q5-Q3 Gap



(Panel C) Q3-Q1 Gap

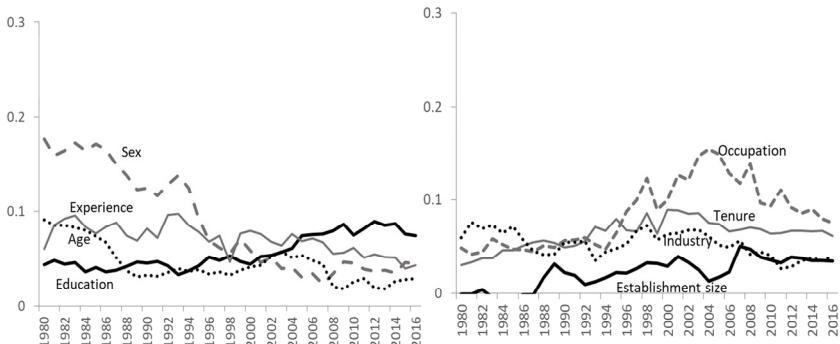
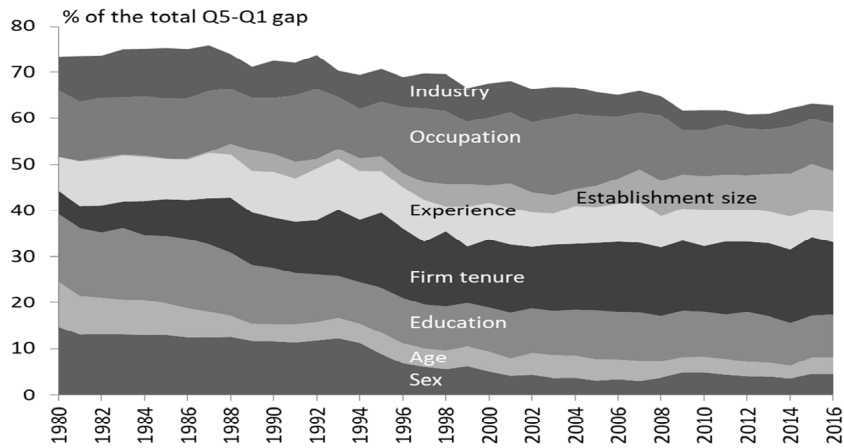


Table 2-3 Relative Contributions to the Q5-Q1 Gap

(Unit: %)

	1980	1990	2000	2010	2016
Sex	14.8	11.5	5.0	4.8	4.5
Age	9.7	3.9	4.4	3.4	3.6
Education	14.6	12.2	9.5	9.8	9.3
Work experience	7.3	10.1	8.0	7.9	6.6
Firm tenure	5.1	10.8	14.7	14.2	15.6
Establishment size	0.1	3.8	3.7	7.4	9.1
Occupation	14.3	12.0	14.8	9.8	10.1
Industry	7.5	8.2	7.5	4.4	4.0
Unexplained	26.6	27.5	32.4	38.3	37.2
Total	100.0	100.0	100.0	100.0	100.0

Figure 2-5 Relative Contributions to the Q5-Q1 Gap



All in all, our model explains about 75 percent of the Q5-Q1 gap in the 1980s and more than 60 percent of it in the 2010s, as can be inferred from the row titled “unexplained” in Table 2-3.

While containing many variables of interest, our dataset lacks information on two important variables—union membership and employment type (regular/non-regular workers). Unions have been frequently claimed as reducing wage inequality in the literature (Farber *et al*., 2018). In addition, given the wage gap between regular workers and non-regular workers (i.e., fixed-term, part-time, temporary work

agency, on-call, and independent workers and domestic laborers) in Korea, employment type is commonly believed to affect wage inequality. Appendix 5 examines the roles of union membership and employment type using a new dataset. As it turns out, no significant roles can be found for these variables.

At this point, it should be pointed out that the contribution of education can be greater than indicated by Table 2-3 or Figure 2-5. Higher educational achievement often helps one land better jobs with higher pay and greater security. To see this, a logit model was estimated for the probability of a worker (1) having a long work experience (5 or more years), (2) having a long firm tenure (6 or more years), (3) working in a large establishment (300 or more employees) and (4) being in a high-paying occupation (professional, technical, and managerial) conditional on her sex, age, and education. Table 2-4 shows that a higher educational achievement is indeed associated with a better job quality.

Panel A of Figure 2-6 plots the contributions of sex, age, and education to the Q5-Q1 gap when only these variables are entered into the wage equation. Comparing Panel A of Figure 2-4 and Panel A of Figure 2-6, we can see that the contribution of education in the latter is

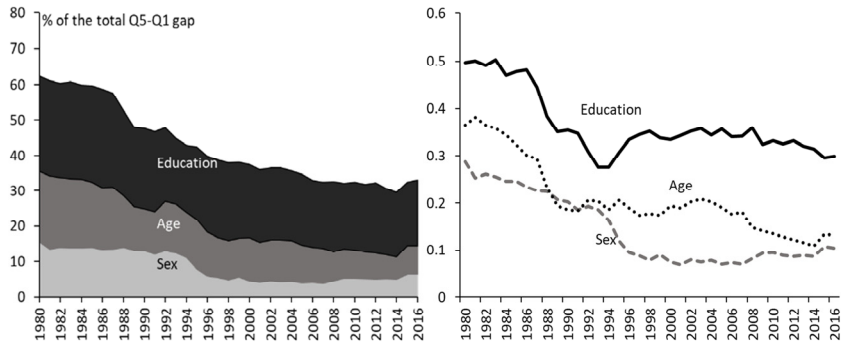
▎Table 2-4 ▎Influence of Sex, Age, and Education on Job Quality (2016)

		Work experience	Firm tenure	Establishment size	Occupation
Sex	Male	0.588***	0.558***	0.149***	0.049***
		(0.009)	(0.009)	(0.008)	(0.010)
Age		0.546***	0.606***	-0.023***	0.039***
		(0.003)	(0.004)	(0.002)	(0.003)
Age squared × 100		-0.553***	-0.631***	0.006**	-0.032***
		(0.004)	(0.004)	(0.003)	(0.003)
Highest Education completed	Middle School	0.114***	-0.097***	0.144***	-1.282***
		(0.022)	(0.022)	(0.021)	(0.059)
	Junior College	0.669***	0.541***	0.175***	1.593***
		(0.014)	(0.013)	(0.012)	(0.016)
	College	0.574***	0.342***	0.241***	2.539***
		(0.011)	(0.010)	(0.009)	(0.014)
Observations		674,100	674,100	674,100	674,100

Note: Logit estimation of (1) work experience (5 or more years), (2) firm tenure (6 or more years), (3) establishment size (300 or more employees), and (4) occupation (professional, technical and managerial) on sex, age, and education.

Figure 2-6 Contributions of Sex, Age, and Education to the Q5-Q1 Gap

(Panel A) Absolute Contributions (Panel B) Relative Contributions



about twice as large as in the former. Panel B of Figure 2-6 shows that these three variables can explain a substantial part of the Q5-Q1 gap, especially in the 1980s. But also note that their combined influence has diminished since then, and can explain only about 30 percent of the Q5-Q1 gap in recent years. In other words, other variables such as firm tenure, establishment size, occupation, and industry are now also exercising important influence on wage inequality. This illustrates the need to broaden our interest to other variables beyond education.

Lastly, let me briefly discuss the "within-group" inequality. According to Table 2-3, the "unexplained" part of the Q5-Q1 gap was around 25 percent in the 1980s and close to 40 percent in the 2010s. This within-group inequality may reflect the influences of other variables not included in the regression. It can also arise from finer differences within the included variables (e.g., different majors in college) that could not be taken into consideration because of data limitations. Recent studies (Card, Heining, and Kline, 2013; Song *et al*., 2015) show that most of the inequality growth comes from establishment-specific premiums, the nature of which is unclear. In our case, such premiums will also show up in the residuals.

Another question is why the within-group inequality has been growing over the decades. Such growth has been observed in the United States as well. Lemieux (2006) claims that most of the growth since the

1970s can be explained by workers' increasing educational achievement and their aging. Wage inequality is higher among college graduates than among high school graduates as the former group has broader job opportunities than the latter. Similarly, wage inequality is higher among older workers as they have a longer history of work for wage differentials to accumulate. Appendix 4 follows Lemieux (2006) and shows that in the third period (2008-2016), a substantial part of within-group inequality growth came from the changing worker characteristics.

Having discussed the decomposition of the *level* of wage inequality, we now turn to the decomposition of the *change* in wage inequality in the next section.

5. Results of the Decomposition of Changes

Let $g_t = y_{\overline{Q5},t} - y_{\overline{Q1},t}$ denote the Q5-Q1 gap in year t, and similarly define $z_t = X_{\overline{Q5},t} - X_{\overline{Q1},t}$ and $\mu_t = \hat{\varepsilon}_{\overline{Q5},t} - \hat{\varepsilon}_{\overline{Q1},t}$. Then we have $g_t = z_t\hat{\beta}_t + \mu_t$ from eq. (4) and

$$g_t - \bar{g} = \bar{z}\left(\hat{\beta}_t - \bar{\hat{\beta}}\right) + (z_t - \bar{z})\bar{\hat{\beta}} + (z_t - \bar{z})\left(\hat{\beta}_t - \bar{\hat{\beta}}\right) + \left(\bar{z}\bar{\hat{\beta}} - \overline{z\hat{\beta}}\right) + (\mu_t - \bar{\mu}), \quad (5)$$

where the upper bars denote averages over the sample period.

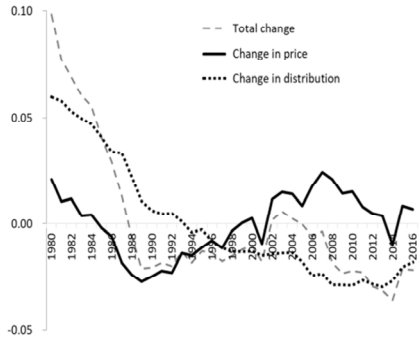
In eq. (5), the first term on the RHS, $\bar{z}\left(\hat{\beta}_t - \bar{\hat{\beta}}\right)$, is the contribution of the changing prices to the changing wage inequality $(g_t - \bar{g})$. The second term, $(z_t - \bar{z})\bar{\hat{\beta}}$, is the contribution of the changing distribution of worker characteristics across quintiles. The third term is an "interaction term," and the fourth term is a constant adjustment. The last term, $(\mu_t - \bar{\mu})$, is the contribution of the changing within-group inequality.

Eq. (5) can be employed to decompose the change in the contribution of each worker characteristic into the part coming from its changing price and the part coming from its changing distribution. Figure 2-7 reports the results of decomposition. For example, in Panel A, the "total change" equals the contribution of sex to wage inequality as plotted in Panel A of Figure 2-4, moved downward by the amount of its sample average. Mathematically, it is defined as

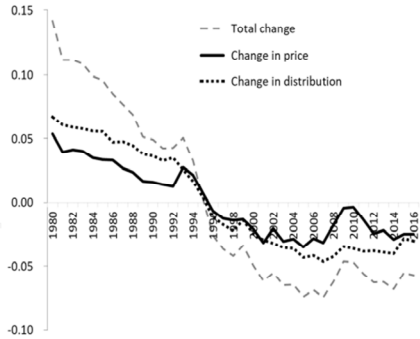
$$z_t\hat{\beta}_t - \bar{z}\bar{\hat{\beta}} = \bar{z}\left(\hat{\beta}_t - \bar{\hat{\beta}}\right) + (z_t - \bar{z})\bar{\hat{\beta}} + (z_t - \bar{z})\left(\hat{\beta}_t - \bar{\hat{\beta}}\right) \quad (6)$$

Figure 2-7 Decomposition into the Changes in Price and Distribution

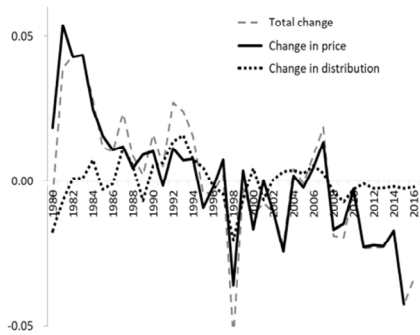
(Panel A) Sex



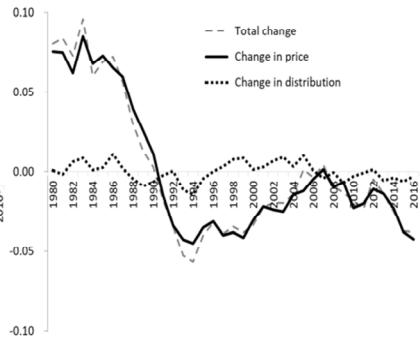
(Panel B) Age



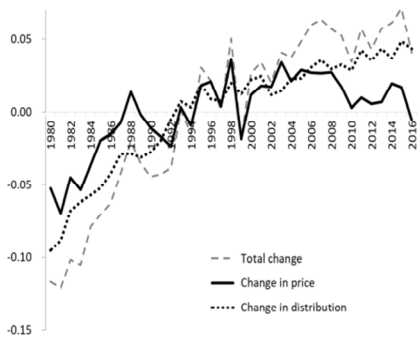
(Panel C) Education



(Panel D) Work Experience



(Panel E) Firm Tenure



(Panel F) Establishment Size

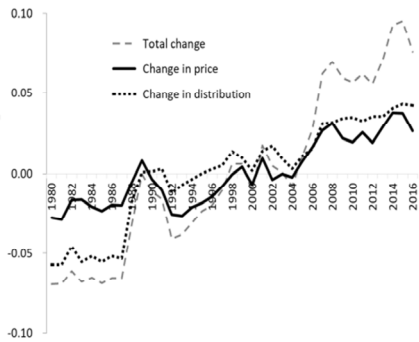
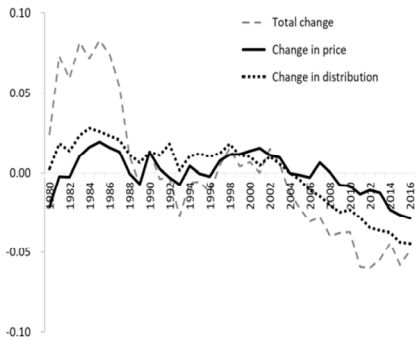
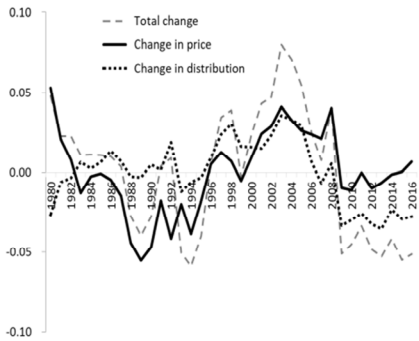


Figure 2-7 *(Continued)*

(Panel G) Occupation



(Panel H) Industry



Note: The "total change" corresponds to $z_t\hat{\beta}_t - \bar{z}\bar{\hat{\beta}}$ in eq. (6), the "change in price" corresponds to $\bar{z}\left(\hat{\beta}_t - \bar{\hat{\beta}}\right)$, and the "change in distribution" corresponds to $(z_t - \bar{z})\bar{\hat{\beta}}$.

when z is understood as referring to the male dummy instead of the vector of entire variables, and similarly for $\hat{\beta}$. The first term on the RHS of eq. (6) is plotted as "change in price" and the second term as "change in distribution" in Panel A. The interaction term is omitted.

Looking at Panel A, we find that both the price and distribution of sex have played similar roles. The same is true with age (Panel B). As for education (Panel C), the total change and the change in price are almost indistinguishable from each other, indicating that the price has been the dominant factor in determining education's changing contribution to wage inequality. Much the same can be told of work experience (Panel D). On the other hand, in the case of firm tenure (Panel E) or establishment size (Panel F), a better part of the total change can be attributed to the change in distribution. In the case of occupation (Panel G) or industry (Panel H), both price and distribution have played important roles as in the cases of sex and age.

Note that in many of these cases, distribution has exercised influence separate from that of price. This point will be elaborated on further in Chapter 4. Unlike my approach, previous research has tended to focus on price, and in particular, on the price of education.

From Figure 2-7, we can compute the total change within each period (1980-1994, 1995-2007, 2008-2016) and its decomposition into

Table 2-5 Change within Each Period and Its Decomposition

	1980-1992			1995-2007			2009-2016		
	T	P	D	T	P	D	T	P	D
Sex	-0.008	-0.003	-0.003	-0.006	-0.003	-0.004	-0.002	-0.003	0.001
Age	-0.010	-0.004	-0.005	0.001	0.003	-0.002	0.000	-0.001	0.002
Education	-0.010	-0.009	0.000	0.004	0.003	0.000	-0.004	-0.005	0.001
Experience	0.003	-0.001	0.003	0.002	0.002	0.000	-0.002	-0.003	0.001
Tenure	0.007	0.002	0.008	0.003	0.001	0.001	-0.002	-0.003	0.002
Est. Size	0.002	0.000	0.004	0.007	0.004	0.003	0.002	0.001	0.001
Occupation	-0.003	-0.008	0.004	0.004	0.003	0.000	0.000	0.002	0.001
Industry	-0.002	0.002	0.001	-0.002	0.001	-0.002	-0.002	-0.003	-0.003
Sum	-0.022	-0.021	0.012	0.012	0.013	-0.005	-0.008	-0.015	0.004

Note: 1) Sample periods (1980-1992, 1995-2007, 2009-2016) were adjusted to match the changes in occupational and industrial classifications.

2) "T" refers to the total change of the contribution of each worker characteristic to the Q5-Q1 gap, "P" the part due to changes in price, and "D" that due to changes in distribution.

3) The changes were annualized by dividing them by the number of years in each period.

the changes in price and distribution. Table 2-5 reports the results. In each period, the first column (T) shows the total change of the contribution of each variable to the Q5-Q1 gap, the second column (P) the part due to changes in price, and the last column (D) that due to changes in distribution. In the last row, the sum of each column is reported.

We can see that the roles of price and distribution have changed significantly across the periods. For example, in the case of sex, both price and distribution played important roles in reducing inequality especially in the first and second periods. The same can be told of age in the first period. In the case of education, price was the main driver in all periods, reducing inequality in the first period, increasing it in the second, and then reducing it again in the third. In the cases of tenure and establishment size, distribution has contributed significantly to widening the wage gap.

This highlights the deficiencies of previous studies that have restricted their attention to prices, and calls for the examination of distributions as well. Chapter 3 takes a traditional approach to study the changes in price, and Chapter 4 investigates the changes in distribution.

CHAPTER 3

Changing Prices

The previous chapter demonstrated that price effect has been very strong for education and to a less extent also for sex and age. Price is determined through the interaction between demand and supply. This chapter studies the demand shifts for sex, age, and education in 1980-2016.

1. Theoretical Framework

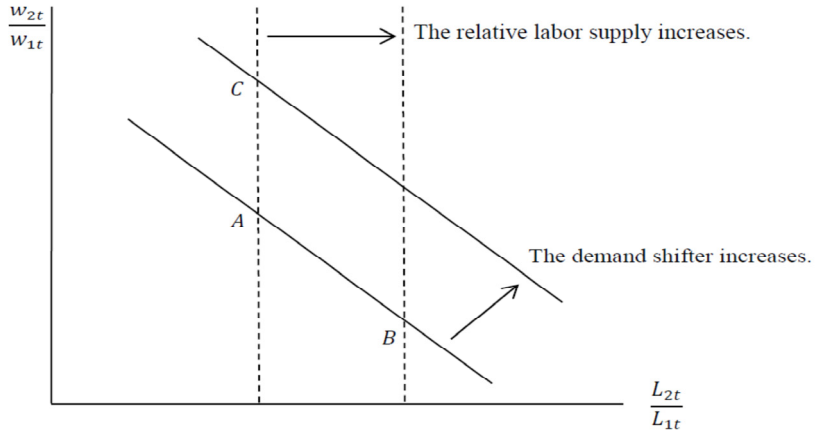
To better understand the movement of prices, I follow the literature and run regressions of the form:

$$\log\left(\frac{w_{2t}}{w_{1t}}\right) = \gamma D_t - \gamma \log\left(\frac{L_{2t}}{L_{1t}}\right) + \epsilon_t, \ \ t = 1980, \dots, 2016, \tag{7}$$

where w_{1t} and w_{2t} are the wages of group 1 and group 2, respectively, L_{1t} and L_{2t} are their labor supplies, and D_t is the demand shifter. For example, if group 1 is high school graduates and group 2 is college graduates, then $\log\left(\frac{w_{2t}}{w_{1t}}\right)$ is the relative price of college education to high school education, and $\log\left(\frac{L_{2t}}{L_{1t}}\right)$ is the relative supply.

The relation between $\frac{w_{2t}}{w_{1t}}$, D_t, and $\frac{L_{2t}}{L_{1t}}$ can be explained with the help of Figure 3-1. Assume for the moment $\gamma > 0$. Starting from point A,

Figure 3-1 Relative Labor Supply and Demand



when $\frac{L_{2t}}{L_{1t}}$ increases, $\frac{w_{2t}}{w_{1t}}$ falls along the demand curve to point B. When D_t increases, on the other hand, $\frac{w_{2t}}{w_{1t}}$ rises from point A to C.

In the literature, D_t is often interpreted as reflecting the different speeds of technological progress for different factors. Following Acemgolu (2002), suppose the production function for the aggregate economy takes the constant elasticity of substitution (CES) form $Q_t = [(A_{1t}L_{1t})^\rho + (A_{2t}L_{2t})^\rho]^{\frac{1}{\rho}}$ where A_{1t} and A_{2t} are factor-augmenting technology terms. In a competitive labor market, the wage for group 1 is equal to its marginal product:

$$w_{1t} = \frac{\partial Q_t}{\partial L_{1t}} = A_{1t}^{\rho} L_{1t}^{\rho-1} [(A_{1t}L_{1t})^\rho + (A_{2t}L_{2t})^\rho]^{\frac{1}{\rho}-1},$$

and similarly for group 2:

$$w_{2t} = \frac{\partial Q_t}{\partial L_{2t}} = A_{2t}^{\rho} L_{2t}^{\rho-1} [(A_{1t}L_{1t})^\rho + (A_{2t}L_{2t})^\rho]^{\frac{1}{\rho}-1}.$$

Then the relative price is given by

$$\frac{w_{2t}}{w_{1t}} = \left(\frac{A_{2t}}{A_{1t}}\right)^{\rho} \left(\frac{L_{2t}}{L_{1t}}\right)^{\rho-1}, \text{ or} \tag{8}$$

$$\log\left(\frac{w_{2t}}{w_{1t}}\right) = \frac{1}{\sigma}\log\left(\frac{A_{2t}}{A_{1t}}\right)^{\sigma-1} - \frac{1}{\sigma}\log\left(\frac{L_{2t}}{L_{1t}}\right) \quad (9)$$

where $\sigma = \frac{1}{1-\rho}$ is the elasticity of substitution.

The relation in eq. (9) holds even when there are more than two factors of production L_{it} $(i = 1,2,3,\dots)$ and the production function is of the form $Q_t = [\sum_i (A_{it}L_{it})^{\rho}]^{\frac{1}{\rho}}$:

$$\log\left(\frac{w_{it}}{w_{1t}}\right) = \frac{1}{\sigma}\log\left(\frac{A_{it}}{A_{1t}}\right)^{\sigma-1} - \frac{1}{\sigma}\log\left(\frac{L_{it}}{L_{1t}}\right), \; i = 2,3,\dots. \quad (10)$$

2. Estimation

From eqs. (7) and (9), we have $D_t = \log\left(\frac{A_2}{A_1}\right)^{\sigma-1}$ and $\gamma = \frac{1}{\sigma}$. So if group 1 and group 2 are substitutes ($\sigma > 0$), and if the elasticity of substitution is sufficiently large (i.e., if $\sigma > 1$), then a technological progress that favors group 2 over group 1 will shift the demand curve out, while if the elasticity is small (i.e., if $0 < \sigma < 1$), such a progress will shift the demand curve in (Acemoglu, 2002, p.21). On the other hand, if group 1 and group 2 are complements ($\sigma < 0$), then such a technical progress will always shift the demand curve out.

In the literature, γD_t is often assumed to be a linear function in time (Katz and Murphy, 1992). In this paper, a spline function for three periods (1980-1994, 1995-2007, 2008-2016) is assumed for γD_t:

$$\begin{aligned}\gamma D_t = {} & \alpha_o + \alpha_1 t \cdot 1(1980 \le t \le 1994) \\ & + [1994(\alpha_1 - \alpha_2) + \alpha_2 t] \cdot 1(1995 \le t \le 2007) \\ & + [1994(\alpha_1 - \alpha_2) + 2007(\alpha_2 - \alpha_3) + \alpha_3 t] \cdot 1(2008 \le t \le 2016),\end{aligned}$$

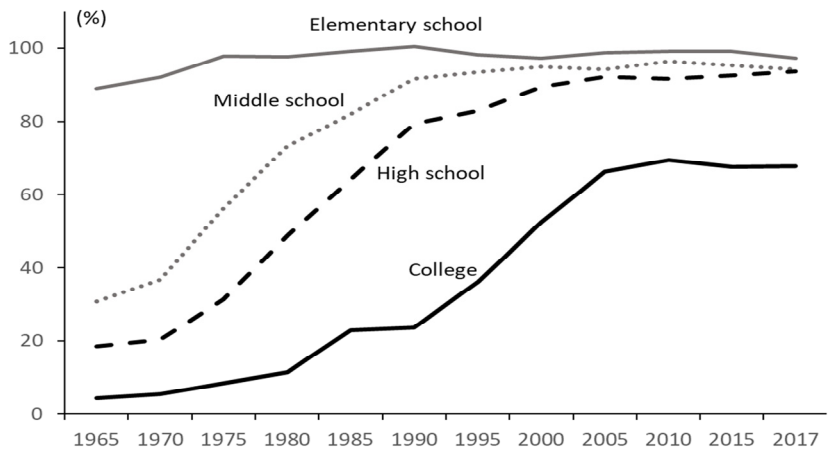
where $1(\cdot)$ is an indicator function. A positive (negative) estimate for α_1, for example, will indicate that the relative demand tended to increase (decrease) during the first period.

In estimating eq. (7), care should be taken to prevent those variables not included in the regression from affecting the results. For example,

suppose group 1 is high school graduates and group 2 is college graduates. Given the rapidly rising college enrollment rate over the past decades (Figure 3-2), L_{2t} will contain more and more and L_{1t} less and less young workers as time passes. In addition, given the rising share of women among college students, L_{2t} will also contain more and more and L_{1t} less and less women. Without an appropriate correction, the estimate of γ would reflect not only the effect of college education but also those of age and sex.

This paper follows Katz and Murphy (1992) to address this problem. First, workers are sorted into six hundred sex-age-education-tenure-experience groups.[7] Next, the average share of each group is calculated over the whole sample period (1980-2016). These averages are then assigned as fixed weights to the groups. The average wage of, say college

Figure 3-2 Enrollment Rate



Source: Koh *et al.* (2010, p.235); Ministry of Education and Korean Education Development Institute, *Brief Statistics on Korean Education*, 2017.

7 Cross-tabulating two sex groups (male and female), three age groups (15-29, 30-54, and 55+ years), four education groups (middle school, high school, junior college, and college), five experience groups (less than 1 year, 1-3, 3-5, 5-10, and 10+ years), and five tenure groups (less than 1 year, 1-3, 3-5, 5-10, and 10+ years) yields a total of 600 (=2x3x4x5x5) groups.

graduates, is then calculated with these fixed weights for each year.[8]

The regression results of eq. (7) are reported in Table 3-1. In the case of sex (Panel A), female workers were chosen as group 1 and male workers as group 2. The slope coefficients are negative in all periods and significant in the second and third periods, indicating that the relative demand for male (female) workers has decreased (increased) over the decades. The estimate of $-\gamma$ is negative and significant, and gives a value of σ=1/0.226=4.4.

In the case of age (Panel B), two regressions were run. In the first regression, three factors of production—young workers (15-29), prime age workers (30-54), and elderly workers (55+)—were assumed, and young workers were chosen as group 1. The result of the first regression, based on the SUR (seemingly unrelated regression) method, is reported in columns (1) and (2). They indicate that the relative demands for prime age workers and elderly workers over young workers have generally increased over the sample period. In the second regression, prime age workers and elderly workers were combined into a group called "elderly equivalents" by utilizing "efficient units," i.e., wage

| Table 3-1 | Regression of Relative Wage on Relative Supply

(Panel A) Sex

		Male / Female
Slope	α_1	-0.001 (0.004)
	α_2	-0.005*** (0.001)
	α_3	-0.009*** (0.003)
$^{-}\gamma$		-0.226** (0.084)
Observations		37
R-squared		0.928

8 Another option is to put the coefficient estimates from Table 2-2 on the left hand side of eq. (7) in place of $\log\left(\frac{w_{2t}}{w_{1t}}\right)$. Appendix 6 reports the regression results when this option is taken.

Table 3-1 *(Continued)*

(Panel B) Age

		SUR		Elderly equivalents (30+) / Young (15-29) (3)
		Prime age (30-54) / Young (15-29) (1)	Elderly (55+) / Young (15-29) (2)	
Slope	α_1	0.002 (0.006)	-0.012** (0.005)	0.026*** (0.009)
	α_2	0.010*** (0.003)	0.001 (0.003)	0.024*** (0.005)
	α_3	0.003 (0.004)	0.012*** (0.004)	0.028*** (0.005)
$-\gamma$		-0.208*** (0.076)	-0.098*** (0.030)	-0.595*** (0.099)
Observations		37	37	37
R-squared		0.914	0.945	0.969

(Panel C) Education

		SUR			College equivalents / High school equivalents (4)
		Middle school / High school (1)	Junior college / High school (2)	College / High School (3)	
Slope	α_1	-0.005 (0.005)	-0.008*** (0.002)	-0.014*** (0.001)	0.008 (0.006)
	α_2	-0.013*** (0.003)	0.003 (0.003)	0.028*** (0.004)	0.041*** (0.008)
	α_3	-0.013*** (0.004)	-0.005*** (0.001)	-0.000 (0.003)	0.004 (0.004)
$-\gamma$		-0.185*** (0.047)	-0.043 (0.041)	-0.346*** (0.050)	-0.446*** (0.100)
Observations		37	37	37	37
R-squared		0.922	0.940	0.916	0.899

Note: 1) Constant estimates not shown.

2) Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

ratios.[9] The result is reported in column (3). Now all slope coefficients are clearly positive: The relative demand for young workers has continuously declined over the sample period while that for older workers has declined. The estimate of $-\gamma$ is negative and significant, and gives a value of σ=1/0.595=1.7.

9 Efficient units were first introduced by Katz and Murphy (1992) for education.

In the case of education (Panel C), again two regressions were run. In the first, high school graduates were chosen as group 1, and the regression was run for middle school, junior college, and college graduates over this group using the SUR method. In the second, the regression was run for college equivalents (a combined group of junior college and college graduates) over high school equivalents (over a combined group of middle school and high school graduates).

Column (1) of Panel C indicates that the demand for middle school graduates relative to that for high school graduates declined in all periods. This looks natural when interpreted as reflecting a general skill upgrading in workplaces which now require at least a high school degree. Similarly, as reported in column (2), the relative demand for junior college graduates declined in the first and third period, but not in the second. In the case of college graduates, column (3) indicates that the relative demand for them declined in the first period, but grew in the second, and then stayed largely unchanged in the third. These are less easy to interpret. An argument based on skill upgrading would have difficulty in explaining the periods of "de-skilling" observed in columns (2) and (3).

The result reported in column (4) of Panel C is similar to that in column (3) except for the absence of the initial de-skilling. Still, the discontinuation of skill upgrading in the third period remains puzzling. Meanwhile, the estimate of $-\gamma$ in column (4) implies the value of σ=1/0.446=2.2. The latter value is about 60 percent larger than the value reported for the United States of around 1.4 (Katz and Autor, 1999).

3. Relative Demand, Relative Supply, and Relative Wage

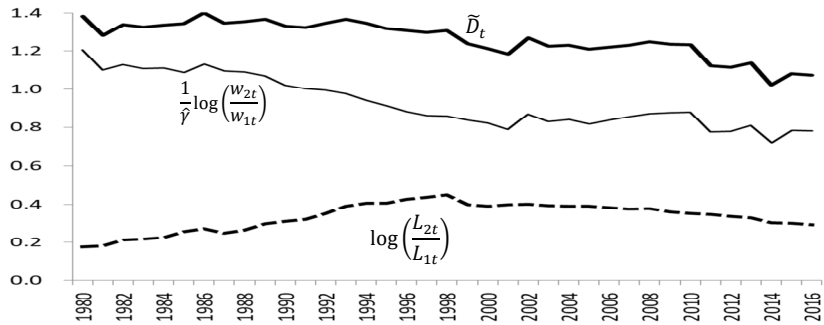
Now from eq. (7), ignoring the error term, we have

$$D_t = \frac{1}{\gamma}\log\left(\frac{w_{2t}}{w_{1t}}\right) + \log\left(\frac{L_{2t}}{L_{1t}}\right). \tag{11}$$

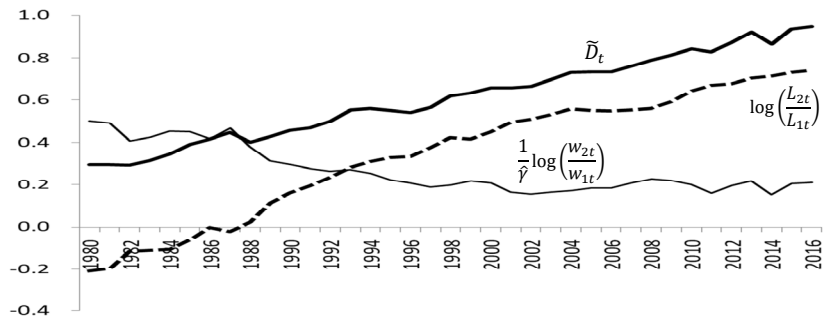
Let $\widetilde{D}_t$ be the value of D_t computed from eq. (11) using $\hat{\gamma}$ from Table 3-1. Figure 3-3 plots $\widetilde{D}_t$, $\log\left(\frac{L_{2t}}{L_{1t}}\right)$, and $\frac{1}{\hat{\gamma}}\log\left(\frac{w_{2t}}{w_{1t}}\right)$. In the case of

Figure 3-3 Relative Demand, Relative Supply, and Relative Wage

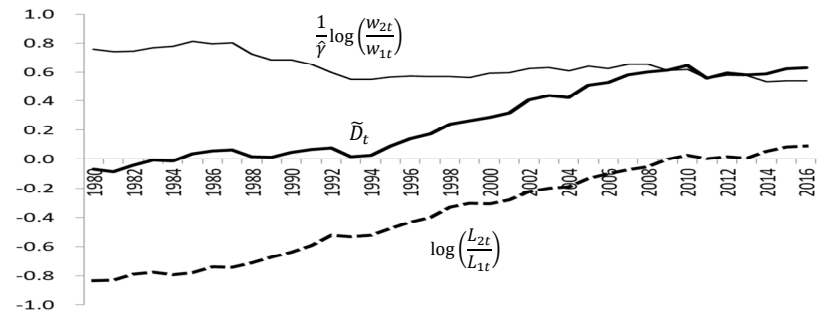
(Panel A) Sex



(Panel B) Age



(Panel C) Education



Note: Panel A compares male over female workers, Panel B elderly equivalents over young workers, and Panel C college equivalents over high school equivalents.

sex (Panel A), the relative demand for male workers decreased over the decades, and their relative wage fell. From the perspective of female workers, the demand for them outpaced their supply, pushing up their wage. Their wage is still below that of male workers but catching up continuously.

In the case of age (Panel B), the relative demand for elderly equivalents increased continuously, but their relative supply increased faster, and as a result their relative wage fell. In the case of education (Panel C), the relative supply of college equivalents increased consistently in the sample period. In the first and third periods, it increased faster than the relative demand and led to a fall in the relative wage, while the opposite was true in the second period. Table 3-2 summarizes the changes in $\widetilde{D}_t$, $\log\left(\frac{L_{2t}}{L_{1t}}\right)$, and $\log\left(\frac{w_{2t}}{w_{1t}}\right)$ for three periods.

Some questions arise from Figure 3-3 and Table 3-2: What has caused different movements of relative demand for sex, age, and education? Why did the relative demand for female workers outpace their increased supply? In contrast, why did the relative demand for elderly workers fall behind their increased supply? Why did the relative

Table 3-2 Changes in Relative Demand, Relative Supply, and Relative Wage

		1980-1994	1995-2007	2008-2016
Sex	$\widetilde{D}_t$	-0.0027	-0.0073	-0.0219
	$\log\left(\frac{L_{2t}}{L_{1t}}\right)$	0.0163	-0.0026	-0.0108
	$\log\left(\frac{w_{2t}}{w_{1t}}\right)$	-0.0043	-0.0011	-0.0025
Age	$\widetilde{D}_t$	0.0191	0.0176	0.0201
	$\log\left(\frac{L_{2t}}{L_{1t}}\right)$	0.0369	0.0188	0.0224
	$\log\left(\frac{w_{2t}}{w_{1t}}\right)$	-0.0106	-0.0007	-0.0013
Education	$\widetilde{D}_t$	0.0069	0.0409	0.0036
	$\log\left(\frac{L_{2t}}{L_{1t}}\right)$	0.0221	0.0334	0.0181
	$\log\left(\frac{w_{2t}}{w_{1t}}\right)$	-0.0068	0.0033	-0.0065

Note: 1) Calculated from Figure 3-3.

2) All changes were annualized by dividing them by the number of years in each period.

demand for college and junior college graduates grow significantly faster than their supply in the second period but not in the first and the third?

The rest of this chapter proposes and examines the answers to these questions. First, we examine the possibility that between-industry change in employment has produced the above results. For example, the growth of those industries that employ relatively more female than male workers could have increased the overall demand for female workers. Similarly, the growth of industries with a high proportion of elderly workers and the decline of those with a high proportion of young workers could have increased the demand for the elderly. As for education, the growth of industries with a high proportion of college graduates could have increased the demand for them in the second period.

Many studies on the American labor market have concluded that such between-industry changes in demand have been a very small part of the overall increase in demand since the 1970s (e.g., Murphy and Welch, 1993). Most of the increase has come instead from within-industry changes: Many, if not all, industries have increased the employment of college graduates substantially.

Section 4 below proposes a generalization of the CES production function model—a "workhorse" in this field—to allow for an arbitrary number of industries in the economy and decomposes the change in demand into between-industry and within-industry changes. The results in Sections 4 and 5 indicate that between-industry changes can explain only a small part of the increased demand for female workers, older workers, and college graduates. The bulk of the increases have been arising from within individual industries.

Accordingly, Section 6 studies within-industry changes in detail. Theoretical explanations based on SBTC and the endogenous technical change are discussed, and the role of skill is examined for the fast increase in the demand for female workers and the slow increase in the demand for older workers (all relative to the supply).

4. Between- and Within-industry Change in Demand Shifter

In this section, a decomposition of the change in the demand shifter

into between- and within-industry changes is proposed. First suppose there exist two industries in the economy, m (manufacturing) and s (services). Each has a CES production function with a common elasticity of substitution, $\sigma = \frac{1}{1-\rho}$, and each requires two input factors, 1 (say, high school graduates) and 2 (say, college graduates):

$$Q^m = [(A_1^m L_1^m)^\rho + (A_2^m L_2^m)^\rho]^{\frac{1}{\rho}} \text{ and } Q^s = [(A_1^s L_1^s)^\rho + (A_2^s L_2^s)^\rho]^{\frac{1}{\rho}},$$

where A_1^m, A_2^m, A_1^s, and A_2^s are factor-augmenting technology terms.

From eq. (8), we have

$$\frac{L_2^m}{L_1^m} = \left(\frac{w_2}{w_1}\right)^{-\sigma} \left(\frac{A_2^m}{A_1^m}\right)^{\sigma-1} \text{and } \frac{L_2^s}{L_1^s} = \left(\frac{w_2}{w_1}\right)^{-\sigma} \left(\frac{A_2^s}{A_1^s}\right)^{\sigma-1}. \quad (12)$$

Suppose that s is more intensive in L_2 than m: $\frac{L_2^m}{L_1^m} < \frac{L_2^s}{L_1^s}$. Then assuming $\sigma > 1$, we have from eq. (12)

$$\frac{A_2^m}{A_1^m} < \frac{A_2^s}{A_1^s}. \quad (13)$$

Now defining $L_1 \equiv L_1^m + L_1^s$ and $L_2 \equiv L_2^m + L_2^s$, we have

$$\frac{L_2}{L_1} = \frac{L_2^m + L_2^s}{L_1} = \frac{L_2^m}{L_1^m} \cdot \frac{L_1^m}{L_1} + \frac{L_2^s}{L_1^s} \cdot \frac{L_1^s}{L_1} = \left(\frac{w_2}{w_1}\right)^{-\sigma} \left[\theta^m \left(\frac{A_2^m}{A_1^m}\right)^{\sigma-1} + \theta^s \left(\frac{A_2^s}{A_1^s}\right)^{\sigma-1}\right] \quad (14)$$

where $\theta^m \equiv \frac{L_1^m}{L_1}$ and $\theta^s \equiv \frac{L_1^s}{L_1}$.

Taking logarithms on both sides of eq. (14) and rearranging gives

$$\log\left(\frac{L_2}{L_1}\right) = -\sigma \log\left(\frac{w_2}{w_1}\right) + \log\left[\theta^m \left(\frac{A_2^m}{A_1^m}\right)^{\sigma-1} + \theta^s \left(\frac{A_2^s}{A_1^s}\right)^{\sigma-1}\right] \text{ and}$$

$$\log\left(\frac{w_2}{w_1}\right) = \frac{1}{\sigma} \log\left[\theta^m \left(\frac{A_2^m}{A_1^m}\right)^{\sigma-1} + \theta^s \left(\frac{A_2^s}{A_1^s}\right)^{\sigma-1}\right] - \frac{1}{\sigma} \log\left(\frac{L_2}{L_1}\right). \quad (15)$$

Eq. (15) is of the same form as eq. (7) with the demand shifter D now defined as

$$D = \log\left[\theta^m \left(\frac{A_2^m}{A_1^m}\right)^{\sigma-1} + \theta^s \left(\frac{A_2^s}{A_1^s}\right)^{\sigma-1}\right]$$

$$= \log\left\{\left(\frac{A_2^m}{A_1^m}\right)^{\sigma-1} + \theta^s \left[\left(\frac{A_2^s}{A_1^s}\right)^{\sigma-1} - \left(\frac{A_2^m}{A_1^m}\right)^{\sigma-1}\right]\right\}, \quad (16)$$

where the second equality is obtained by setting $\theta^m = 1 - \theta^s$.

Proposition 1: If $\sigma > 1$, then D as defined in eq. (16) is an increasing function of $\frac{A_2^m}{A_1^m}$ and $\frac{A_2^s}{A_1^s}$ and also of θ^s.

Proof: See the first equality of eq. (16). Also from eq. (13),

$$\frac{\partial D}{\partial \theta^s} = \frac{\left(\frac{A_2^s}{A_1^s}\right)^{\sigma-1} - \left(\frac{A_2^m}{A_1^m}\right)^{\sigma-1}}{\left(\frac{A_2^m}{A_1^m}\right)^{\sigma-1} + \theta_s\left[\left(\frac{A_2^s}{A_1^s}\right)^{\sigma-1} - \left(\frac{A_2^m}{A_1^m}\right)^{\sigma-1}\right]} > 0. \quad (17)$$

QED

According to Proposition 1, the growth of s, which is intensive in L_2, and the subsequent increase in θ^s will increase the relative demand for L_2, as will the within-industry technical change that augments L_2.

Proposition 2: The larger the elasticity of substitution (σ) is, the larger the between-industry change in the demand shifter is for a given reallocation of input factors.

Proof: Differentiating eq. (17) with respect to σ yields

$$\frac{\partial}{\partial \sigma}\left(\frac{\partial D}{\partial \theta^s}\right) = \frac{\left(\frac{A_2^s}{A_1^s}\right)^{\sigma-1}\left(\frac{A_2^m}{A_1^m}\right)^{\sigma-1}\left[\log\left(\frac{A_2^s}{A_1^s}\right) - \log\left(\frac{A_2^m}{A_1^m}\right)\right]}{\left(\frac{A_2^m}{A_1^m}\right)^{\sigma-1} + \theta_s\left[\left(\frac{A_2^s}{A_1^s}\right)^{\sigma-1} - \left(\frac{A_2^m}{A_1^m}\right)^{\sigma-1}\right]} > 0. \quad (18)$$

QED

As will be explained shortly, previous studies on the decomposition of between- and within-industry changes implicitly assumed that the

value of σ equals zero or one. Our results in Table 3-1 indicate that σ is far larger than one, and Proposition 2 implies that such assumptions can lead to underestimation of the between-industry changes.

Adding time subscripts to eq. (16), D_t is now expressed as a function of $\left(\frac{A_2^m}{A_1^m}\right)_t$, $\left(\frac{A_2^s}{A_1^s}\right)_t$, and θ_t^s:

$$D_t = D\left[\left(\frac{A_2^m}{A_1^m}\right)_t, \left(\frac{A_2^s}{A_1^s}\right)_t, \theta_t^s\right]. \tag{19}$$

In general, when there exist a total of J industries, D_t will take the form

$$D\left[\left(\frac{A_2^j}{A_1^j}\right)_t, \theta_t^j;\ j = 1, \dots, J\right] = \log\left[\sum_{j=1}^{J} \theta_t^j \left(\frac{A_2^j}{A_1^j}\right)_t^{\sigma-1}\right]$$
$$\text{with } \left(\frac{A_2^j}{A_1^j}\right)_t^{\sigma-1} = \left(\frac{L_2^j}{L_1^j}\right)_t \left(\frac{w_2}{w_1}\right)_t^{\sigma},\ j = 1, \dots, J. \tag{20}$$

Then the change in D_t between year 0 and year T can be decomposed as follows:

$$\begin{aligned} & D\left[\left(\frac{A_2^j}{A_1^j}\right)_T, \theta_T^j; j\right] - D\left[\left(\frac{A_2^j}{A_1^j}\right)_0, \theta_0^j; j\right] \\ &= \left\{D\left[\overline{\left(\frac{A_2^J}{A_1^J}\right)}, \theta_T^j; j\right] - D\left[\overline{\left(\frac{A_2^J}{A_1^J}\right)}, \theta_0^j; j\right]\right\} \\ &\quad + \left\{D\left[\left(\frac{A_2^j}{A_1^j}\right)_T, \overline{\theta^J}; j\right] - D\left[\left(\frac{A_2^j}{A_1^j}\right)_0, \overline{\theta^J}; j\right]\right\} + residuals, \end{aligned} \tag{21}$$

where $\overline{\left(\frac{A_2^J}{A_1^J}\right)}$ and $\overline{\theta^J}$ denote the averages of $\left(\frac{A_2^j}{A_1^j}\right)_t$ and θ_t^j over $t = 0, \dots, T$, respectively. The first term on the RHS of eq. (21) is the between-industry change in D_t due to the reallocation of employment, and the second term is the within-industry change due to technical changes. Inferring from Proposition 1, the reallocation toward industries

with high intensity of L_2 will increase the first term, while technical changes that augment L_2 will increase the second term.

The decomposition in eq. (21) is a generalized version of those suggested in prior studies. For example, the decomposition by Katz and Autor (1999, p.1530) is conceptually equivalent to the case when $\sigma = 1$ in eq. (20):

$$D\left[\left(\frac{A_2^j}{A_1^j}\right)_t, \theta_t^j;\ j\right] = \log\left[\sum_{j=1}^{J} \theta_t^j \left(\frac{L_2^j}{L_1^j}\right)_t \left(\frac{w_2}{w_1}\right)_t\right].^{10}$$

Similarly, the decomposition suggested by Katz and Murphy (1992) is equivalent to the case when $\sigma = 0$:

$$D\left[\left(\frac{A_2^j}{A_1^j}\right)_t, \theta_t^j;\ j\right] = \log\left[\sum_{j=1}^{J} \theta_t^j \left(\frac{L_2^j}{L_1^j}\right)_t\right].$$

Table 3-3 reports the changes in $\widetilde{D}_t$ from Figure 3-3 and Table 3-2 and their decomposition according to eq. (21) for three periods. The first row of each panel shows the total change in $\widetilde{D}_t$ averaged over the years, and the rest of the rows show the decompositions.

In the table, the shaded cells indicate that their values are greater than 0.0100 in absolute terms (a rather arbitrary choice of benchmark). None of the between-industry changes are greater than 0.0100 while many of the within-industry changes are, and the latter closely match the movement of total changes. Thus within- rather than between-industry changes explain most of the results reported in Figure 3-3 and

10 Katz and Autor (1999) uses the total employment of groups 1 and 2 ($L_{1t} + L_{2t}$) rather than the employment of group 1 only (L_{1t}) in computing industry share ($\theta_t^j = \frac{L_{1t}^j}{L_{1t}}$), and uses industry j's share in total wage bill rather than the wage bill ratio between groups 1 and 2 ($\left(\frac{L_2^j}{L_1^j}\right)_t \left(\frac{w_2}{w_1}\right)_t$).

Table 3-3 Average Annual Change in the Demand Shifter

(Panel A) Sex

	1980-1994	1995-2007	2008-2016
Total change	-0.0027	-0.0073	-0.0219
Between-industry	0.0084	-0.0003	-0.0088
Within-industry	-0.0106	-0.0069	-0.0140
Residual	-0.0004	-0.0002	0.0009

(Panel B) Age

	1980-1994	1995-2007	2008-2016
Total change	0.0191	0.0176	0.0201
Between-industry	0.0026	-0.0032	-0.0042
Within-industry	0.0177	0.0211	0.0253
Residual	-0.0011	-0.0003	-0.0010

(Panel C) Education

	1980-1994	1995-2007	2008-2016
Total change	0.0069	0.0409	0.0036
Between-industry	0.0072	0.0029	0.0048
Within-industry	0.0000	0.0386	-0.0013
Residual	-0.0002	-0.0006	0.0000

Note: The shaded cells indicate that their absolute values are greater than 0.0100.

Table 3-2.[11]

Before moving on to theoretical discussions on the within-industry changes, let us take a look at graphic presentations of between- and within-industry changes.

11 Of course, it is not always easy to believe that an increase in college graduates in an industry reflects an increase in its skill demand. In the United States, the share of college graduates among waiters rose from almost zero in 1970 to 16 percent in 2015, presumably not because skill demand has risen for waiters but because many graduates could not find an adequate job and have lowered their reservation wage (*The Economist*, 2018). In fact, Caplan (2018) argues that college education produces very low (even negative) value-for-money for most major fields of study and for most students. Assuming that college education guarantees the same amount of wage to all graduates regardless of their fields of study or abilities, as I do in this paper, may be simplifying the reality a bit too much.

5. Graphic Presentation of Changes

Figure 3-4 illustrates the case of sex. The three graphs on the left plot $\theta_T^j - \theta_0^j$ (titled "change in employment share") on the vertical axis and $\overline{\left(\frac{A_2^J}{A_1^J}\right)}$ (titled "male intensity") on the horizontal axis, with the notations appropriately defined. If the dots in these graphs cluster around a downward sloping line, it would indicate a decline of male-intensive industries and a growth of female-intensive industries, in which case the overall demand for female workers would increase and the between-industry change would be negative.

As it happens, it is not easy to discern such a pattern in these graphs. In the first graph, textiles, apparel, and leather products (32) is located on the lower left corner of the graph, and appears to have contributed to the positive between-industry change (0.0084) reported in Panel A of Table 3-3. This industry used to employ a large number of young female workers, but in the 1980s began to shrink in size as the Korean economy moved up into higher value-added industries. In the second graph, its shrinking continued, but other female-intensive industries—notably social services (93) and business services (84)—increased their shares rapidly, compensating for the loss of female employment. In the last

Figure 3-4 Male Intensity and Employment Share

(Panel A) 1980-1994

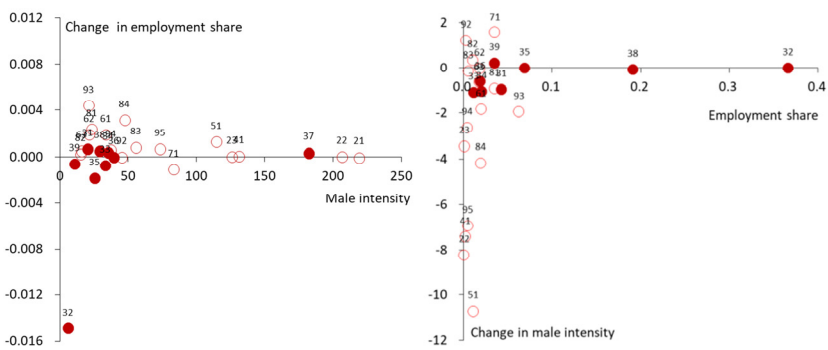
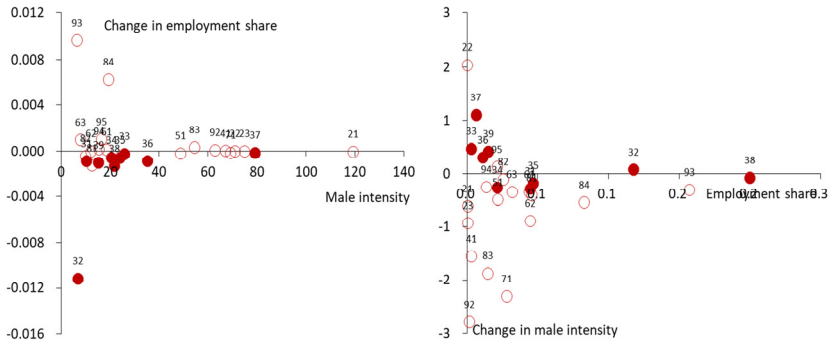
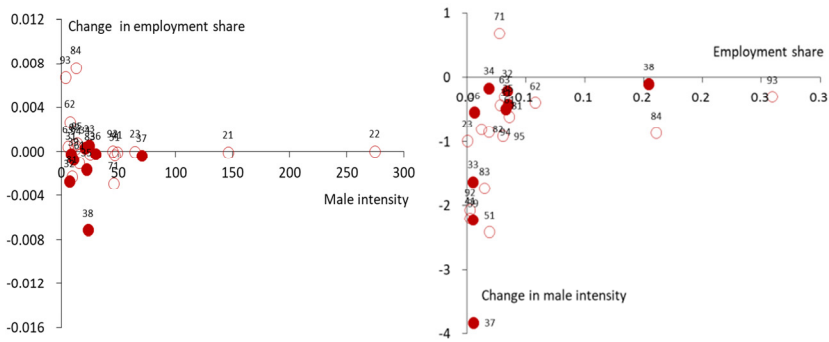


Figure 3-4 *(Continued)*

(Panel B) 1995-2007



(Panel C) 2008-2016



Note: 1) The industry code is as follows: (21) Mining of coal, petroleum, and uranium, (22) Mining of metal ores, (23) Other mining and quarrying, (31) Food products, beverages, and tobacco. (32) Textiles, apparel, and leather products, (33) Wood and products of wood (including furniture), (34) Paper, products of paper, and printing, (35) Chemicals, rubber, plastics, and fuel products, (36) Other non-metallic mineral products, (37) Basic metals, (38) Fabricated metal products, machinery, and equipment, (39) Manufacturing, n. e. c., (41) Electricity, gas, and steam supply, (51) Construction, (61) Wholesale trade, (62) Retail trade, (63) Accommodation and food service, (71) Transportation and storage, (81) Finance, (82) Insurance, (83) Real estate, (84) Business services, (92) Hygiene and related services, (93) Social services, (94) Entertainment, culture, and arts, (95) Personal and household services.

2) Solid circles indicate manufacturing and blank circles other industries.

3) Some extreme observations were dropped from the graphs on the right (37 in Panel A, and 21 and 22 in Panel C).

graph, these service industries continued to play an important role in creating jobs for women, and contributed to the negative between-industry change (-0.0088).

Next, the three graphs on the right of Figure 3-4 plot $\left(\frac{A_2^j}{A_1^j}\right)_T - \left(\frac{A_2^j}{A_1^j}\right)_0$ (titled "change in male intensity") on the vertical axis and $\overline{\theta_j}$ (titled "employment share") on the horizontal axis. In these graphs, the dots tend to lie below the horizontal axis, indicating that technical changes that favored female over male workers have occurred across many industries. In the second period, these changes occurred mainly in the service industry, but the in the third period, even manufacturing became more female-intensive. This showed up as a large negative value (-0.0106) of within-industry change in the third period in Panel A of Table 3-3.

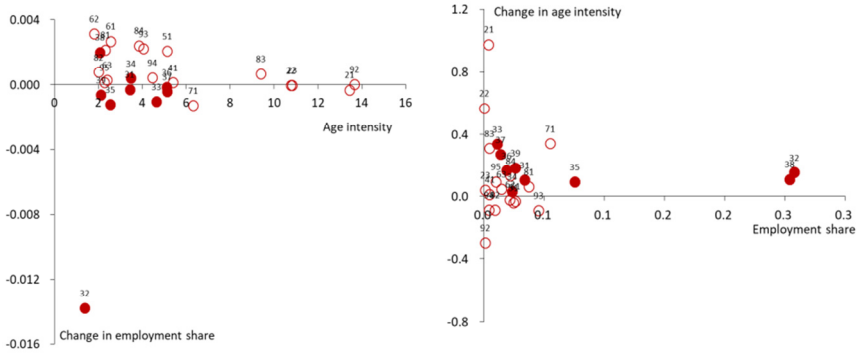
Figure 3-5 gives a somewhat similar picture for age intensity. The three graphs on the left plot the "change in employment share" on the vertical axis and the "age intensity" on the horizontal axis. For the between-industry change to be positive, the dots in these graphs should cluster around an upward sloping line. But these graphs have their dots scattered around the horizontal axis, again indicating a small role for between-industry change. On the other hand, the three graphs on the right illustrate age intensity rising across almost all industries in all periods, demonstrating a large role for within-industry change.

Lastly, Figure 3-6 confirms a weak between-industry change in all periods, a weak within-industry change in the first and third periods, and a strong within-industry change in the second period, as reported in Panel C of Table 3-3. The industries that exhibited strong growth in education intensity in the second period were mostly services, including business services (84), social services (93), wholesale trade (61), and finance (81). In the third period, however, many of these industries stopped increasing education intensity and some even reduced it, the most notable example being social services (93).[12]

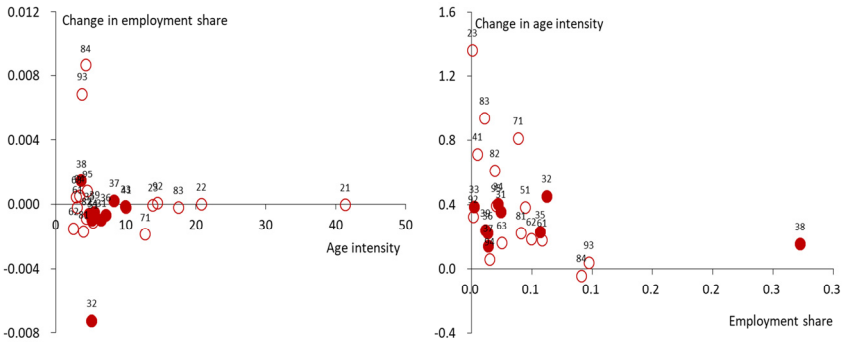
12 It would be interesting to know if the decline in education intensity of social services is related to the expansion of public support to pre-school childcare and long-term care for the elderly and the associated increase in the employment of caretakers.

Figure 3-5 Age Intensity and Employment Share

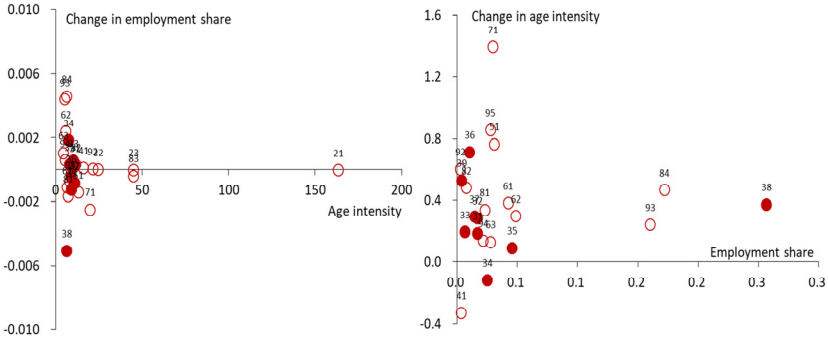
(Panel A) 1980-1994



(Panel B) 1995-2007



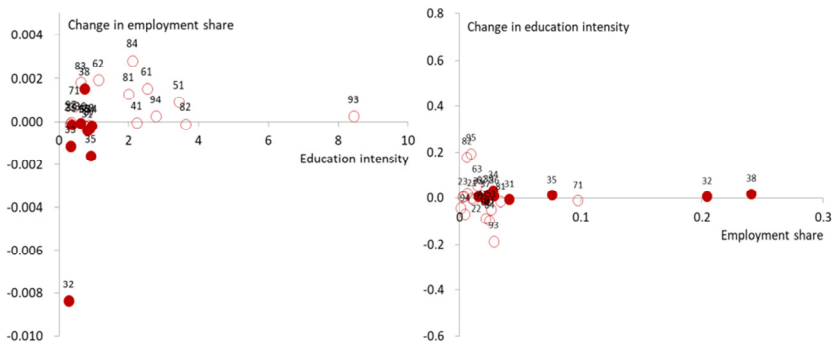
(Panel C) 2008-2016



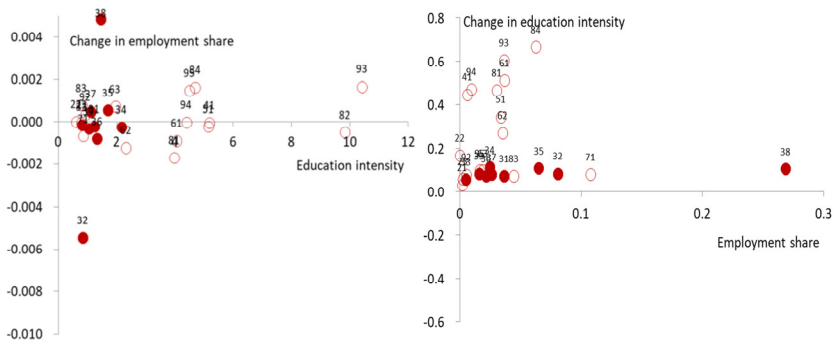
Note: See the note in Figure 3-4 except that no observations were dropped from the graphs here.

Figure 3-6 Education Intensity and Employment Share

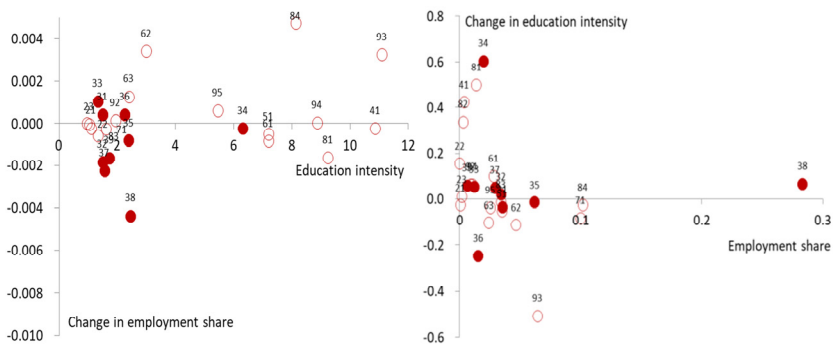
(Panel A) 1980-1994



(Panel B) 1995-2007



(Panel C) 2008-2016



Note: See the note in Figure 3-4 except that no observations were dropped from the graphs here.

6. Explaining Within-industry Changes

Having demonstrated that between-industry changes have been small in size, we now focus our attention on within-industry changes. In this regard, the most extensively studied case is the United States where college education premium rose rapidly in the 1980s and 1990s. This has been often attributed to SBTC (in particular, the wide-spread use of computers and information and communication technology (ICT)) which has increased the demand for high-skilled labor (JMP; Katz and Autor, 1999; Goldin and Katz, 2007).

But there remain doubts on SBTC as a major source of rising inequality as mentioned at the introduction. In addition, there are questions as to what has caused SBTC in the first place. The SBTC hypothesis implicitly assumes that technical changes come exogenously and take place independently of economic conditions. Such views, also shared by the real business cycle theory and Schumpeter's scientism, have drawn criticisms (Stadler, 1994; Phelps, 2013, pp.8-15). Acemoglu (2002) proposes an interesting hypothesis in this regard. He argues that technological progress is initiated by profit motives and sustained by market demands, and constructs a model where the increased supply of college graduates generates innovations that make more use of high-skilled labor. According to him, causality runs from the increased supply of college graduates to SBTC and then to the increased demand for them.[13]

Acemoglu (2002, p.42) presents several cases in history as circumstantial evidence for his endogenous technical change hypothesis. For example, in the early nineteenth century, the supply of unskilled labor increased in English cities as a result of enclosures, population growth, and other changes. As predicted by the endogenous technical change hypothesis, important unskilled labor-biased technologies were introduced in this period, the most notable of which was the factory

13 Thoenig and Verdier (2003) also proposes a theoretical model where SBTC is a by-product of globalization as growing international competition biases firms' innovation towards skilled labor-intensive technologies.

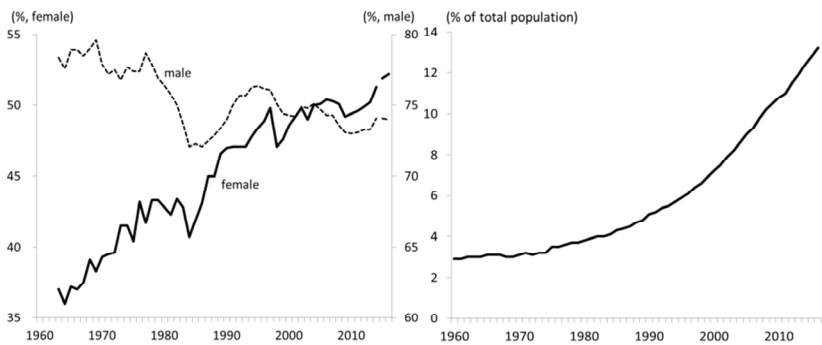
system replacing tasks previously performed by skilled artisans.

The Korean experience may provide another piece of circumstantial evidence for this line of story. From Table 2-1, Figure 3-2, and Panel C of Table 3-1, we can discern the following patterns; an increasing supply of high school graduates in the 1970s and 1980s and the subsequent increase in the demand for them in the first period; an increasing supply of college graduates in the 1990s and early 2000s and the subsequent increase in the demand for them in the second period; and the leveling off of their supply at the end of the 2000s and the subsequent leveling off of the demand for them in the third period. As for female workers, we can similarly hypothesize that the increasing labor market participation of women (Panel A of Figure 3-7) has stimulated female worker-biased technical changes and increased the demand for women in workplaces (Panel A of Table 3-1). As for older workers, the rapid population aging (Panel B of Figure 3-7) has increased the supply of older workers, which has presumably accelerated older worker-biased technical changes and increased the demand for them (Panel B of Table 3-1).

It should be noted that the SBTC hypothesis and the endogenous technical change hypothesis are not mutually exclusive as far as the latter is an exploration of the sources of SBTC. Still, the endogenous

Figure 3-7 Supply-side Factors for Female Workers and Older Workers

(Panel A) Labor Market Participation Rate (Panel B) Elderly Population (65+) Share



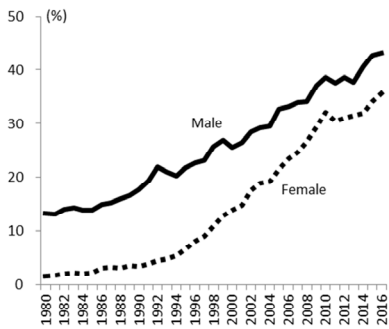
Note: There was a break in the labor market participation rate series in 2015.
Source: Korean Statistical Information Service (http://kosis.kr).

technical change hypothesis can provide an explanation for a broader range of events than the SBTC hypothesis, including unskilled labor-biased technical changes. In our case, there were workers who were relatively low-skilled but the demand for whom increased. They were female workers in the second and third periods (Panel A of Table 3-1 and Panel A of Figure 3-8), elderly (55+) workers in the third period (Panel B of Table 3-1 and Panel B of Figure 3-8), and high school graduates in the first period (Panel C of Table 3-1).[14] The endogenous technical change hypothesis will point the finger at the increased supply of these workers as the source of increased demand, while the SBTC hypothesis will remain silent on these episodes.

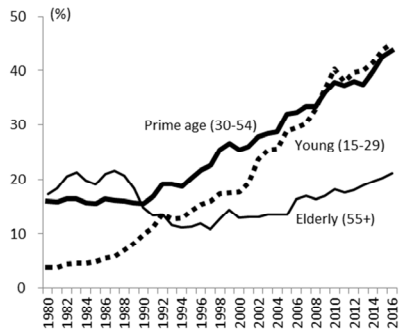
Another important difference between the SBTC hypothesis and the endogenous technical change hypothesis concerns policy implications. To reduce wage inequality, the former would argue for expanding college education to meet the increasing demand for skills, while the latter would be more cautious as it can increase the demand for college

Figure 3-8 Share of College Graduates

(Panel A) by Sex



(Panel B) by Age



Note: Hours worked were used as weights in the calculation.
Source: Ministry of Employment and Labor, *Wage Structure Survey*, various years.

14 The United States has also witnessed between 1890 and the late 1920s a rapidly increasing supply of high school graduates and a subsequent improvement in wage inequality (Goldin and Katz, 1995).

education, and can even aggravate inequality if the demand increases fast enough. The importance of higher education in improving productivity and accelerating growth cannot be denied, but attention needs to be paid to the possible side-effects.

Regarding the relevance of the SBTC hypothesis to the Korean labor market, many studies have confirmed it using the standard empirical framework (Kwon and Kim, 2001; Shin, 2007). I replicate these studies by running the regression of the following equation:

$$\Delta(education\ intensity)^j = a_0 + a_1(education\ intensity)_0^j + a_2\Delta ICT^j + \epsilon^j.$$

Here j is industry, Δ denotes the change between the first and the last years in the sample, $(education\ intensity)^j$ is the value of $\left(\frac{A_2^j}{A_1^j}\right)$, and ICT^j is the share of ICT in the intermediate inputs. The subscript 0 denotes the starting year, and the variable $(education\ intensity)_0^j$ was introduced to take into account the possible mean reversion, in which case $a_1 < 0$. The ICT variable was obtained from the input-output tables published by the Bank of Korea.[15] According to the SBTC hypothesis, industries with greater ICT use would exhibit higher skill intensity ($a_2 > 0$). In the regression, only those industries with data in all periods were included, and θ^j for the starting year was used to weight industries.

Table 3-4 reports the regression results for the three periods. The coefficient estimate of ΔICT^j is statistically insignificant in the second and third periods, and significant in the first period but with a wrong sign.

---

15 ICT products include precision instruments, computers and related machines, semiconductors, medical and measuring instruments, optical instruments, and telecommunication, video, and broadcasting equipment.

Table 3-4 Regression of Education Intensity on ICT Use

Dependent variable: $\Delta(education\ intensity)^j$

	1980-1994	1995-2007	2008-2016
$(education\ intensity)_0^j$	-0.271*** (0.048)	1.706** (0.746)	-0.200** (0.089)
ΔICT^j	-9.600** (3.928)	28.944 (17.562)	4.068 (6.857)
Observations	25	25	25
R-squared	0.552	0.484	0.365

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Lastly, we examine the role of skill in adding to or subtracting from the demand for female workers and older workers. Female workers have rapidly improved their educational achievement and narrowed the gap with male workers (Panel A of Figure 3-8). Young workers (15-29) have made similar progress, who now have more college graduates than prime age workers or elderly workers as a proportion of the age group (Panel B of Figure 3-8).

The rising skill level of female workers would have added to the demand for them, and the same would have been true with young workers. The other side of the coin is the declining attractiveness of male workers and older workers to employers. This might be the reason why the demand for female workers has increased rapidly and that for older workers slowly (all relative to the supply), as noted at the end of Section 3.

To test this possibility, we run the following regressions:

$$\Delta(male\ intensity)_t^j = b_o + b_1(male\ intensity)_{t-1}^j + b_2(skill)_{t-1}^j + b_{3t} + \varepsilon_t^j$$

and

$$\Delta(age\ intensity)_t^j = c_0 + c_1(age\ intensity)_{t-1}^j + c_2(skill)_{t-1}^j + c_{3t} + \eta_t^j.$$

Here Δ_t represents the difference between year $t-1$ and year t, *male intensity* and *age intensity* are defined similarly to *education intensity* above, *skill* is proxied by the education intensity, and b_{3t} and c_{3t} represent time fixed effects. If skills affect the labor demand, then we

Table 3-5 Regression of Male Intensity and Age Intensity

(Panel A) $\Delta(male\ intensity)_t^j$

	1980-1994	1995-2007	2008-2016
$(male\ intensity)_{t-1}^j$,	-0.069**	-0.043*	-0.055
	(0.033)	(0.022)	(0.058)
$(skill)_{t-1}^j$,	-0.174***	-0.068**	-0.069**
	(0.055)	(0.031)	(0.033)
Observations	364	338	234
R-squared	0.174	0.255	0.222

(Panel B) $\Delta(age\ intensity)_t^j$

	1980-1994	1995-2007	2008-2016
$(age\ intensity)_{t-1}^j$	0.013	0.038*	-0.001
	(0.025)	(0.021)	(0.074)
$(skill)_{t-1}^j$,,	-0.041***	-0.014	-0.005
	(0.012)	(0.010)	(0.015)
Observations	364	338	234
R-squared	0.134	0.123	0.154

Note: 1) All regressions include time fixed effects.

2) Only the coefficient estimates on lagged intensities and skills shown.

3) Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

would expect $b_2 < 0$ and $c_2 < 0$: The rising skills of women and the young will reduce the demand for men and older workers, and the reduction will be larger in those industries that rely more on skilled labor than in those that rely less. The regressions employed θ_{t-1}^j's as weights for industries.

Table 3-5 reports the results. The coefficient estimates on *skill* are all negative and significant in many cases. Thus skills appear to have affected the labor demand in the expected direction.

CHAPTER 4

Changing Distributions

According to Figure 2-7, the distribution effects of sex, age, tenure, and establishment size have been particularly large. This chapter examines how the quintile averages ($X_{\overline{Q1}}$, $X_{\overline{Q3}}$, $X_{\overline{Q5}}$) of these variables have changed over time, and how these changes have affected the wage gaps. For example, if $\beta > 0$, an increase in $X_{\overline{Q5}} - X_{\overline{Q1}}$ will increase the Q5-Q1 gap by eq. (4) in Chapter 2. This exercise allows us to go beyond the discussion on prices (β) in Chapter 3, make interesting discoveries, and gain a better understanding of wage inequality development in Korea.

1. Sex

Table 4-1 shows the share of female workers by wage quintile. It rose from 4.9 to 16.0 percent between 1980 and 2016 at the top while falling from 82.8 to 53.9 percent at the bottom. The difference between the top and bottom narrowed from -77.9 to -38.0 percentage points. Female workers thus have increased their presence at the top and reduced it at the bottom, thereby weakening the influence of sex on wage inequality.

As noted before, the weakening influence of sex was most pronounced in the Q3-Q1 gap (Figure 2-4). An explanation can be found in the significant reduction of female workers' share at the bottom as

noted above. The reduction was concentrated in craft workers and operators by occupation and in light manufacturing by industry. Female craft workers and operators accounted for 75.4 percent of all workers, male or female, at the bottom in 1980, but their share fell to 8.8 percent by 2016. Similarly, female workers in light manufacturing accounted for 52.5 percent of all workers in 1980, but their share fell to 5.5 percent by 2016.

Table 4-1 Share of Female Workers by Wage Quintile

(Unit: %, %p)

Wage quintile			1980	1990	2000	2010	2016
Top	All occupations and industries		4.9	5.8	12.0	13.2	16.0
	Occupation	Professional, technical, and managerial	2.4	2.6	7.2	6.8	7.4
		Clerks	2.0	2.8	4.0	5.4	6.6
		Services and sales	0.3	0.2	0.3	0.5	0.8
		Craft workers and operators	0.2	0.2	0.4	0.4	1.0
		Elementary occupations	0.0	0.0	0.1	0.0	0.1
	Industry	Light manufacturing	0.4	0.5	0.4	0.6	0.6
		Heavy and chemical industry	0.7	0.5	1.0	2.3	2.7
		Industry exc. manufacturing	0.1	0.1	0.1	0.3	0.4
		Service	3.8	4.7	10.5	10.1	12.2
Middle	All occupations and industries		32.3	26.0	23.3	29.3	30.9
	Occupation	Professional, technical, and managerial	0.6	2.3	5.5	10.6	11.3
		Clerks	10.7	9.4	10.8	12.1	12.6
		Services and sales	4.8	2.7	2.1	2.7	2.5
		Craft workers and operators	16.0	11.4	4.2	3.1	3.0
		Elementary occupations	0.2	0.1	0.7	0.8	1.4
	Industry	Light manufacturing	12.4	5.8	3.3	2.5	2.4
		Heavy and chemical industry	9.5	11.3	5.2	5.5	5.4
		Industry exc. manufacturing	0.8	0.4	0.7	0.7	0.7
		Service	9.5	8.4	14.1	20.7	22.4
Bottom	All occupations and industries		82.8	71.2	52.1	48.6	53.9
	Occupation	Professional, technical, and managerial	0.2	1.3	2.8	7.4	10.0
		Clerks	2.8	9.8	12.7	10.0	8.5
		Services and sales	3.9	5.8	4.1	7.6	13.8
		Craft workers and operators	75.4	53.5	24.1	13.1	8.8
		Elementary occupations	0.5	0.8	8.5	10.5	12.8
	Industry	Light manufacturing	52.5	42.0	17.7	6.7	5.5
		Heavy and chemical industry	25.4	18.3	15.2	11.4	7.8
		Industry exc. manufacturing	0.3	0.7	1.2	1.1	0.9
		Service	4.7	10.2	18.0	29.4	39.8
Top - Bottom			-77.9	-65.4	-40.1	-35.5	-38.0

Note: The sums over occupations and over industries are each equal to the value reported in the row "all occupations and industries."

Female workers at the bottom moved increasingly toward clerical jobs in the 1980s and 1990s and then toward services and sales jobs and also toward professional, technical, and managerial jobs in the 2000s and 2010s. At the same time, they moved away from manufacturing and toward service as the Korean economy went through de-industrialization. Thus the decline of light manufacturing such as textiles, apparel, and leather products that relies heavily on female craft workers and the rise of the service industry appears to have significantly contributed to narrowing the wage gap between male and female workers.

2. Age and Firm Tenure

The distribution of age across wage quintiles has also experienced significant changes (Table 4-2). In 1980, the average ages in the top and bottom wage quintile were 36.3 and 22.6 years, respectively. As older workers generally enjoy higher pay, this gap of 13.7 years contributed to large wage gap among workers. But since then, the average age of workers at the bottom quintile increased faster than that at the top, and the gap turned negative and recorded -0.5 years in 2016. Now workers at the bottom quintile are on average slightly older than those at the top. By occupation, services and sales workers and elementary occupations workers were older at the bottom than at the top, and by industry, service industry workers were.

What has caused the reversal of the age gap between the top and bottom quintiles? Table 4-3 reports the average firm tenure by wage quintile. The average tenure at the top quintile almost tripled from 5.1 to 14.3 years between 1980 and 2016. That at the bottom quintile increased from 1.2 to 3.1 years, and the gap between the top and bottom quintiles widened from 3.9 to 11.2 years. Workers at the bottom have on average much shorter tenure than those at the top across all occupations and industries.

In addition, work experience is also much shorter at the bottom than at the top (Table 4-4). In 2016, workers with work experience of less than 3 years accounted for 7.0 percent of all workers at the top and 57.4 percent of all workers at the bottom, with a difference of -50.4 percentage

Table 4-2 Average Age by Wage Quintile

(Unit: %, %p)

Wage quintile			1980	1990	2000	2010	2016
Top	All occupations and industries		36.3	37.5	40.0	42.1	44.2
	Occupation	Professional, technical, and managerial	38.5	38.6	41.2	41.8	43.7
		Clerks	32.8	31.9	36.5	41.8	44.5
		Services and sales	39.3	37.8	38.8	40.2	43.8
		Craft workers and operators	36.2	38.3	40.3	44.2	45.2
		Elementary occupations	37.9	40.5	43.2	45.8	42.0
	Industry	Light manufacturing	36.8	39.1	42.5	42.1	45.4
		Heavy and chemical industry	35.2	36.6	40.0	40.8	42.6
		Industry exc. manufacturing	36.9	38.8	40.9	44.2	45.2
		Service	36.7	37.6	39.7	42.5	44.8
Middle	All occupations and industries		28.1	31.7	35.4	36.5	38.4
	Occupation	Professional, technical, and managerial	28.0	31.8	32.9	33.4	35.0
		Clerks	25.3	26.5	30.4	34.6	36.2
		Services and sales	32.3	36.3	33.0	35.0	37.7
		Craft workers and operators	28.1	32.5	38.5	39.9	42.3
		Elementary occupations	34.4	37.3	42.6	42.2	43.4
	Industry	Light manufacturing	27.5	32.3	37.1	38.1	39.9
		Heavy and chemical industry	27.9	30.3	35.0	36.3	38.3
		Industry exc. manufacturing	32.1	34.1	34.6	38.9	41.2
		Service	28.6	32.8	35.3	36.1	38.0
Bottom	All occupations and industries		22.6	30.4	37.6	41.7	44.7
	Occupation	Professional, technical, and managerial	23.6	25.7	28.3	34.8	38.4
		Clerks	22.8	22.4	26.4	33.0	35.5
		Services and sales	29.7	41.3	33.6	38.9	45.6
		Craft workers and operators	22.1	29.6	35.5	41.7	44.5
		Elementary occupations	29.1	40.9	52.0	51.5	52.2
	Industry	Light manufacturing	21.9	29.3	38.0	42.7	44.3
		Heavy and chemical industry	23.1	29.3	32.2	36.8	38.5
		Industry exc. manufacturing	31.1	27.3	31.5	40.2	44.3
		Service	25.4	34.1	41.3	43.7	46.4
Top - Bottom			13.7	7.2	2.5	0.4	-0.5

points. More than half of workers at the bottom had entered the labor market less than three years ago, again across almost all occupations and industries.

The bottom may have shorter tenure and less experience because it contains a larger number of young workers than the top. This possibility looks small given the similar average ages at the top and the bottom (Table 4-2). To check out this possibility, the sample was restricted to older workers (45 years or older), and the average firm tenure and the share of less experienced workers (those with less than three years of

Table 4-3 Average Firm Tenure by Wage Quintile

(Unit: %, %p)

Wage quintile			1980	1990	2000	2010	2016
Top	All occupations and industries		5.1	8.0	10.7	13.2	14.3
	Occupation	Professional, technical, and managerial	5.6	8.0	10.3	11.2	12.5
		Clerks	4.8	6.2	9.7	13.9	15.0
		Services and sales	6.3	7.8	10.1	10.9	13.8
		Craft workers and operators	4.7	9.3	13.5	18.5	18.8
		Elementary occupations	6.7	9.1	12.5	16.6	14.0
	Industry	Light manufacturing	5.7	8.5	10.7	11.9	12.8
		Heavy and chemical industry	4.9	7.7	11.9	13.6	14.5
		Industry exc. manufacturing	5.3	8.0	9.3	15.3	13.4
		Service	5.0	8.0	10.3	12.8	14.4
Middle	All occupations and industries		2.3	3.1	4.7	5.5	5.7
	Occupation	Professional, technical, and managerial	2.1	2.9	3.4	4.2	4.5
		Clerks	2.2	2.6	4.0	5.3	5.4
		Services and sales	2.5	4.1	3.8	4.6	5.1
		Craft workers and operators	2.3	3.1	5.5	6.7	6.8
		Elementary occupations	3.5	3.6	6.8	7.6	6.2
	Industry	Light manufacturing	2.6	3.4	5.6	6.8	6.4
		Heavy and chemical industry	2.2	2.9	5.6	6.2	6.0
		Industry exc. manufacturing	2.5	3.2	3.4	4.2	4.4
		Service	2.0	3.0	4.0	5.1	5.4
Bottom	All occupations and industries		1.2	1.3	1.7	3.0	3.1
	Occupation	Professional, technical, and managerial	1.2	1.1	1.1	2.5	2.8
		Clerks	1.0	0.8	1.1	2.7	2.8
		Services and sales	1.4	1.7	1.4	2.6	2.9
		Craft workers and operators	1.2	1.3	1.8	3.4	3.6
		Elementary occupations	1.6	1.5	2.2	2.8	3.1
	Industry	Light manufacturing	1.3	1.5	2.3	3.5	3.9
		Heavy and chemical industry	1.1	1.0	1.3	2.7	2.9
		Industry exc. manufacturing	2.0	1.1	1.0	2.5	3.7
		Service	1.2	1.3	1.7	3.1	3.1
Top - Bottom			3.9	6.6	9.0	10.2	11.2

experience) were calculated. The results are reported in Tables 4-5 and 4-6. The differences in tenure and experience between the top and the bottom remain large. In 2016, the average tenure at the top was 15.0 years longer than at the bottom, and the share of less experienced workers was 40.4 percentage points lower.

These tables demonstrate that those who have successfully stayed with an employer for a long time enjoy high pay. But many workers have failed to do so, with some of them entering the labor market at later ages and others hopping around short-term and low-paying jobs

Table 4-4 Share of Workers with Work Experience of Less than 3 Years

(Unit: %, %p)

Wage quintile			1980	1990	2000	2010	2016
Top	All occupations and industries		30.7	12.2	5.0	7.2	7.0
	Occupation	Professional, technical, and managerial	28.9	9.7	5.4	10.1	9.2
		Clerks	40.2	26.6	5.9	5.4	5.3
		Services and sales	24.2	13.7	4.0	7.6	7.8
		Craft workers and operators	25.5	8.4	2.4	2.0	3.5
		Elementary occupations	20.7	6.1	2.9	3.3	5.6
	Industry	Light manufacturing	24.3	10.0	6.5	6.2	5.7
		Heavy and chemical industry	32.4	12.0	3.2	6.0	6.9
		Industry exc. manufacturing	30.9	8.4	3.6	5.1	8.2
		Service	31.8	13.7	5.9	8.1	7.1
Middle	All occupations and industries		60.0	36.9	23.2	29.8	31.3
	Occupation	Professional, technical, and managerial	66.6	38.6	33.7	39.2	37.6
		Clerks	69.7	50.2	28.5	31.2	32.2
		Services and sales	66.2	35.0	32.0	38.3	38.3
		Craft workers and operators	56.5	32.8	16.1	21.0	24.4
		Elementary occupations	55.3	32.7	17.9	20.7	29.4
	Industry	Light manufacturing	53.2	31.2	17.4	24.6	26.1
		Heavy and chemical industry	63.3	40.0	20.6	26.8	29.9
		Industry exc. manufacturing	67.7	37.7	22.2	30.1	29.2
		Service	61.9	36.6	26.9	32.3	33.1
Bottom	All occupations and industries		84.0	71.0	59.3	57.6	57.4
	Occupation	Professional, technical, and managerial	84.2	74.7	75.1	59.8	58.1
		Clerks	93.2	85.6	74.1	64.4	66.4
		Services and sales	83.8	65.9	70.5	65.8	59.8
		Craft workers and operators	83.6	69.5	56.8	53.2	53.2
		Elementary occupations	89.9	72.5	48.2	56.7	56.2
	Industry	Light manufacturing	80.9	66.6	50.1	51.7	51.8
		Heavy and chemical industry	88.9	78.9	69.0	64.8	64.2
		Industry exc. manufacturing	85.0	76.0	61.3	48.6	38.3
		Service	86.5	71.0	57.7	56.1	57.3
Top - Bottom			-53.2	-58.8	-54.4	-50.4	-50.4

during most of their career. Of course this does not mean that instability has increased in the labor market. In fact, the average tenure has continuously risen from 2.8 to 7.1 years between 1980 and 2016 (Table 2-1). It only means that career differentiation has increased between those workers who can and would stay with an employer for long and those who cannot or would not.

In summary, the declining age gap between the top and bottom quintiles has helped narrow the wage gap, while the growing tenure gap has helped widen it. The increasing differentiation between those workers

Table 4-5 Average Firm Tenure of Workers Aged 45 Years or More

(Unit: years)

Wage quintile			1980	1990	2000	2010	2016
Top	All occupations and industries		8.1	12.4	15.6	18.7	18.9
	Occupation	Professional, technical, and managerial	8.2	11.7	14.6	16.8	17.3
		Clerks	9.5	14.3	16.6	19.0	19.1
		Services and sales	8.6	13.3	15.5	15.7	17.6
		Craft workers and operators	7.1	13.8	19.0	22.8	23.1
		Elementary occupations	10.0	11.9	15.6	19.8	16.8
	Industry	Light manufacturing	8.2	12.9	14.5	18.3	16.5
		Heavy and chemical industry	7.3	12.1	16.9	20.0	19.9
		Industry exc. manufacturing	8.4	10.9	12.8	19.8	17.2
		Service	8.4	12.7	15.6	18.0	18.9
Middle	All occupations and industries		3.9	5.5	7.4	8.2	8.0
	Occupation	Professional, technical, and managerial	5.3	5.5	6.3	7.3	6.9
		Clerks	4.0	4.7	7.8	8.1	7.8
		Services and sales	3.9	6.4	7.2	6.8	7.0
		Craft workers and operators	3.6	5.3	7.4	8.6	8.5
		Elementary occupations	6.5	5.3	8.4	8.7	7.6
	Industry	Light manufacturing	4.1	6.0	8.7	10.2	8.9
		Heavy and chemical industry	3.4	5.2	9.1	9.4	8.6
		Industry exc. manufacturing	4.5	5.5	4.8	5.5	5.5
		Service	4.0	5.4	6.2	7.5	7.8
Bottom	All occupations and industries		2.1	2.3	2.9	4.0	3.9
	Occupation	Professional, technical, and managerial	9.8	4.4	6.6	4.1	3.9
		Clerks	1.6	3.2	3.0	5.0	4.8
		Services and sales	2.7	2.2	3.4	3.4	3.4
		Craft workers and operators	1.9	2.3	3.5	4.8	4.7
		Elementary occupations	3.4	1.7	2.4	3.2	3.5
	Industry	Light manufacturing	2.0	2.4	3.9	4.5	5.0
		Heavy and chemical industry	1.7	2.1	3.2	4.2	4.5
		Industry exc. manufacturing	4.5	2.7	2.2	3.2	4.6
		Service	3.3	2.2	2.4	3.9	3.7
Top - Bottom			6.0	10.1	12.8	14.7	15.0

with high employability and strong labor market attachment and those without these qualities has made age less important and firm tenure more important as determinants of wage.

Table 4-6 Less Experienced Workers among Those Aged 45 Years or More

(Unit: %, %p)

Wage quintile			1980	1990	2000	2010	2016
Top	All occupations and industries		16.8	3.4	2.9	3.6	4.4
	Occupation	Professional, technical, and managerial	18.5	3.9	3.3	4.5	5.4
		Clerks	17.8	3.1	2.5	3.5	3.9
		Services and sales	14.3	2.7	2.0	5.6	6.3
		Craft workers and operators	12.3	2.3	1.5	1.4	2.2
		Elementary occupations	8.5	2.4	2.4	1.6	5.3
	Industry	Light manufacturing	14.5	3.4	3.7	3.8	3.5
		Heavy and chemical industry	18.8	3.8	2.9	2.9	4.6
		Industry exc. manufacturing	18.2	3.0	2.6	3.9	7.3
		Service	16.2	3.2	2.7	3.8	4.0
Middle	All occupations and industries		37.6	14.0	10.7	16.3	18.6
	Occupation	Professional, technical, and managerial	38.3	13.5	10.4	17.3	19.6
		Clerks	40.4	16.7	12.3	16.4	19.7
		Services and sales	44.3	14.5	12.5	26.6	25.9
		Craft workers and operators	33.7	13.3	10.3	14.6	16.5
		Elementary occupations	32.6	17.8	12.0	18.1	21.0
	Industry	Light manufacturing	32.8	14.1	5.2	12.1	15.2
		Heavy and chemical industry	43.2	15.9	9.9	15.4	16.7
		Industry exc. manufacturing	45.5	17.9	9.2	18.0	17.2
		Service	33.5	11.4	13.4	17.5	20.6
Bottom	All occupations and industries		72.2	53.3	37.7	41.3	44.8
	Occupation	Professional, technical, and managerial	16.2	36.7	24.0	38.5	39.3
		Clerks	85.1	33.4	46.3	31.3	39.4
		Services and sales	69.1	56.7	43.9	48.5	50.9
		Craft workers and operators	72.8	51.1	27.6	34.9	38.7
		Elementary occupations	73.9	67.6	43.4	48.4	48.9
	Industry	Light manufacturing	70.5	47.8	26.6	35.2	37.9
		Heavy and chemical industry	78.2	56.1	32.4	40.7	42.6
		Industry exc. manufacturing	74.2	50.6	26.4	30.0	26.5
		Service	64.7	59.0	43.8	43.0	46.8
Top - Bottom			-55.4	-49.9	-34.8	-37.8	-40.4

Note: Less experienced workers refer to those with less than 3 years of experience.

3. Establishment Size

Establishment size has played an increasingly important role in widening the wage gap. Table 4-7 reports the share of workers in "large" establishments by wage quintile, where "large" establishments refers to those with 300 or more employees. This share was almost the same for the top (46.3 percent) and the bottom (42.9 percent) in 1980 with a gap

Table 4-7 Employment Share of Large Establishments by Wage Quintile

(Unit: %, %p)

Wage quintile	1980	1990	2000	2010	2016
Top	46.3	52.3	39.2	48.7	49.1
Middle	44.4	34.3	21.9	18.5	15.4
Bottom	42.9	23.6	11.2	8.5	6.0
Top - Bottom	3.3	28.7	28.0	40.2	43.1

Note: "Large" establishments are those with 300 or more employees.

of only 3.3 percentage points. Since then the gap has increased to 43.1 percentage points by 2016. While the share at the top has rose to 49.1 percent, that at the bottom has fallen to 6.0 percent by 2016.

Overall, the share of large establishments in total employment has declined from 45.2 to 21.7 percent between 1980 and 2016 (Table 2-1). What has caused such a decline? One possibility is the expansion of the service industry, where economies of scale due to capital investment or R&D activities is presumably less pronounced. A second is the wider and deeper penetration of ICT into workplaces, which reduces transaction costs and facilitates outsourcing (or "market transactions" in the terminology of Coase (1937)). A third is the policies and practices —such as government supports to small- and medium-sized enterprises and hostile labor relations—that reduce employers' incentive to grow large. Unfortunately, studies on this issue are scant and no firm evidence can be put forward for or against these possibilities.

Table 4-8 sheds some light in this regard. In light manufacturing, large establishments accounted for 46.9 percent of workers in 1980, but their share declined to 16.3 percent by 2016. In service, their share fluctuated around 20 percent. Light manufacturing thus became populated by more and more small establishments, and nowadays the share of large establishments is smaller in this industry than in service (16.3 percent vs. 18.5 percent). Similarly, heavy and chemical industry came to be dominated by small establishments though to a lesser extent than light manufacturing. The "economies of scale" explanation is not compatible with this trend.

What lies behind the diminishing size of manufacturing establishments? To answer this question, we identify the occupations and industries that are over-represented by large establishments. In 1980, for example, 49.1

Table 4-8 Share of Large Establishments by Occupation and Industry

(Unit: %)

		1980	1990	2000	2010	2016
All occupations and industries		45.2	36.9	24.2	24.0	21.7
Occupation	Professional, technical, and managerial	35.3	35.2	25.3	30.5	27.2
	Clerks	39.9	32.6	22.4	27.0	23.9
	Services and sales	34.4	28.7	18.5	18.6	12.8
	Craft workers and operators	49.1	40.7	27.0	18.8	19.9
	Elementary occupations	55.5	36.4	16.8	16.5	14.5
Industry	Light manufacturing	46.9	39.9	24.6	18.0	16.3
	Heavy and chemical industry	54.5	50.4	35.6	37.0	36.6
	Industry exc. manufacturing	54.9	36.7	20.2	29.9	20.3
	Service	25.4	22.0	18.7	20.6	18.5

Note: 1) "Large" establishments are those with 300 or more employees.
2) The shaded cells indicate an over-represention by large establishments.

percent of craft workers and operators belonged to large establishments. Because 45.2 percent of all workers belonged to large ones (the first row of Table 4-8), we can say that craft workers and operators were over-represented by large ones. The shaded cells in the table indicate the occupations and industries that are similarly over-represented by large ones.

By occupation, craft workers and operators were over-represented by large establishments in the early years as noted above. But their position was gradually replaced by professional, technical, and managerial workers and also by clerical workers. By industry, light manufacturing workers were over-represented by large ones in the early years but became under-represented later on. In contrast, heavy and chemical industry workers remained over-represented and service industry workers remained under-represented throughout the sample period.

In summary, the picture is compatible with large establishments increasingly relegating blue-collar jobs and low value-added activities to small establishments and concentrating on white-collar jobs and high value-added activities, spurred by the spread of ICT or by public policies and labor market practices. In any case, the falling employment share of large establishments has affected the bottom quintile more than the top (Table 4-7), and together with the rising price (Panel F of Figure 2-2), has helped widen the overall wage gap.

4. Occupation and Industry

The results above indicate that the changing mix of occupations and industries has influenced wage inequality in various ways. The decline of the occupation of craft workers and operators and also of light manufacturing, and the rise of clerical, sales, and services occupations and of the service industry, have provided female workers with better job opportunities and have helped narrowing the gender gap in wages. But the decline of labor-intensive light manufacturing was also accompanied by the decreasing share of large establishments and the concentration of the latter's presence in the top wage quintile, which increased wage inequality.

Apart from these, occupation and industry have had direct impact on wage inequality as can be seen in Figures 2-4 and 2-5 and Tables 2-3 and 2-5. In particular, according to Table 2-5, occupation lowered wage inequality in the first period, raised it in the second, and had a neutral effect in the third, while industry tended to reduce wage inequality moderately throughout the sample period. This section takes a look at how employment and wage have moved over the decades across different occupations and industries to produce these results.

In Figure 4-1, the three graphs on the left plot the wages in the starting years (1980, 1995, 2009) on the horizontal axis against the subsequent

Figure 4-1 Changes in Employment and Wage by Occupation

(Panel A) 1980-1992

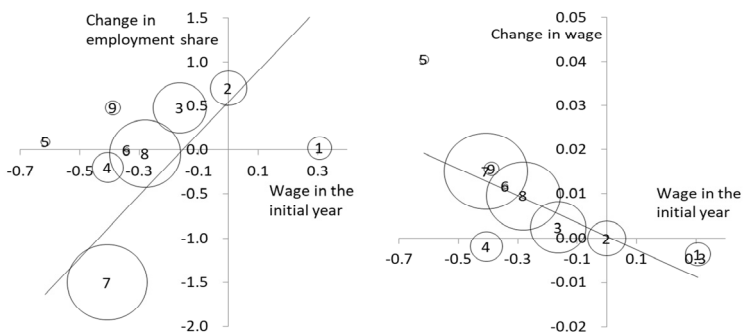
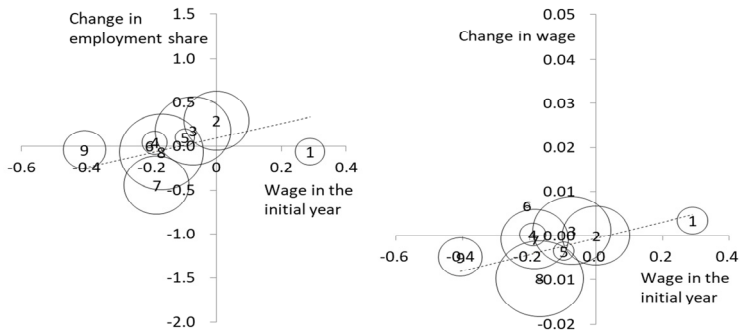
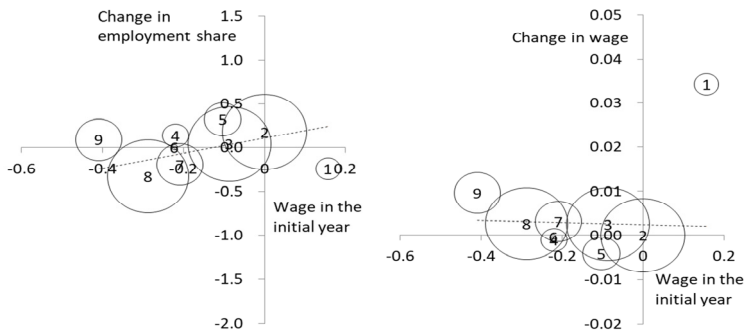


Figure 4-1 *(Continued)*

(Panel B) 1995-2007



(Panel C) 2009-2016



Note: 1) Sample periods (1980-1992, 1995-2007, 2009-2016) were adjusted to match the changes in occupational classification.

2) Wages were measured with the coefficient estimates of occupation dummies in Table 2-2.

3) The occupation code is as follows: (1) managers, (2) professionals, technicians, and associate professionals, (3) clerical support workers, (4) services workers, (5) sales workers, (6) Skilled agricultural, forestry, and fishery workers, (7) Craft and related trades workers, (8) plant and machine operators and assembles, and (9) elementary occupations.

4) The area of a circle represents the employment share in the starting years (1980, 1995, and 2009). Lines were fitted with these shares as weights. The solid line indicates that the slope is statistically significant ($p<0.1$) while the dotted line indicates that it is not ($p>0.1$).

changes in employment share (1980-1992, 1995-2007, 2009-2016) on the vertical axis. Wages were measured with the coefficient estimates of occupation dummies in Table 2-2; they are thus stripped off of the influence of other variables and reflect the occupational differences only, with the occupation of professionals, technicians, and associate

professionals (code: 2) serving as the reference occupation. Similarly, the graphs on the right plot the changes in wage against the wages in the starting years.

In the first period (Panel A), the graph on the left ("employment growth graph") indicates that employment growth was stronger for high-paying occupations, while that on the right ("wage growth graph") indicates that wage growth was stronger for low-paying occupations. Thus supply factors appear to have been dominant in the first period: Workers chose to migrate from low-paying to high-paying occupations,[16] which helped lower wage inequality across occupations. This in turn would have helped lower inequality among workers as noted above.

Unlike in the first period, it is difficult to find a clear relation between variables in the second and third periods. In the second period, if anything, employment and wage both grew faster for higher-wage workers, possibly due to increased demand for high-skilled labor. This may have contributed to increased wage inequality in this period.

Another notable feature of the second and third periods is the sustained demand for elementary occupation (code: 9) as indicated by its location above the fitted line in both the employment growth and wage growth graphs.[17] One explanation would be the bipolarization of skill demand due to the increasing ICT use in workplaces. Autor (2010) and Autor and Dorn (2013) claim that computers are replacing human workers engaged in routine works of both manual and cognitive nature, increasing the demand for both high- and low-skilled jobs, and hollowing out the middle. Panels B and C are compatible with this hypothesis when elementary occupations are taken to be non-routine.

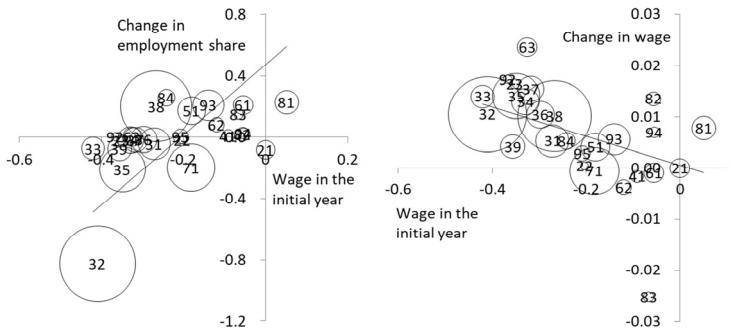
Now turning to industry, much the same can be told from Figure 4-2. In the first period, workers migrated into those industries with higher pay, increasing employment and reducing wage in those industries, and

16 "Migration" here is meant to describe not only those workers changing jobs in the middle of their career but also those new entrants into the labor market beginning their career in high-paying jobs.

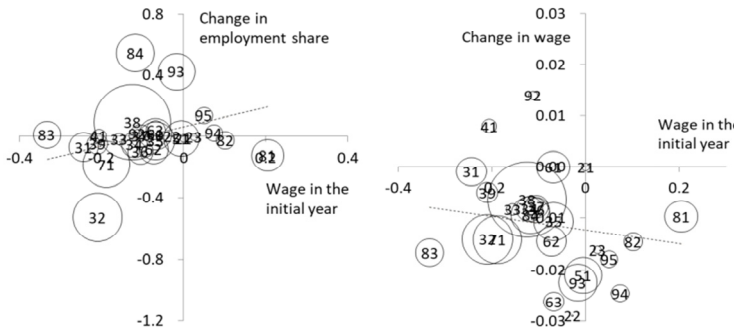
17 The fitted line on the left in Panel C becomes statistically significant when this occupation is dropped from the graph.

Figure 4-2 Changes in Employment and Wage by Industry

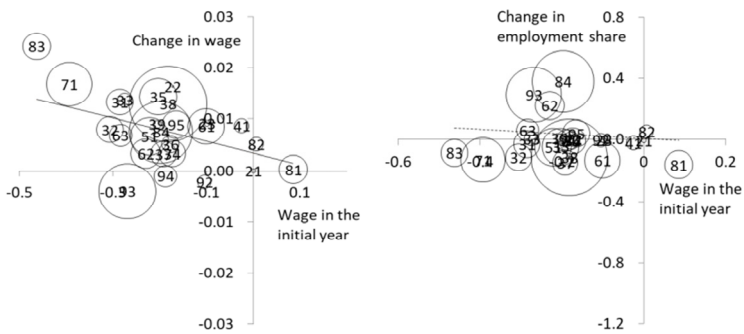
(Panel A) 1980-1992



(Panel B) 1995-2007



(Panel C) 2009-2016



contributing to reduced wage gap.[18] In the second period, this tendency was maintained although to a less extent. In the third period, both the employment growth and the wage growth were faster for lower-wage workers, presumably indicating increased demand for these workers and creating a favorable condition for wage distribution.

18 It is indeed surprising that such migration does not occur instantaneously to eliminate wage differentials between industries in a competitive market environment. A large volume of studies have confirmed the persistence of these differentials and found it difficult to explain their existence (Groshen, 1991; Katz and Summers, 1989; Krueger and Summers, 1988).

CHAPTER 5

Discussions

1. Main Findings

Main findings of the previous chapters can be summarized as follows:

- Worker characteristics have changed significantly between 1980 and 2016. Most notable are the rapid aging of labor force, improvement in educational attainment, lengthening of firm tenure, and shrinking size of establishments.

- The relative contribution of these worker characteristics to wage inequality has changed as well. In the early years, sex, age, and education were the three most important factors (apart from occupation). But in later years, firm tenure has become the most important one, followed by education and establishment size.

- The influence of worker characteristics can be decomposed into the price and distribution effects. In the cases of sex and age, both price and distribution played important roles in reducing inequality especially in the early periods. In the case of education, price has been the main driver in all periods, reducing inequality in the first period, increasing it in the second, and again reducing it in the third. In the cases of tenure and establishment size, distribution has contributed significantly to increasing inequality.

- Union membership and employment type have had insignificant influence on wage inequality.

- Price is determined through the interaction between supply and demand. As for sex, the relative demand for male workers (over female workers) declined in all periods, lowering their relative wage. As for age, the relative demand for older workers (over younger workers) increased, but it was outpaced by the increase in supply, and as a result their relative wage fell. As for education, the relative demand for college graduates (over high school graduates) increased faster than the supply in the second period but not in the first and third periods, and their relative wage rose in the second period but not in the other periods.

- The endogenous technical change hypothesis would attribute the changes in relative demand described above to the changes in supply: The increasing supplies of female workers and older workers in all periods, and the increasing supply of college graduates in the second period, increased the demands for these workers. This hypothesis can also explain the increase in the relative demand for *unskilled* labor—female workers, elderly workers (in the third period), and high school graduates (in the first period)—while SBTC cannot.

- The rapidly rising skill levels of female workers and young workers appear to have added to the demand for them. On top of the endogenous technical change, this may explain the fast decline of the relative demand for male workers and the slow growth of the relative demand for older workers (relative to the supply).

- In addition to the price, the distribution of worker characteristics across wage quintiles has had important impact on wage inequality. In the case of sex, light manufacturing (most notably textiles, apparel, and leather products) had provided low-pay blue-collar jobs for the mass of female workers, but the decline of this industry and the expansion of service industry and white-collar jobs since the 1980s provided female workers with the opportunity to move up the wage

ladder and helped reduce the wage gap between sexes.

- The average tenure has grown continuously, and so has the wage gap between long and short tenure. This has increased the importance of tenure as a determinant of wage inequality. In the meantime, the group of workers with short tenure came to include not only younger workers but also older ones who have entered the labor market at later ages or who have had to hop around unstable jobs during their career. This has made age less important as a predictor of wage gap.

- Over the decades, large establishments have increasingly relegated blue-collar jobs and low value-added activities to smaller establishments and focused instead on white-collar jobs and high value-added activities. Now a smaller share of workers are enjoying the higher pay associated with large establishments, and establishment size has become more important.

- A look at the changes in employment and wage across occupations indicates that supply factors were at work in the first period to reduce the gap between low-paying and high-paying occupations. In contrast, it is difficult to find a clear pattern in the second and third periods, while demand factors appear to have been slightly stronger in the second period. In addition, elementary occupation could sustain its growth in employment and wage, a fact compatible with the bipolarization hypothesis of skill demand. Much the same story can be told of the changes in employment and wage across industries.

2. Policy Implications

What are the policy implications of these findings? Following are some of the actions that can be taken by government to improve wage distribution.

- In further reducing the wage gap between sexes, one important issue concerns guiding female students to choose the major fields of study

| Table 5-1 | Employment Rate and Number of Graduates by Major (2016)

Major field of study	Employment rate		College graduates			
			Male		Female	
	(Ranking)	(%)	(,000)	(%)	(,000)	(%)
Medicine and pharmacology	1	83.4	16	5.6	41	13.9
Engineering	2	71.6	118	41.5	27	9.0
Education	3	66.8	8	2.7	25	8.5
Social sciences	4	64.7	71	24.9	86	29.2
Natural sciences	5	64.0	29	10.3	34	11.3
Arts and sports	6	63.6	25	8.8	47	15.8
Liberal arts and humanities	7	57.6	18	6.3	36	12.2
Total	-	67.7	285	100.0	295	100.0

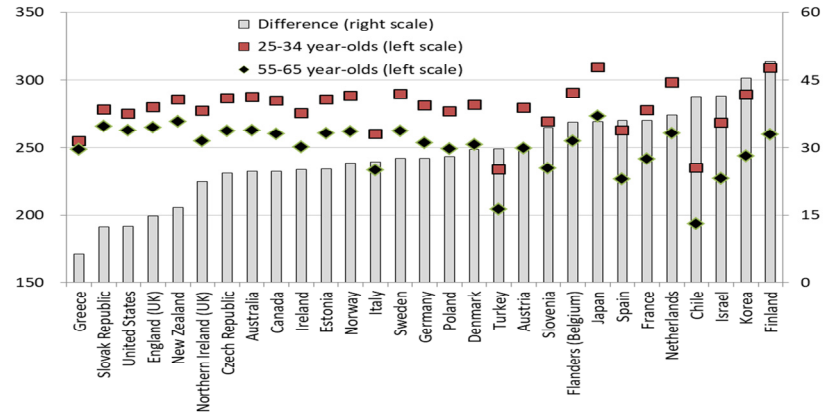
Source: Korean Statistical Information Service (http://kosis.kr).

in college with better job prospects. In 2016, over 41 percent of male graduates have majored in engineering, which recorded an employment rate after graduation of 72 percent, but only 9 percent of female graduates have (Table 5-1). A larger part of the latter group has chosen instead those fields with low employment rate, such as liberal arts and humanities (58 percent) and arts and sports (64 percent).[19] Policy intervention would focus on supplying better information to students and facilitating the internal reorganization of colleges. On the other hand, it seems less urgent to further encourage female participation in college education because female college graduates are already larger than their male counterparts in number (295 thousand vs. 285 thousand in 2016).

- Many older workers have weak labor market attachment and are trapped in low-paying jobs. They are perhaps the most disadvantage group because of their very low employability: When skill is measured with literacy proficiency as compiled by OECD (2016), Korea has one of the largest skill gap among OECD countries

19 This tendency has been observed in other countries as well (Turner and Bowen, 1999). I am not saying that liberal arts and humanities or arts and sports are useless. They are important parts of our lives and have very high educational value (see Zakaria (2015) for a forceful argument in defense of liberal education). Perhaps a larger number of students need to receive more solid education in these fields. But getting a solid education is not the same as majoring in these fields in college.

Figure 5-1 Mean Literacy Proficiency by Age Group



Source: OECD (2016).

between the 25-34 year-olds and the 55-65 year-olds (Figure 5-1). Training is in general known to work rather poorly for older workers because of their low learning capacity and low willingness to participate given their short remaining working life. A combination of various measures are being called for, including; allowing greater freedom in employment contracts[20]; preventing the minimum wage from pricing older workers out of the labor market; providing in-work benefits such as earned income tax credits; and strengthening targeted training and job placement programs.

- There have been repeated calls to expanding higher education in order to meet the challenges posed by rapid technological progress and to win the "race between education and technology (Goldin and Katz, 2007)." While admitting the importance of higher education in accelerating productivity growth and fostering economic prosperity, we should also note that according to the endogenous technical change hypothesis, expanding higher education can increase the

20 For example, workers aged 55 years or more are exempted from the restrictions on fixed-term employment and the employment through temporary work agencies. The age floor could be lowered to allow more workers to benefit from these exemptions.

demand for college graduates, and in the extreme case, widen the wage gap further. In addition, there is suspicion that higher education is currently being over-supplied rather than under-supplied in Korea.[21] About 70 percent of high school graduates enter college (Table 5-2), and the enrollment rate in tertiary education is very high (Figure 5-2). But many college graduates fail to find jobs, and become inactive. The so-called NEET (neither in employment nor in education or training) take up a quarter of college graduates (Figure 5-3). It seems better to stress the efforts to improve the quality of education rather than expanding its quantity, for example by realigning the contents of all levels of education to the changing economic and social needs.

Table 5-2 Advancement Rate from High School to College

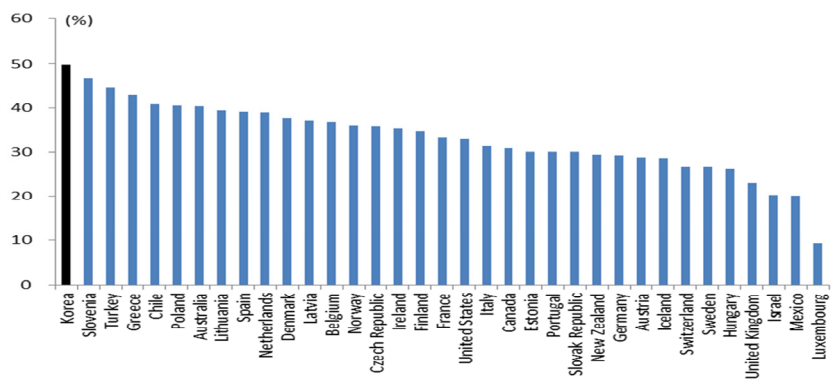
(Unit: %)

Year	2000	2005	2010	2015	2017
Advancement rate	62.0	73.4	75.4	70.8	68.9

Note: Advancement rate is the share of those who enter college upon graduation from high school.

Source: Ministry of Education and Korean Education Development Institute, *Brief Statistics on Korean Education*, 2017.

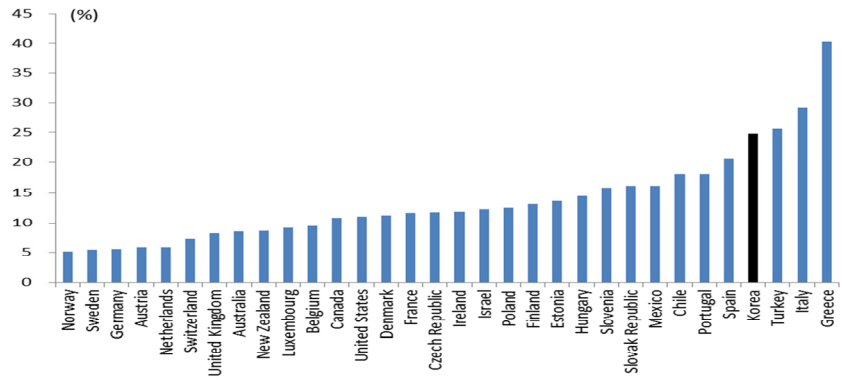
Figure 5-2 Enrollment Rate of the 20-24 Year-olds in Tertiary Education (2015)



Source: OECD (http://stats.oecd.org).

21 Caplan (2018) makes a similar argument for the United States.

Figure 5-3 Share of NEET among College Graduates Aged 15-29 Years (2014)

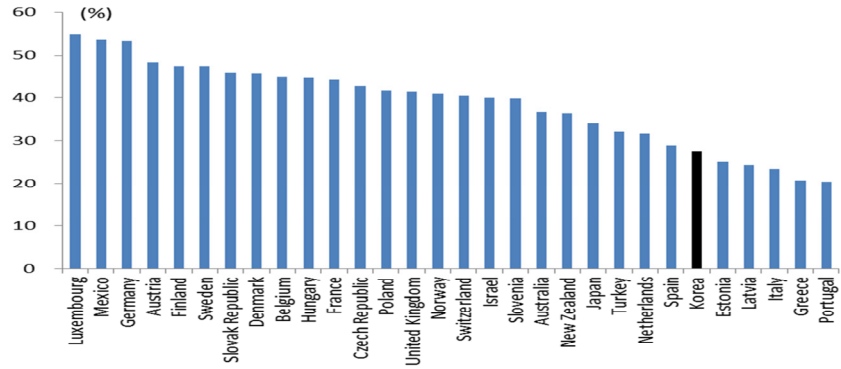


Source: OECD (http://stats.oecd.org).

- Tenure has played an increasingly important role in increasing wage inequality. One way to counter this trend is to encourage employers and employees to move away from the seniority-based pay scheme, which is dominant in Korea, toward the performance-based pay scheme, thereby reducing the "price" of tenure. The prime difficulty, of course, lies in deriving consensus among the stakeholders, especially among incumbent workers. Another way is to help disadvantaged workers accumulate tenure in one workplace rather than changing workplaces frequently, thereby reducing the gap in the "quantity" of tenure between workers. The fundamental causes of disadvantaged workers' frequent movements can be found in their low employability on the one hand, and financial instability of many firms that employ them—small- and medium-sized enterprises (SMEs) in particular—on the other. It will take time to improve the situation on both accounts. Any short-term solutions, such as strengthening the restrictions on fixed-term contract as advocated by labor unions, could be counterproductive.

- Large establishments have been continuously shedding employment while moving toward more capital- and knowledge-intensive activities and relying increasingly on outsourcing, often from overseas. This is

Figure 5-4 Employment Share of Firms with 250 or More Workers (Manufacturing, 2013)



Source: OECD (http://stats.oecd.org).

a global trend, and difficult to reverse. Still, there is indication that the average firm size is too small in Korea. According to Figure 5-4, the employment share of firms with 250 or more workers is less than 30 percent in Korea, while it is over 50 percent in Germany. The Korean government has attempted various policy interventions to help SMEs to grow into large firms, but has not been particularly successful. It would be useful to reexamine the effectiveness of these interventions and check if they are in reality weakening the incentive to grow large rather than boosting it.

- Lastly, it needs to be remembered that workers' mobility across occupations and industries (and in fact, also across firms, geographic areas, and so forth) can have an important impact on wage inequality. In addition to the active measures such as training and job placement services, efforts should be made to promote flexibility in the labor market, and balance it with the need to protect job security. When both the economy and the labor force were growing fast in the 1980s and early 1990s, mobility could be secured without much difficulty. But nowadays the growths are stalling (Table 5-3). The reallocation of workers would need more conscious efforts by all parties concerned, including workers, unions, firms, and government.

Table 5-3 Output, Population, and Employment Growth in Korea

(Unit: %)

	1960-1970	1970-1980	1980-1990	1990-2000	2000-2010	2010-2016
GDP growth	9.5	9.2	9.9	6.9	4.4	3.0
Population (15-64) growth	2.5	3.1	2.3	1.3	0.7	0.6
Employment growth	3.5[1)]	3.6	2.8	1.6	1.3	1.6
Unemployment rate	6.6[2)]	4.0[3)]	3.8[4)]	3.3[5)]	3.6[6)]	3.5

Note: 1) 1963-1970, 2) 1963-1969, 3) 1970-1979, 4) 1980-1989, 5) 1990-1999 6) 2000-2009. There was a change in the definition of unemployment in 1999.

Source: Bank of Korea (http://ecos.bok.or.kr); Korea Statistical Information Service (http://kosis.kr).

3. The Future

How would wage inequality evolve in the coming years? Would it continue falling or would it rebound and rise again? Looking back at Table 2-5 in Chapter 2, we find that almost all variables have contributed to falling inequality since 2009. Among them, education was the most important: It explains a half of the fall (-0.008) induced by all variables combined. Two predictions are possible: Given the slightly declining advancement rate from high school to college (Table 5-2), the prediction based on SBTC would bet on rising inequality while that based on the endogenous technical change would bet on falling inequality.

Apart from education, sex will probably continue to help inequality fall as the average skill gap between sexes keep falling. Age is now playing a limited role for the reason explained above, but when the current generation of prime age workers, who are better skilled than the current generation of older workers, grow older, age may begin to play a more significant role in raising inequality. Tenure has seen its price declining in recent years, possibly reflecting the decreasing value of firm-specific skill or the movement away from seniority-based pay scheme. In any case, the slowdown in average tenure growth will combine with the declining price to restrict the role of tenure in increasing inequality. Lastly, establishment size will probably continue

to widen the wage gap unless SMEs improve their productivity and profitability against large firms.

All in all, there are reasons to be both optimistic and pessimistic on the future development of wage inequality.[22] In the meantime, the role of education and technology will continue to dominate debates. But attention should be paid also to other determinants of inequality, including sex, age, tenure, establishment size, and other product and labor market factors.

22 See Scheidel (2017) for an extremely pessimistic view on the future of income distribution.

CHAPTER 6

Conclusion

Many factors have had varying influences on wage inequality in Korea. Greater female participation in the labor market, population aging, expansion of higher education, lengthening firm tenure, shrinking size of establishments, and changes in industrial structure and occupational composition have increased or decreased inequality in one way or another.

First, the movement of female workers from low-paying craft jobs to better-paying white-collar jobs, together with the increasing demand for female workers (possibly coming from the endogenous technical change and the rising skill levels of female workers), has contributed to the falling wage gap between sexes. Second, the demand for older workers has increased (again, possibly due to the endogenous technical change), but their supply has outpaced the demand. At the same time, the number of older workers with weak employability and low labor market attachment has increased. All these have helped reduce the wage gap between older and younger workers. Third, the premium on college education grew rapidly in the second period but not in the first and the third. This coincides with the overall movement of wage inequality across three periods. Education is still a very important determinant of wage inequality. Fourth, the wage gap due to tenure has widened over the decades. It is not because the price of tenure has risen but because the dispersion of tenure among workers has increased; the top earners now have a longer tenure than before, and enjoy a far higher wage than those at the bottom. Fifth, the share of workers in large establishments

has declined. The top earners and the bottom earners are being increasingly differentiated by the size of establishments they work in. Thus establishment size has become an important predictor of wages. Sixth, the high mobility of workers across occupations and industries in the first period contributed to falling wage inequality. Since then, however, the mobility appears to have declined.

These findings lead us to important policy implications. First, to reduce the wage gap between sexes further, women should be encouraged to continue to upgrade their skill levels, for example by choosing majors in college with better job prospects. Second, efforts are needed to strengthen the labor market attachment of older workers, possibly by relaxing the regulations on their employment and preventing the minimum wage from pricing them out of the labor market. Third, regarding the education premium, priority should be given to improving the quality of education, especially at the upper-secondary level, which played an important role in equalizing wages in the first period. The well-recognized problem of Korea's public education system[23] is worrisome in this respect. Fourth, to weaken the role of tenure in exacerbating wage inequality, it is necessary to improve the employability of disadvantaged workers as well as the financial viability of firms. Fifth, the government should reexamine its supports to SMEs, remove any disincentives to their growing larger, and expose them to greater market competition. Sixth, flexibility should be increased in the labor market to accommodate rapid structural changes in the economy.

23 Private tutoring is wide-spread in Korea. Some claim that private tutoring has replaced public education in all but name and increases the influence of family background on students' educational achievement.

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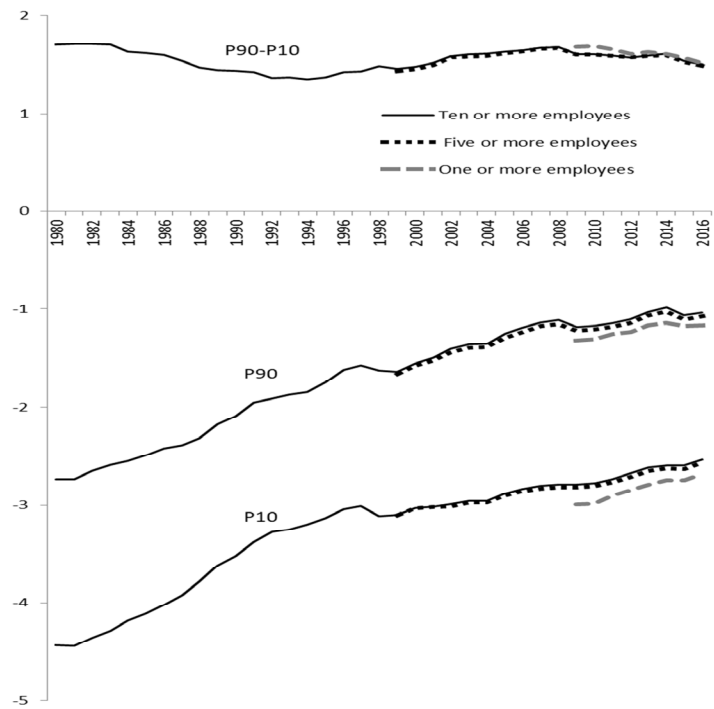
Appendix 1 Wage Gaps when All Observations are Used

The figure below shows the wage gaps (p90-p10) and percentiles (p90, p10) when all available observations are included in the calculation and compares them to the case when establishments with less than ten employees or with less than five employees are dropped from the sample. The trends are quite similar to each other, implying that information loss from sample restrictions is not large.

Figure A1 Wage Gaps for Different Sets of Observations



Appendix 2 | New Classifications of Occupations and Industries

A. Occupations

New Classification		Revision 3 (1980-1992)	Revision 4 (1993-1999)	Revision 5 (2000-2008)	Revision 6 (2009-2016)
1	Professionals, Technicians, and associate professionals	Natural scientists and related technicians (1), Construction, engineering, and related technician (2-3), High-ranking crew of airplanes and ships (4), Life scientists and related technicians (5), Medical doctors, dentists, veterinarians, and related workers (6-7), Statisticians, mathematicians, systems specialists, and related technicians (8), Economists (9), Accountants (11), Legal professionals (12), Teachers (13), Religious professionals (14), Writers, journalists, and related writers (15), Sculptors, painters, photographers, and related creative artists (16), Composers and performing artists (17), Athletes and sportspersons (18), Professionals, technicians, and associate professionals n. e. c. (19), Clerical supervisors (30)	Physicists, mathematicians, and engineers (21), Life scientists and health professionals (22), Teaching professionals (23), Other professionals (24), Natural science and engineering technicians (31), Life science and health associate professionals (32), Teaching associate professionals (33), Other associate professionals (34)	Science professionals (11), Computer professionals and related occupations (12), Engineering professionals (13), Health and medical professionals (14), Teaching professionals (15), Administrative, managerial, and finance professionals (16), Legal, social service, and religious professionals (17), Cultural, arts, and broadcasting professionals and related occupations (18), Science technicians and related occupations (21), Computer associate professionals and related occupations (22), Engineering associate professionals and related occupations (23), Health and medical associate professionals (24), Teaching associate professionals (25), Managerial and finance associate professionals (26), Social service and religious associate professionals (27), Arts, performing arts, and sports associate professionals (28), Other associate professionals (29)	Science professionals and related occupations (21), Information and communication professionals and technicians (22), Engineering professionals and technicians (23), Health, social service, religion, and related occupations (24), Teaching professionals and related occupations (25), Legal and administrative professionals (26), Managerial and finance professionals and related occupations (27), Culture, arts, and sports professionals and related occupations (28), Water supply, sewerage, recovery, and treatment machine operators (88)
2	Managers	Legislators and senior officials (20), Managers (21), Transport and communication sector supervisors (35), Wholesale and retail managers (40), Accommodation and food service managers (50), Farm managers and supervisors (60), Agricultural managers (61), Production managers (70)	Legislators and senior officials (11), Corporate managers (12), General managers (13)	Legislators and senior officials (1), Administrative and business managers (2), General managers (3)	Senior managers in public and private entities (11), Administrative and business support managers (12), Professional service managers (13), Construction, electrical, and production related managers (14), Sales and customer service managers (15)
3	Clerical Support workers	Government officials (31), Stenographers, typists, and perforating typists (32), Bookkeepers, tellers, and related clerks (33), Calculating-machine operators (34), Mail handling clerks (37), Telephone and telegraph operators (38), Clerical and related workers n. e. c. (39)	General office clerks (41), Customer service clerks (42)	General office clerks (31), Customer service clerks (32)	Business, accounting, and related clerks (31), Finance and insurance clerk (32), Legal and auditing clerks (33), Consultation, guide, statistical, and other clerks (39)

A. Occupations *(Continued)*

New Classification		Revision 3 (1980-1992)	Revision 4 (1993-1999)	Revision 5 (2000-2008)	Revision 6 (2009-2016)
4	Services workers	Transport conductor (36), Self-employed in accommodation and food services activities (51), Household and related service supervisors (52), Cooks, waiters, bartenders, and related workers (53), Domestic housekeepers and related workers n. e. c. (54), Building caretakers, cleaners, and related workers (55), Barbers, hairdressers, and related worker (57), Protective services workers (58), Services workers n. e. c. (59)	Personal and protective services workers (51)	Personal service workers (41), Cooks and food service workers (42), Travel attendants and transport conductors (43), Protective services workers (44)	Police, firefighters, and protective service workers (41), Barbers and hairdressers, and wedding and medical support service workers (42), Transport and recreation service workers (43), Cooks and food service workers (44)
5	Sales workers	Self-employed in wholesale and retail trade (41), Sales supervisors and buyers (42), Technical salespersons, commercial travelers, and producers' sales agents (43), Insurance, real estate, securities, and corporate service salespersons and auctioneers (44), Salespersons, shop salespersons, and related workers (45), Sales workers n. e. c. (49)	Models, salespersons, and demonstrators (52)	Wholesale and retail trade workers (51), Telephone salespersons (52), Models, salespersons, and demonstrators (53)	Sales agents (51), Shop salespersons (52), Door-to-door, street, and telephone sales and related occupations (53)
6	Skilled agricultural, forestry, and Fishery workers	Crop and animal producers (62), Forestry workers (63), Fishers, hunters, and related workers (64), Livestock processing workers (76)	Market-oriented skilled agricultural and fishery workers (61), Subsistence agricultural and fishery workers (62))	Skilled agricultural workers (61), Skilled forestry workers (62), Skilled fishery workers (63)	Skilled crop and animal producers (61), Skilled forestry workers (62), Skilled fishery workers (63)
7	Craft and Related trades workers	Food and beverage processing and treatment workers (77), Tobacco makers (78), Dressmakers, sewers, upholsterers, and related workers (79), Shoemakers and leather products workers (80), Cabinet-makers and related workers (81), Stone cutters and handlers (82), Blacksmiths, toolmakers, and mechanical tool operators (83), Mechanical equipment workers, machine assemblers, and precision instrument makers except electricians (84), Electric equipment workers and related electric and electronic workers (85), Molders, welders, sheet-metal workers, structural metal preparers, and erectors (87), Jewelry and precious metal workers (88), Glass makers, potters, and related workers (89), Printing trades workers (92), Painters (93), Craft and related trades workers n. c. e. (94), Bricklayers, carpenters and other building workers (95)	Extraction and building craft workers (71), Craft workers in metal, machinery, and related trades (72), Craft workers in precision instrument, handicraft, printing, and related trades (73), Other craft and related trades workers (74)	Extraction and building craft workers (71), Craft workers in metal, machinery, and related trades (72), Machinery mechanics and repairers (73), Craft workers in precision instrument, handicraft, printing, and related trades (74), Other craft and related trades workers (75)	Food processing craft workers (71), Textile, apparel, and leather craft workers (72), Wood, furniture, musical instrument, and signboard craft workers (73), Metal forming craft workers (74), Transport and machinery craft workers (75), Electric and electronic craft workers (76), Construction, mining, and related trade workers (77), Visual and communication equipment craft workers (78), Other craft and related trades workers (79)
8	Plant and machine operators and assemblers	Miners, quarry workers, well-drillers, and related workers (71), Metal processing and treatment workers (72), Wood processing workers and paper makers (73), Chemical processing and related workers (74), Spinning, knitting, weaving, dyeing, and related workers (75), Broadcasting and audio equipment operators and film projector operators (86), Rubber and plastics products makers (90), Paper and cardboard products makers (91), Stationary plant and machine operators (96), Transport equipment operators (98)	Stationary plant and machine operators (81), Machine operators and assemblers (82), Drivers and mobile plant operators (83)	Stationary plant and machine operators (81), Machine operators and related workers (82), Assemblers (83), Drivers and related workers (84)	Food processing and related products machine operators (81), Textile, shoemaking, and related machine operator (82), Chemical and related products machine operators (83), Metal and non-metal and related products machine operators (84), Machine manufacturing and related machine operators (85), Electric and electronic products machine operators (86), Drivers and transport workers (87), Wood products, printing, and other machine operators (89)
9	Elementary occupations	Laundry workers (56), Freight handling and related equipment operators, longshoremen and freight handlers (97), Elementary workers n. e. c. (99)	Street and related services workers (91), Agricultural, forestry, and fishery laborers (92), Mining, construction, manufacturing, and transport laborers (93)	Elementary services workers (91), Agricultural, forestry, and fishery laborers (92), Manufacturing laborers (93), Mining, construction, and transport laborers (94)	Construction and mining laborers (91), Transport laborers (92), Manufacturing laborers (93), Cleaning and protective services laborers (94), Domestic, food-serving, and sales laborers (95), Agricultural, forestry, fishery, and other services laborers (99)

B. Industries

New classification		Revision 4 (1980-1983)	Revision 5 (1984-1992)	Revision 6 (1993-2001)	Revision 8 (2002-2008)	Revision 9 (2009-2016)
11	Agriculture and hunting	Agriculture and hunting (11)	Agriculture and hunting (11)	Agriculture, hunting, and related services (1)	Agriculture (1)	Agriculture (1)
12	Forestry	Forestry (12)	Forestry (12)	Forestry, logging, and related services (2)	Forestry (2)	Forestry (2)
13	Fishing	Fishing (13)	Fishing (13)	Fishing, fish farming, and related services (5)	Fishing (5)	Fishing (3)
21	Mining of coal, petroleum, and uranium	Mining of coal, petroleum, and natural gas (22)	Mining of coal, petroleum, and natural gas (22)	Mining of coal (10), Mining of petroleum and natural gas and related services (11), Mining of uranium and thorium (12)	Mining of coal, petroleum, and uranium (10)	Mining of coal, petroleum, and natural gas (5)
22	Mining of metal ores	Mining of metal ores (23)	Mining of metal ores (23)	Mining of metal ores (13)	Mining of metal ores (11)	Mining of metal ores (6)
23	Other mining and quarrying	Other mining (29)	Other mining (29)	Other mining and quarrying (14)	Mining of non-metallic minerals for non-fuel use (12)	Mining of non-metallic minerals for non-fuel use (7)
31	Food products, beverages, and tobacco products	Food products, beverages, and tobacco products (31)	Food products, beverages, and tobacco products (31)	Food products and beverages (15), Tobacco products (16)	Food products and beverages (15), Tobacco products (16)	Food products (10), Beverages (11), Tobacco products (12)
32	Textiles, apparel, and leather products	Textiles, apparel, and leather products (32)	Textiles, apparel, and leather products (32)	Textile products (17), Apparel and fur products (18), Leather products, bag, furniture, and footwear (19)	Textile products not by needlework (17), Needlework and fur products (18), Leather products, bags, and footwear (19)	Textile products except apparel (13), Apparel, associated accessories, and fur products (14), Leather products, bags, and footwear (15)
33	Wood and wood products including furniture	Wood and wood products including furniture (33)	Wood and wood products including furniture (33)	Wood and wood products except furniture (20)	Wood and wood products except furniture (20)	Wood and wood products except furniture (16), Furniture (32)
34	Paper, paper products, and printing	Paper, paper products, publishing, and printing (34)	Paper, paper products, publishing, and printing (34)	Pulp, paper, and paper products (21), Publishing , printing, and reproduction of recorded media (22)	Pulp, paper, and paper products (21), Publishing , printing, and reproduction of recorded media (22)	Pulp, paper, and paper products (17), Printing and reproduction of recorded media (18), Publishing (58)
35	Chemicals, rubber, plastics, and fuel products	Chemical, petroleum, coal, rubber, and plastic products (35)	Chemical, petroleum, coal, rubber, and plastic products (35)	Cokes, refined petroleum, and nuclear fuel products (23), Chemical products (24), Rubber and plastic products (25)	Cokes, refined petroleum, and nuclear fuel products (23), Chemical products (24), Rubber and plastic products (25)	Cokes, briquette, and refined petroleum products (19), Chemical products except pharmaceuticals (20), Medical products and pharmaceuticals (21), Rubber and plastic products (22)
36	Other non-metallic mineral products	Other non-metallic mineral products except petroleum and coal products (36)	Other non-metallic mineral products except petroleum and coal products (36)	Other non-metallic mineral products (26)	Other non-metallic mineral products (26)	Other non-metallic mineral products except petroleum and coal products (23)
37	Basic metals	Basic metals (37)	Basic metals (37)	Basic metals (27)	Basic metals (27)	Basic metals (24)
38	Fabricated metal products, machinery, and equipment	Fabricated metal products, machinery, and equipment (38)	Fabricated metal products, machinery, and equipment (38)	Fabricated metal products except machinery and furniture (28), Machinery and equipment n. e. c. (29), Equipment for clerical, calculation, and accounting work (30), Electric machinery and converter n. e. c. (31), Visual, audio, and communication equipment (32), Medical, precision, and optical equipment and watches (33), Motor vehicles and trailers (34), Other transport equipment (35)	Fabricated metal products except machinery and furniture (28), Machinery and equipment n. e. c. (29), Computers and equipment for clerical work (30), Electric machinery and converter n. e. c. (31), Electronic parts and visual, audio, and communication equipment (32), Medical, precision, and optical equipment and watches (33), Motor vehicles and trailers (34), Other transport equipment (35)	Fabricated metal products except machinery and furniture (25), Electronic parts, computers, and visual, audio, and communication equipment (26), Medical, precision, and optical equipment and watches (27), Electric equipment (28), Machinery and equipment n. e. c. (29), Motor vehicles and trailers (30), Other transport equipment (31)
39	Manufacturing, n. e. c.	Manufacturing, n. e. c. (39)	Manufacturing, n. e. c. (39)	Furniture and manufacturing, n. e. c. (36), Processing and treatment of recovered material (37)	Furniture and manufacturing, n. e. c. (36), Processing and treatment of recovered material (37)	Manufacturing, n. e. c. (39)
41	Electricity, gas, and steam supply	Electricity, gas, and steam supply (41)	Electricity, gas, and steam supply (41)	Electricity, gas, and steam supply (40)	Electricity, gas, and steam supply (40)	Electricity, gas, steam, and air supply (35)
42	Water supply	Water supply (42)	Water supply (42)	Water supply (41)	Water supply (41)	Water supply (36)
51	Construction	General construction (51), Specialized construction (52)	General construction (51), Specialized construction (52)	Construction (45)	General construction (45), Specialized construction (46)	General construction (41), Specialized construction (42)

B. Industries *(Continued)*

New classification		Revision 4 (1980-1983)	Revision 5 (1984-1992)	Revision 6 (1993-2001)	Revision 8 (2002-2008)	Revision 9 (2009-2016)
61	Wholesale trade	Wholesale trade (61)	Wholesale trade (61)	Wholesale trade and commodity brokerage (51)	Wholesale trade and commodity brokerage (51)	Wholesale trade and commodity brokerage (46)
62	Retail trade	Retail trade (62)	Retail trade (62)	Sales and repair of motor vehicles and retail trade of motor vehicle fuel (50), Retail trade and repair of consumer goods except of motor vehicles (52)	Sales of motor vehicles and retail trade of motor vehicle fuel (50), Retail trade except of motor vehicles (52)	Sales of motor vehicles and their parts (45), Retail trade except of motor vehicles (47)
63	Accommodation and food service activities	Accommodation and food service activities (63)	Accommodation and food service activities (63)	Accommodation and food service activities (55)	Accommodation and food service activities (55)	Accommodation (55), Food and alcoholic beverage service activities (56)
71	Transportation and storage	Transportation and storage (71)	Transportation and storage (71)	Land transport and transport via pipelines (60), Water transport (61), Air transport (62), Travel agency and transport-related services (63)	Land transport and transport via pipelines (60), Water transport (61), Air transport (62), Travel agency, warehousing, and transport-related services (63)	Land transport and transport via pipelines (49), Water transport (50), Air transport (51), Warehousing and transport-related services (52)
72	Communication	Communication (72)	Communication (72)	Communication (64)	Communication (64)	Communication (61)
81	Financial service	Financial service (81)	Financial service (81)	Financial service (65)	Financial service (65)	Financial service (64)
82	Insurance	Insurance (82)	Insurance (82)	Insurance and pension funding (66)	Insurance and pension funding (66)	Insurance and pension funding (65)
83	Real estate activities	Real estate activities (83)	Real estate activities (83)	Real estate activities (70)	Real estate activities (70)	Real estate activities (68)
84	Business services	Outsourced support activities (84)	Business services (84)	Rental activities of machinery, equipment, and consumption goods (71), Information processing and other computer operation-related activities (72), Research and development (73), Other business-related services (74)	Rental activities of machinery, Equipment, and consumption goods (71), Information processing and other computer operation-related activities (72), Research and development (73), Professional, scientific, and technical activities (74), Business support services (75)	Computer programming and system integration and management (62), Information services (63), Rental activities except of real estates (69), Research and development (70), Professional activities (71), Construction-related engineering, scientific, and technical activities (72), Other professional, scientific, and technical activities (73), Business property management and landscaping (74), Business support services (75)
91	Public administration and defense	Public administration and defense (91)	Public administration and defense (91)	Public administration, defense, and social security (75)	Public administration, defense, and social security (76)	Public administration, defense, and social security (84)
92	Hygiene and related services	Hygiene and related services (92)	Hygiene and related services (92)	Hygiene and related services (90)	Sewerage, waste treatment, and cleaning (90)	Sewerage, waste water, and excrement treatment (37), Waste collection, transportation, and treatment and materials recovery (38), Environmental cleaning and recovery (39)
93	Social services	Social services (93)	Social services (93)	Education (80), Human health and social work (85),	Education (80), Human health (85), Social work (86)	Education (85), Social work (87), Human health (86)
94	Entertainment, culture, and arts	Entertainment, culture, and arts (94)	Entertainment, culture, and arts (94)	Entertainment, culture, and sports (92)	Film, broadcasting, and performance (87), Other entertainment, cultural, and sports activities (88)	Production and distribution of visual and audio records (59), Broadcasting (60), Creative arts and recreation services (90), Sports and entertainment services (91)
95	Personal and household services	Personal and household services (95)	Personal and household services (95)	Financial and insurance-related services (67), Membership organizations (91), Other services (93), Household services (95)	Financial and insurance-related services (67), Membership organizations (91), Repair activities (92), Other services (93), Household services (95)	Support services for mining (8), Financial and insurance-related services (66), Associations and organizations (94), Repair activities (95), Other personal services (96), Activities of households as employers (97), Undifferentiated activities of households for own use (98)
96	Extraterritorial organizations and bodies	Extraterritorial organizations and bodies (96)	Extraterritorial organizations and bodies (96)	Extraterritorial organizations and bodies (99)	Extraterritorial organizations and bodies (99)	Extraterritorial organizations and bodies (99)

Source: Original classifications are from Ministry of Employment and Labor, *Wage Structure Survey*, various years. New classifications are author's own.

Appendix 3 | Comparison to Other Approaches

There exist two studies—JMP and Fields (2003)— that have suggested alternative approaches to decomposing the wage inequality into worker characteristics.

First, the approach by JMP can be summarized in the following way. Let $\varepsilon_{it} = F_t{}^{-1}(\theta_{it}|X_{it})$ where θ_{it} is the individual's position or percentile in the cumulative distribution of residuals, $F_t(\cdot\,|X_{it})$. Then construct two hypothetical values,

$$y_{it}^1 = X_{it}\hat{\beta}_o + F_o^{-1}(\theta_{it}|X_{it}) \text{ and } y_{it}^2 = X_{it}\hat{\beta}_t + F_o^{-1}(\theta_{it}|X_{it}) \quad \text{(A1)}$$

where the subscript "o" refers to the first year in the sample. Then

$$y_{it}^1 - y_{io} = (X_{it} - X_{io})\hat{\beta}_o + [F_o^{-1}(\theta_{it}|X_{it}) - F_o^{-1}(\theta_{io}|X_{io})], \quad \text{(A2)}$$
$$y_{it}^2 - y_{it}^1 = X_{it}(\hat{\beta}_t - \hat{\beta}_o), \text{ and} \quad \text{(A3)}$$
$$y_{it} - y_{it}^2 = F_t^{-1}(\theta_{it}|X_{it}) - F_o^{-1}(\theta_{it}|X_{it}). \quad \text{(A4)}$$

Eq. (A2) indicates that y_{it}^1 is obtained from y_{io} by changing worker characteristics from X_{io} to X_{it} while keeping the price $\hat{\beta}_o$ and the residual distribution F_{o} unchanged. Similarly, y_{it}^2 is obtained from y_{it}^1 by changing the price from $\hat{\beta}_o$ to $\hat{\beta}_t$ (eq. (A3)), and y_{it} from y_{it}^2 by changing the residual distribution from F_o to F_t (eq. (A4)). Accordingly, the effect of changing worker characteristics on wage inequality can be measured by comparing, say, the Q5-Q1 gaps of y_{it}^1 and y_{io}. Similarly, the effect of changing prices can be measured by comparing the Q5-Q1 gaps of y_{it}^2 and y_{it}^1, and that of changing residual distribution by comparing the Q5-Q1 gaps of y_{it} and y_{it}^2.

Seen this way, JMP is interested in the *change* in wage inequality and in the contributions of changing worker characteristics, changing

prices, and changing residual distributions. Their approach cannot give a decomposition of the *level* of wage inequality as I do. Incidentally, my approach also allows an analysis of the *change* as explained in the text.

My approach has a couple of advantages over JMP's. First, it allows a separate measurement of each characteristic's (say, education's) contribution to wage inequality while JMP's can measure only the aggregate contribution of all characteristics. Second, the order of decomposition does not matter in my case while JMP's can give different results depending on whether one starts with worker characteristics or prices.

An approach closer to mine is by Fields (2003), who employs the variance measure for wage inequality. Again suppressing time subscripts and letting $X = \{1, x_1, \dots, x_K\}$ and $\beta = \{\beta_o, \beta_1, \dots, \beta_K\}'$, we have

$$y = X\beta + \varepsilon = \beta_o + \beta_1 x_1 + \cdots + \beta_K x_K + \varepsilon. \quad \text{(A5)}$$

Then multiplying each side by y and taking mathematical expectations yields

$$Var(y) = \beta_1 Cov(x_1, y) + \cdots + \beta_K Cov(x_K, y) + Var(\varepsilon). \quad \text{(A6)}$$

Eq. (A6) provides a neat decomposition of $Var(y)$ into worker characteristics. The intuitions behind eqs. (4) and (A6) are more or less the same. Suppose $\beta_1 > 0$. If $Cov(x_1, y) > 0$, then x_1 will contribute positively to $Var(y)$ according to eq. (A6). At the same time, $Cov(x_1, y) > 0$ means $x_{1,\overline{Q5}} > x_{1,\overline{Q1}}$ with high probability, in which case x_1 contributes positively to $y_{\overline{Q5}} - y_{\overline{Q1}}$ according to eq. (4). Similarly, if $Cov(x_1, y) < 0$, then $x_{1,\overline{Q5}} - x_{1,\overline{Q1}} < 0$ with high probability and the contributions of x_1 to $Var(y)$ and to $y_{\overline{Q5}} - y_{\overline{Q1}}$ are both negative.

My approach, however, has an obvious advantage over that of Fields (2002) as it allows us to look at different parts of the wage distribution. Given the very different behaviors of the p50-p10 gap and the p90-p50 gap as illustrated in Figure 1-1, I employ the decomposition embodied in eq. (4) rather than eq. (A6).

Appendix 4 | Within-group Inequality

Following Lemieux (2006), I construct counterfactual weights ω_{it}^{*} that make the distribution of worker characteristics in year t the same as in the base year 1980. For this purpose, a logit model is estimated on data for year 1980 and year t in which the dependent variable is a dummy variable for year t and independent variables are sex, age, and education.

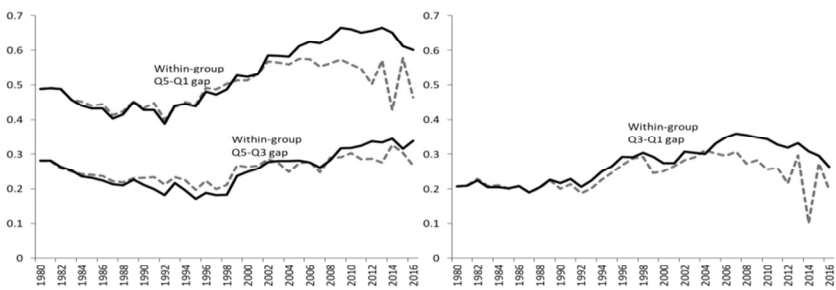
The predicted probability that worker i is in year t, P_{it}, is used to compute

$$\omega_{it}^{*} = [(1 - P_{it})/P_{it}]\omega_{it}$$

where ω_{it} is the sample weight. Then ω_{it}^{*} rather ω_{it} are used to calculate quintile averages in eq. (3) and the within-group gaps in eq. (4).

The results are reported in the figure below, which indicates that in the third period (2008-2016), a substantial part of within-group inequality growth came from the changing worker characteristics.

Figure A2 | Within-group Inequalities with Sex, Age, and Education Held Constant



Note: The solid and the dotted lines indicate the cases of historical and counterfactual weights, respectively.

Appendix 5 Union Membership and Employment Type

Below, we examine two additional variables—union membership and employment type—on top of the ones discussed in the text.

Given unions' tendency to promote "solidarity wage" and oppose individual performance pay that can undermine collective bargaining, wide-spread union membership is likely to be associated with compressed wage distribution. On the other hand, unions can widen the wage gap between members and non-members and thereby increase the overall inequality, especially when their membership is concentrated in the high-paying sectors. The relationship between union membership and wage inequality is thus an empirical issue, and the debate is still going on (Farber *et al*., 2018).

In addition to union membership, employment type can also affect wage inequality. It is often claimed that non-regular workers—fixed-term, part-time, temporary work agency, on-call, or independent workers and domestic laborers—suffer from lower pay and lower job security. The increased public attention to non-regular workers has led the Korean government to begin collecting data on them in the early 2000s.

To measure the contribution of union membership and employment type to wage inequality, I utilize the Survey on Labor Conditions by Employment Type (SLCET)—another survey conducted by the Korean Ministry of Employment and Labor—which collects information on these variables in addition to that contained in the WSS. The SLCET covers the years 2009-2016 and establishments with one or more employees.

Table A1 reports the regression results of wage equation. The coefficient estimates on union membership (members = 1) indicate that members enjoy a positive wage premium of zero to six percent over

Table A1 Regression on Union Membership and Employment Type

Year		2010	2012	2014	2016
Sex	Male	0.228*** (0.003)	0.204*** (0.002)	0.198*** (0.002)	0.203*** (0.002)
Age		0.040*** (0.001)	0.034*** (0.001)	0.033*** (0.001)	0.034*** (0.001)
Age squared × 10		-0.005*** (0.000)	-0.004*** (0.000)	-0.004*** (0.000)	-0.004*** (0.000)
Highest education completed	Middle School	-0.059*** (0.006)	-0.029*** (0.004)	-0.064*** (0.005)	-0.032*** (0.006)
	Junior College	0.059*** (0.003)	0.075*** (0.003)	0.073*** (0.003)	0.071*** (0.003)
	College	0.241*** (0.004)	0.252*** (0.003)	0.227*** (0.003)	0.218*** (0.003)
Tenure		0.021*** (0.001)	0.018*** (0.001)	0.022*** (0.001)	0.016*** (0.001)
Tenure squared × 100		0.002 (0.000)	0.010*** (0.000)	-0.000 (0.000)	0.009*** (0.000)
Work experience	Less than 1 year	-0.115*** (0.005)	-0.118*** (0.004)	-0.113*** (0.004)	-0.076*** (0.004)
	1-3 years	-0.053*** (0.004)	-0.059*** (0.003)	-0.060*** (0.003)	-0.050*** (0.003)
	5-10 years	0.052*** (0.004)	0.053*** (0.004)	0.052*** (0.004)	0.050*** (0.003)
	More than 10 years	0.136*** (0.005)	0.139*** (0.004)	0.134*** (0.004)	0.130*** (0.004)
Establish -ment Size	10-29 employees	-0.319*** (0.004)	-0.295*** (0.003)	-0.257*** (0.003)	-0.285*** (0.003)
	30-99 employees	-0.102*** (0.002)	-0.102*** (0.002)	-0.086*** (0.002)	-0.090*** (0.002)
	300 or more employees	0.244*** (0.002)	0.237*** (0.002)	0.311*** (0.002)	0.269*** (0.002)
Union membership		0.043*** (0.003)	0.062*** (0.002)	0.001 (0.003)	0.058*** (0.002)
Employ-ment type	Regular workers	0.030*** (0.004)	-0.007** (0.003)	-0.008*** (0.003)	0.004 (0.003)
Occupation		O	O	O	O
Industry		O	O	O	O
Observations		783,683	808,253	836,052	778,299
R-squared		0.567	0.525	0.544	0.528

Note: 1) The constant term and the coefficients for occupation dummies and industry dummies not shown.

2) Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

3) Observations on workers were weighted by the number of hours worked.

non-members. Unions appear to be successful in securing higher pay for their members. In contrast, the coefficient estimates on employment

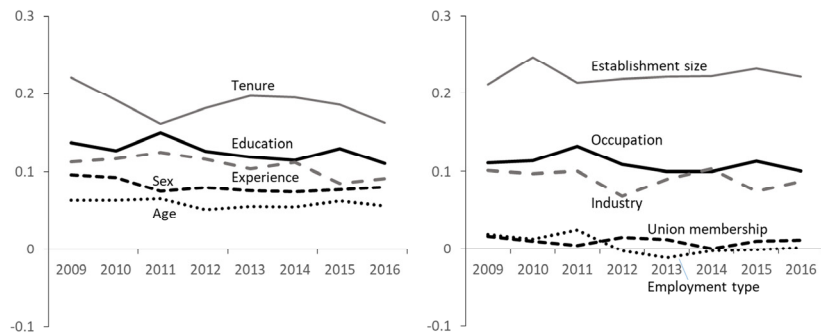
type (regular workers = 1) is not always positive, exhibiting negative or insignificant values in some years. Discrimination against non-regular workers is not apparent from the regression results.

Figure A3 plots the contributions of union membership and employment type together with others to wage gaps. The parts of wage inequality attributable to these two variables are very small and almost insignificant compared to the contributions made by other worker characteristics. Union membership tends to raise rather than reduce wage inequality, and employment type raises wage inequality in some years and lowers it in others.

That union membership raises inequality can be expected from the positive union premium and also from the fact that union density is higher

Figure A3 Contributions of Union Membership and Employment Type

(Panel A) Q5-Q1 Gap



(Panel B) Q5-Q3 Gap

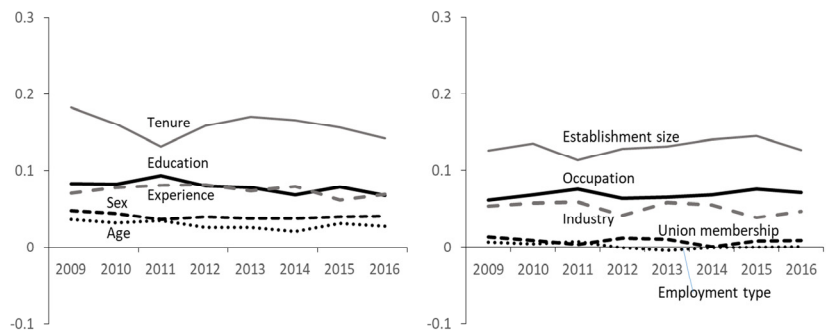
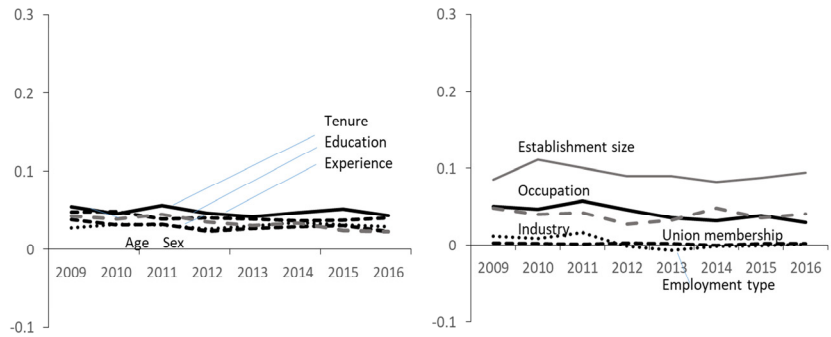


Figure A3 *(Continued)*

(Panel C) Q3-Q1 Gap



in larger establishments (Table A2), where pay is higher than in smaller ones even for non-members.

On the other hand, that non-regular workers are not particularly worse off than regular workers in terms of hourly wage is rather surprising. This implies that the apparent wage differential between regular and non-regular workers arise mostly from the differences in worker characteristics, such as sex, age, education, and experience. When these characteristics are controlled for, employment type does not produce a significant wage differential.

But then we may ask again if employment type really does not matter in large establishments, where many cases of discrimination against non-regular workers have been reported. To answer this question, we split the dummy for employment type ("Regular") across enterprise sizes ("Regular × S1," …, "Regular × S4"). The results are reported in Table A3. The wage gap between regular and non-regular workers is indeed positive in larger establishments while negative in smaller ones.

Table A2 Union Density by Establishment Size

(Unit: %)

Number of employees	2010	2012	2014	2016
1-4	1.6	1.2	0.9	0.8
5-29	5.0	4.5	4.8	4.5
30-299	19.6	16.8	15.7	16.4
More than 300	32.3	34.3	27.9	26.4

In 2016, for example, regular workers in establishments with 300 or more workers earned 30.7 percent *more* than non-regular workers, while regular workers in establishments with 1 to 4 employees earned 9.1 percent *less* than non-regular workers. The reason for the latter fact is not clear: Perhaps non-regular workers in small establishments are more skilled than regular workers and work voluntarily as non-regular workers.

As shown in Table A4, the majority—69.2 percent in 2016—of non-regular workers work in small establishments with less than 30 employees, where they are paid on average better than regular workers with the same characteristics. Thus despite the reported cases of discrimination, it does not look strange that employment type has on average over the establishment sizes insignificant impact on wage inequality.

The results above on union membership were concerned with the wage differential between members and non-members. What about the wage differential *among* union members? We ask two questions in this regard. First, we ask if union membership affects tenure profile: If unions try to compress wages among their members, tenure profile

Table A3 An Alternative Specification for Employment Type

	2010	2012	2014	2016
Regular × S1 (1-4)	-0.005	-0.109***	-0.116***	-0.091***
	(0.008)	(0.006)	(0.007)	(0.007)
Regular × S2 (5-29)	-0.045***	-0.007	-0.035***	-0.031***
	(0.006)	(0.005)	(0.004)	(0.004)
Regular × S3 (30-299)	0.095***	0.051***	0.083***	0.083***
	(0.004)	(0.003)	(0.003)	(0.003)
Regular × S4 (300+)	0.297***	0.309***	0.314***	0.307***
	(0.004)	(0.004)	(0.004)	(0.003)
Observations	783,683	808,253	836,052	778,299
R-squared	0.571	0.531	0.551	0.533

Note: 1) This table extends Table A1 by replacing "Employment type" by "Regular × Sk (k=1,…,4)," where "Regular" is the regular worker dummy and "Sk" is the establishment size dummy (S1=1-4, S2=5-29, S3=30-299, and S4=300+). Coefficient estimates are reported only for these new variables.

2) Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

3) Observations on workers were weighted by the number of hours worked.

Table A4 Regular and Non-regular Workers by Establishment Size

(Unit: %)

	2010			2012			2014			2016		
	R	NR	T	R	NR	T	R	NR	T	R	NR	T
1-29	52.6	76.4	58.3	52.2	72.7	56.8	51.9	72.3	56.4	53.8	69.2	57.2
1-5	20.3	51.3	27.8	19.9	43.5	25.2	19.2	44.0	24.7	20.6	39.9	24.9
5-29	32.3	25.1	30.5	32.2	29.2	31.6	32.7	28.3	31.7	33.2	29.3	32.3
30-299	31.6	16.3	27.9	31.7	20.2	29.1	32.8	19.8	29.9	31.8	22.3	29.7
300+	15.9	7.3	13.8	16.1	7.1	14.1	15.3	7.9	13.7	14.4	8.5	13.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: 1) R=Regular workers, NR=Non-regular workers, T=Total.
2) Number of workers were measured in work-hours.

should be flatter for members than for non-members. To examine this possibility, we include two additional variables, "Union × Tenure" and "Union × Tenure squared," to the wage regression in Table A3. Figure A4 illustrates the estimated log wage premium for union members over non-members. The premium increases as tenure lengthens and reaches a peak at around 20 years. Tenure profile is therefore not flatter but steeper at least up to 20 years for union members, adding to our doubts on the wage-compressing role of unions.[24]

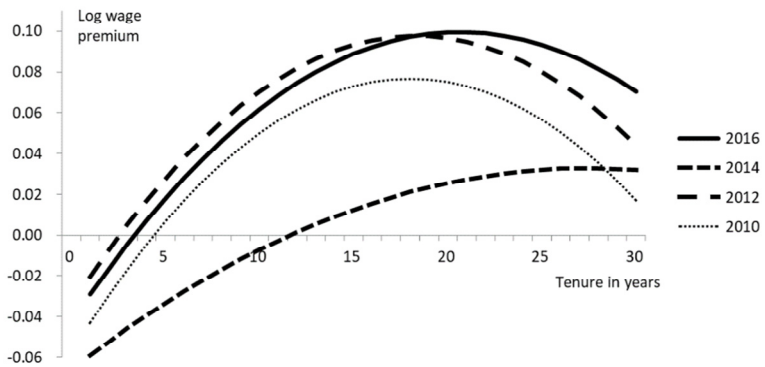
Second, we ask if union membership reduces the wage gap between regular and non-regular workers. This is done by adding "Union × Regular" to the regression in Table A3. The wage-compressing role of unions would dictate a negative coefficient on "Union × Regular." Table

24 Of course, these results concern the *aggregate* tenure profile. Conceivably, tenure profile may be flatter for union members *within each firm* even though steeper *in the aggregate*. But it is not easy to imagine a case where flatter profiles at the firm level would add up to a steeper profile in the aggregate. One possibility is that there exist multiple unions within a firm. For instance, suppose that there are two unions, one for regular workers (with a relatively long tenure and a high wage) and another for non-regular workers (with a relatively short tenure and a low wage). If we do not distinguish between these two unions and assume that all union members belong to a single union, then the tenure profile of union members would appear steeper even if it is flatter within each union. Still, this would reveal a lack of solidarity between unions, and their limited role in compressing wages. I thank an anonymous referee for pointing out this possibility to me.

A5 reports the results. The coefficient estimate on the interaction term is positive and significant in 2010 and 2012 and negative and significant in 2014. In 2010, for example, regular workers earned 20 percent more than non-regular workers within unions. Thus the wage-compressing role of unions for regular and non-regular workers looks at most uncertain.

Second, we ask if union membership reduces the wage gap between regular and non-regular workers. This is done by adding "Union × Regular" to the regression in Table A3. The wage-compressing role of unions would dictate a negative coefficient on "Union × Regular." Table A5 reports the results. The coefficient estimate on the interaction term is positive and significant in 2010 and 2012 and negative and significant in 2014. In 2010, for example, regular workers earned 20 percent more than non-regular workers within unions. Thus the wage-compressing role of unions for regular and non-regular workers looks at most uncertain.

Figure A4 Tenure Profile of Union Wage Premium



Note: Estimated by adding "Union × Tenure" and "Union × Tenure squared" to the wage regression in Table A3.

Table A5 Regular Worker Premium within Unions

	2010	2012	2014	2016
Union	-0.162***	-0.028**	0.029***	0.048***
	(0.020)	(0.011)	(0.010)	(0.007)
Union × Regular	0.201***	0.080***	-0.045***	-0.005
	(0.021)	(0.011)	(0.010)	(0.008)

Note: Estimated by adding "Union × Regular" to the regression in Table A3.

Appendix 6 Estimating Demand Shifters Using Coefficient Estimates from Wage Equations

(Panel A) Sex

		Male / Female
Slop	α_1	-0.007* (0.004)
	α_2	-0.006*** (0.001)
	α_3	0.002 (0.003)
$^{-}\gamma$		-0.027 (0.087)
Observations		37
R-squared		0.907

(Panel B) Age

		SUR		Elderly equivalents (30+) / Young (15-29) (3)
		Prime age (30-54) / Young (15-29) (1)	Elderly (55+) / Young (15-29) (2)	
Slop	α_1	-0.003 (0.003)	0.009*** (0.003)	-0.003 (0.004)
	α_2	0.003* (0.002)	0.004** (0.002)	0.003 (0.002)
	α_3	-0.001 (0.002)	0.026*** (0.003)	-0.001 (0.002)
$^{-}\gamma$		-0.005 (0.041)	-0.121*** (0.019)	0.001 (0.040)
Observations		37	37	37
R-squared		0.529	0.842	0.520

(Panel C) Education

		SUR			College equivalents / High school equivalents (4)
		Middle school / High school (1)	Junior college / High school (2)	College / High School (3)	
Slop	α_1	-0.010*** (0.003)	-0.008*** (0.002)	-0.015*** (0.001)	-0.006* (0.003)
	α_2	-0.007*** (0.002)	0.007*** (0.002)	0.026*** (0.002)	0.022*** (0.004)
	α_3	-0.008*** (0.002)	0.002** (0.001)	0.007*** (0.002)	0.008*** (0.002)
$^{-}\gamma$		-0.130*** (0.027)	-0.053* (0.030)	-0.306*** (0.033)	-0.234*** (0.046)
Observations		37	37	37	37
R-squared		0.824	0.941	0.946	0.967

Note: See the note in Table 3-1.