

Growth in College Education and Wage Differentials in Korea

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This paper investigates how overall wage structure has responded to changing labor supplies in Korea between 1978 and 2002, with the main emphasis on changes in educational and age distributions of labor supply during the period. These supply changes mostly reflect ever-increasingly educated new cohorts of varying sizes, and it bears critical importance in understanding the labor market mechanism to see how these entry-level changes are absorbed in Korea's market.

The main findings are as follows. Both educational upgrading and changing cohort sizes, despite being entry-level changes, have a strongly common effect on all age groups in such a way that their wages highly co-move. The commonness in wage movements arises because workers of varying ages are good substitutes for each other within education. Age structure of wages has relatively been stable within each education, implying that there exists almost a single wage rate within education. Consequently, the time-series patterns of college premiums are accounted for mostly by changes in the single prices. In addition, differences in cohort-specific productivities between high-school and college graduates account for some of the remaining variations.

Keywords: College premium, Substitutability, Cohort effects

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I. Introduction

Labor supply structure has been changing rather rapidly in Korea's labor market, and one of the most evident changes is dramatic educational upgrading among newly entering cohorts. The share of those in college or with a college diploma among 25-29 year-old population has risen from 17.3% in 1985 to 37.2% in 1995, and further to 54.9% in 2002. Currently four out of five high-school graduates are obtaining at least some tertiary education.¹ Educational upgrading is not the only change taking place at the entry level. The size of newly entering cohorts has recently been decreasing due to falling fertility rates. Baby boomers born between 1958 and 1962 accounted for 24.2% of 25-54 year-old population and for 20.9% of employment of the age group in 1987. In contrast, those born between 1973 and 1977 occupy only 17.7% of 25-54 year-old population and 16.3% of workers in 2002.

I investigate in this paper how wage structure has responded to the changes in labor supplies in Korea's labor market. Rapid educational upgrading and declining cohort size have continuously changed both the composition and size of newly entering cohorts and have pressured for a change in wage structure over education and age groups. Given that these labor supply changes take place almost exclusively at the entry level, it is of great importance to understand whether such entry-level changes would have a market-wide impact or a limited impact on the entering cohorts. This is important as it is directly linked to wage and earnings inequality. To the extent that a given change in supply is absorbed by the entire market, the distributional implication will be small. Alternatively if it is concentrated among young workers, the distributional and welfare implications will be more significant.

The implication is not limited to distribution issues, however. The overall changes in wage structure will depend on various parameters, and in particular, on elasticities of substitution among workers of varying education levels and ages. These parameters are of great importance, not just because they determine wage changes, but also because they are, in general, indicative of how integrated the

¹ High-school completion rate is currently almost 100% among the young in Korea, and the share of high-school graduates advancing to higher education has risen to 79.7% in 2003.

labor market is. The more integrated, the more likely is a change in a group of workers to have a spill-over effect on other groups. For example if old and young workers are highly substitutable, wage and employment effects of an economic recession are less likely to be concentrated among young entering cohorts. Further, the negative effect of a recession on starting wages of entering cohorts, if any, is less likely to persist in an integrated market.² Substitutability among age groups may also have an implication on youth unemployment. If workers of varying ages are highly substitutable for each other, a disproportionate increase in youth unemployment is less likely to result from age-twisted demand shift against young workers. Instead, one will have to look to supply-side or institutional factors for the cause of concentration of unemployment among young workers.³ Thus identifying these parameters and the underlying labor market mechanism is crucial in understanding the changes in labor market outcomes and designing effective policy measures for the outcomes.

The results from empirical analysis in this paper indicate that labor supply changes at entry level have a market-wide effect in the sense that wages have been moving in a similar way between newly entering and already existing cohorts. The primary reason for this outcome appears to be high substitutability among workers of varying ages. Educational upgrading at entry level has similarly lowered college graduates' wages at all ages relative to high-school graduates, while the age structure of wages has been relatively stable. This means that Korea's labor market can be reasonably approximated by a single-price market for each education, and the

² For example in the U.S. Devereux (2002) shows that a substantial portion of initial wage shocks persists for several years. Ellwood (1982) reports similar persistency in unemployment. These are rather consistent with Welch (1979) who find a large cohort size effect at entry-level wages. To the extent that markets are not integrated due to low substitutability among workers, the effects of an exogenous shock are concentrated among directly affected groups. Little is known about such persistence in Korea's labor market, however, as it was very recent when panel data set was constructed and put to use.

³ As for institutional factors, one may consider wage rigidity among young workers caused by minimum wages, union effects or employment regulations. Indeed, there is some evidence that increased discretion in hiring due to restriction on layoff has been an important cause of youth joblessness in recent years (Kim 2004).

time-series patterns of college premiums are mostly explained by changes in the single prices. The empirical model of this paper identifies an additional cause of the declining trend in college premium, which is the decline in college graduates' relative productivity to high-school graduates among the recent cohorts.

This paper proceeds in the following way. The next section briefly describes several important features of the data used in the analysis. It illustrates construction of the key variables in the analysis, and discusses why these variables are drawn from different surveys. Section III provides the main results from the empirical analysis and their interpretations. Section IV concludes.

II. Data Sets and Construction of Key Variables

A. Price Data

Wage data are extracted from the *Wage Structure Survey* (WSS) administered by the Ministry of Labor in Korea. It is an establishment survey that covers firms with 10 or more regular employees in non-agricultural sectors.⁴ Regular employees are defined as those satisfying at least one of the following conditions; 1) a worker who has a fixed-term contract in excess of one month or an unspecified-term contract,⁵ 2) a temporary or daily worker who has worked for no fewer than 45 days during the previous 3-month cycle, 3) high ranking workers (executives) who are on the payroll and physically present at the establishment, or 4) family members of a firm's owner who are on the payroll and physically present at the establishment.

The sampling scheme in the Survey is stratified sampling based on the Neyman Allocation method.⁶ Firms are grouped into various cells based on their size (in employment) and 2-digit industry (the Korean Standard Industry Classification), and 6% of firms are

⁴ From 1999, the Survey was expanded to include firms with 5-9 regular employees. For the current analysis, the sample is limited to firms with 10 or more regular employees throughout the years in order to maintain time-series consistency.

⁵ The Labor Standard Law in Korea has only recently allowed a fixed-term contract exceeding a year. For the reason, a typical worker has a contract with unspecified length.

⁶ See Narayan C. Giri (1974) for Neyman Allocation in stratified sampling.

sampled from each cell unless the total number of firms in a cell falls below ten, in which case all firms are sampled. From the sampled firms, a fixed share of workers is sampled from their payrolls, where the share monotonically decreases with firm size. Sampled workers are assigned a weight to represent the population in each industry-size cell. As a result, the 1999 survey, for example, carries information on 479,655 wage/salary workers, who are expected to represent 5.47 million wage/salary workers, or 44.3% of all wage/salary workers. Information on each worker's gender, education, job characteristics, and monthly wages is provided in the data.

As the Survey does not cover small firms, the data do not necessarily represent the whole economy, and indeed, some serious sample selection bias is known to be present. For example, wages are estimated much higher in service, retail and wholesale trade sectors than in manufacturing from the data, which is not typical in many other industrialized countries.⁷ This arises because the 10-or-more employee restriction is more binding for non-manufacturing sectors in which firms are typically smaller. Given that smaller firms pay lower wages, the upward bias in wage estimates arising from sample selection is non-neutral across industries, and in fact, is greater among non-manufacturing than in manufacturing.⁸ Given that firm size differentials have been increasing in Korea, the Survey data are likely to overstate wage growths, too.

Despite these drawbacks, the Survey offers a valuable long time-series on wages that no other existing surveys can match. Further, the size differentials have moved similarly over time among various types of workers, implying that the sample selection bias is likely to have been stable across worker types.⁹ This allows one to analyze time-series variation of wages without losing too much generality. In particular, sample selection bias that makes cross-section comparison of wages difficult is expected to mostly cancel out in time-series variations.

⁷ See Krueger and Summers (1987) and Thaler (1989) for discussion on industry wage structure in the US and other countries.

⁸ Within manufacturing, industry wage structure is found to be quite similar between Korea and other countries. For the industry wage structure in Korea, see Yoo (1995).

⁹ For example, see Kim (2000a) for comparing wage levels and their fluctuations between small and large firms.

That being said, wage data used in this paper are based on the sample of 25-54 year-old full-time male workers in non-agricultural sectors from the 1978-2002 WSSs. These are the price variable used in the analysis. The sample is limited to full-time men because they are the most strongly attached group to the market.¹⁰ The age restriction is imposed because the typical mandatory retirement age in private firms in Korea is 55. From this sample, mean wages for 120 cells defined over 4 education and 30 single-year ages are calculated for each year. Wages of any subgroup G of workers at time t , W_{Gt} , are calculated from these cell means (W_{eat}) and fixed weights (s_{ea}) for education e and age a , as defined below.

$$W_{Gt} = \frac{\sum_{e,a \in G} s_{ea} W_{eat}}{\sum_{e,a \in G} s_{ea}} \quad \text{where} \quad s_{ea} = \frac{1}{T} \sum_{t=1978}^{2002} s_{eat} \quad (1)$$

In the above, s_{eat} is the share of age group a with education e as a fraction of total population at time t , and its sum over e and a equals 1 for all t . The time-invariant (fixed) weights, s_{ea} , are calculated as the mean for the entire period, and they are used in calculating various group-means of wages to prevent the price variable from being affected by changes in age and educational distributions of workers, or changes in quantity variables. All wages are converted into real terms using the *Consumer Price Index* from the Bank of Korea as the deflator.

B. Quantity Data

Sample selection bias in the WSS is probably more of a problem in estimating employment. As pointed out by Kim (2000b), a lot of labor market adjustment has taken place along business cycles at the extensive margins as many workers enter and exit the labor force frequently. They marginally attached workers typically obtain a job in small non-manufacturing firms when they enter the market, and they are not covered in the Survey.¹¹ However, wages

¹⁰ Excluding women in the analysis may cause biased estimates if men and women are substitutable in the market. However, the evidence for strong impact of women on male wages is weak in the literature. See, for example, Juhn and Kim (1999) for the U.S. case.

do depend on the magnitude of such adjustment to the extent that workers are substitutable. Thus employment statistics extracted from the *Wage Structure Survey* may not be tightly linked to wages, not to mention failing to represent the employment as a whole.

To overcome the problem, employment data are extracted from more representative data sources, the *Survey on Economically Active Population* (SEAP) and the *Population Projections* (PP), both of which are administered by the National Statistical Office in Korea. The SEAP is a monthly household survey that carries information on labor market activity of each individual of age 15 or older.¹² It represents whole population of age 15 or older, and population and employment from the SEAP are used as the quantity variables against the wage data (price variables) from the *Wage Structure Survey*.

One problem with the SEAP is that the raw data set is available only from 1985, before which only a few published cross-tabulations are available. As the analysis in this paper covers the 1978-2002 period, employment and population data for the pre-1985 period need be estimated. The estimation procedure is as follows. First, from the 1985-2002 SEAP data, I calculate the share of those with education e in birth-year cohort b in year t , and denote it as z_{et}^b .¹³ For given e and b , the cohort's age is $t-b$ and thus a higher t means an older age. I regress these shares on a polynomial of age, $t-b$, and a set of cohort dummy variables to identify the common age profile of educational distribution and the cohort differences in educational attainment as in the following equation.¹⁴

$$z_{et}^b = \alpha_e^b + Z(t-b; \beta_e) + \varepsilon_{et}^b \quad (2)$$

¹¹ See Kim (2000b) and Yun (2004) for the employment patterns of marginally attached workers.

¹² The major drawback of SEAP is that it does not carry earnings information, and it is why the data are used for quantity variables only.

¹³ Thus the sum of z_{et}^b over education level (e) will always return 1 for any b and t .

¹⁴ A similar method was used in Juhn, Kim, and Vella (2005) for the US data.

In the above, α_e^b measures cohort-specific differences in educational attainment and Z function with education-specific coefficients, β_e , on age polynomials identifies the common age-profile in educational attainment among all birth-year cohorts. The estimates from equation (2) are used to predict educational attainment of each cohort at each age, and these estimates are combined with population-by-age data from the *Population Projections* to produce age and educational distribution of the 25-54 year-old population during the pre-1985 period.¹⁵

Equation (2) can also be applied to the sample of wage/salary workers, not population, in order to project the educational distribution of employment. However, I use for this paper the population estimates, not employment estimates, primarily because employment is endogenously determined in the market jointly with wages by supply and demand factors. One of the main purposes in this paper is to associate wage changes with exogenous supply changes, and I expect the population estimates to reflect such exogenous changes better. In fact, using the population estimates is equivalent to instrumenting endogenous employment with population.

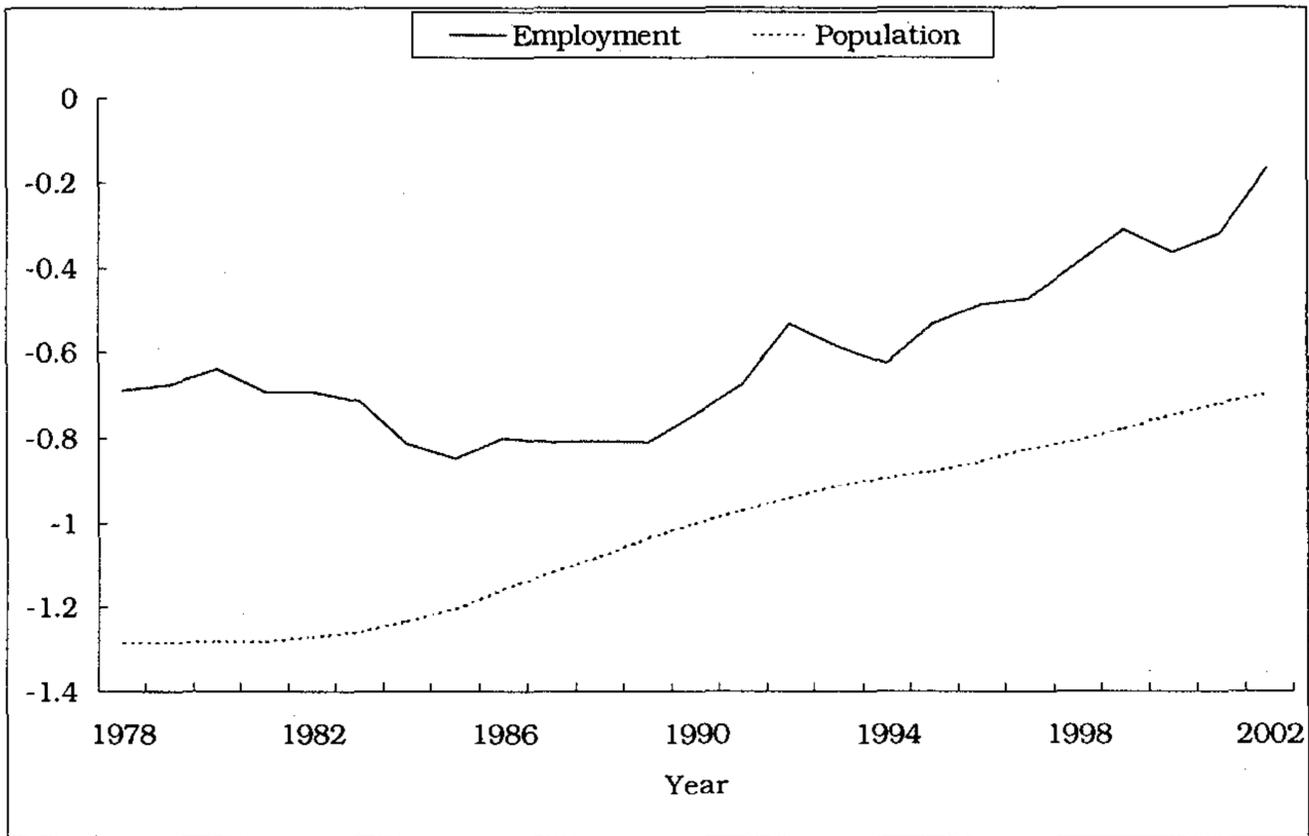
III. Changes in Labor Supply and Wage Structures

A. Aggregate Patterns of Supply and Wages

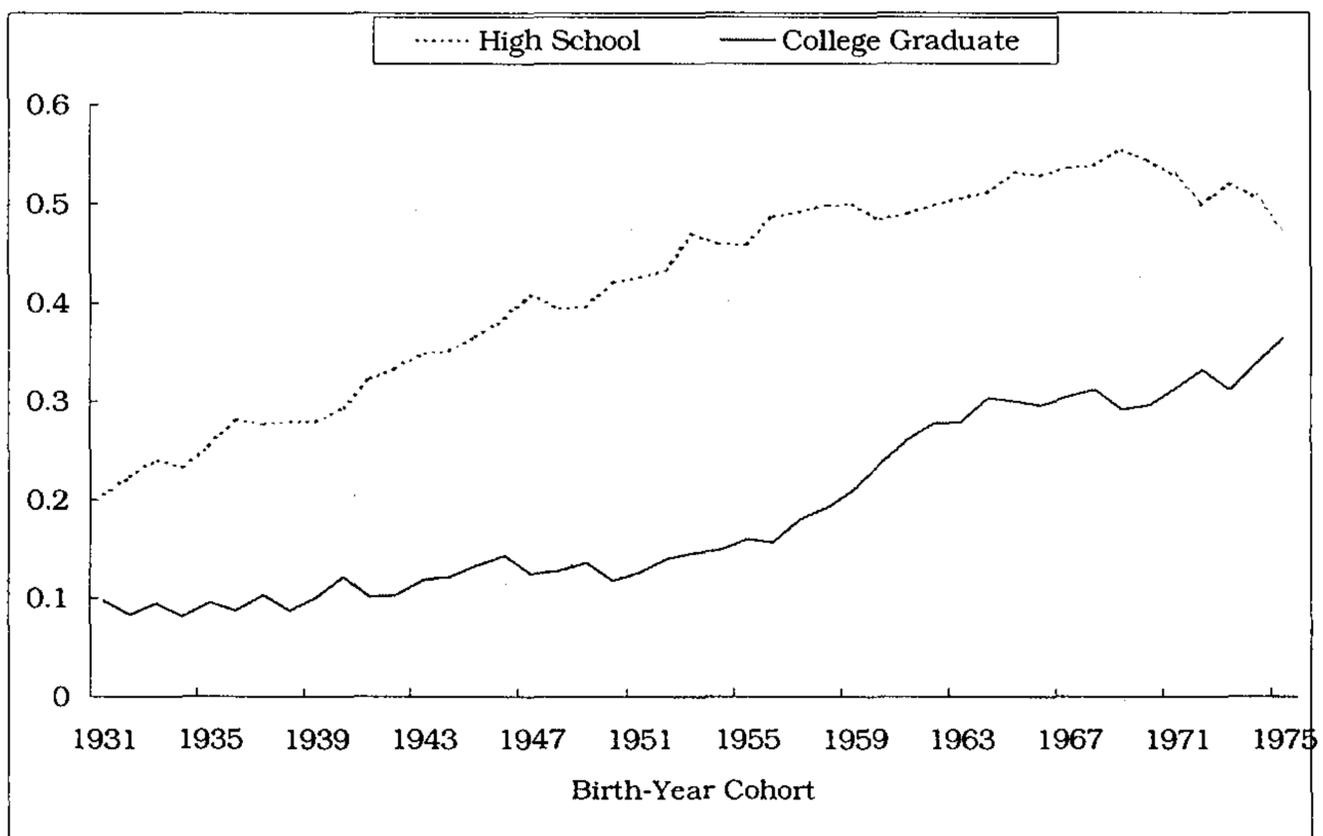
One of the most apparent changes in male labor supply during the last 25 years in Korea is rapid educational upgrading. Figure 1 shows that the log employment and population ratios of college and high-school graduate men have continuously been on a rising trend during the last two decades. Figure 1-(A) shows that the log population ratio has increased rather fast between 1983 and 1990 and the log employment ratio started to rise in the mid-1980s. According to the figure, college/high-school ratio in population increased by 0.61 log points, or from 0.28 in 1978 to 0.50 in 2002. The ratio in employment increased by 0.52 log points, or from 0.50 to 0.85, during the same period. By any standard, these changes are huge.

¹⁵The projected educational distribution is also used for the post-1985 period to maintain time-series consistency. As the projected distribution does not significantly differ from the actual during the period, this does not cause any significant bias in empirical analysis in the paper.

(A) Log Ratio of College/High-School Graduates



(B) Estimated Educational Distribution at Age 35 by Birth-Year Cohorts



Source: The author's calculation from the WSS, SEAP and PP.

FIGURE 1
INCREASE IN EDUCATIONAL ATTAINMENT

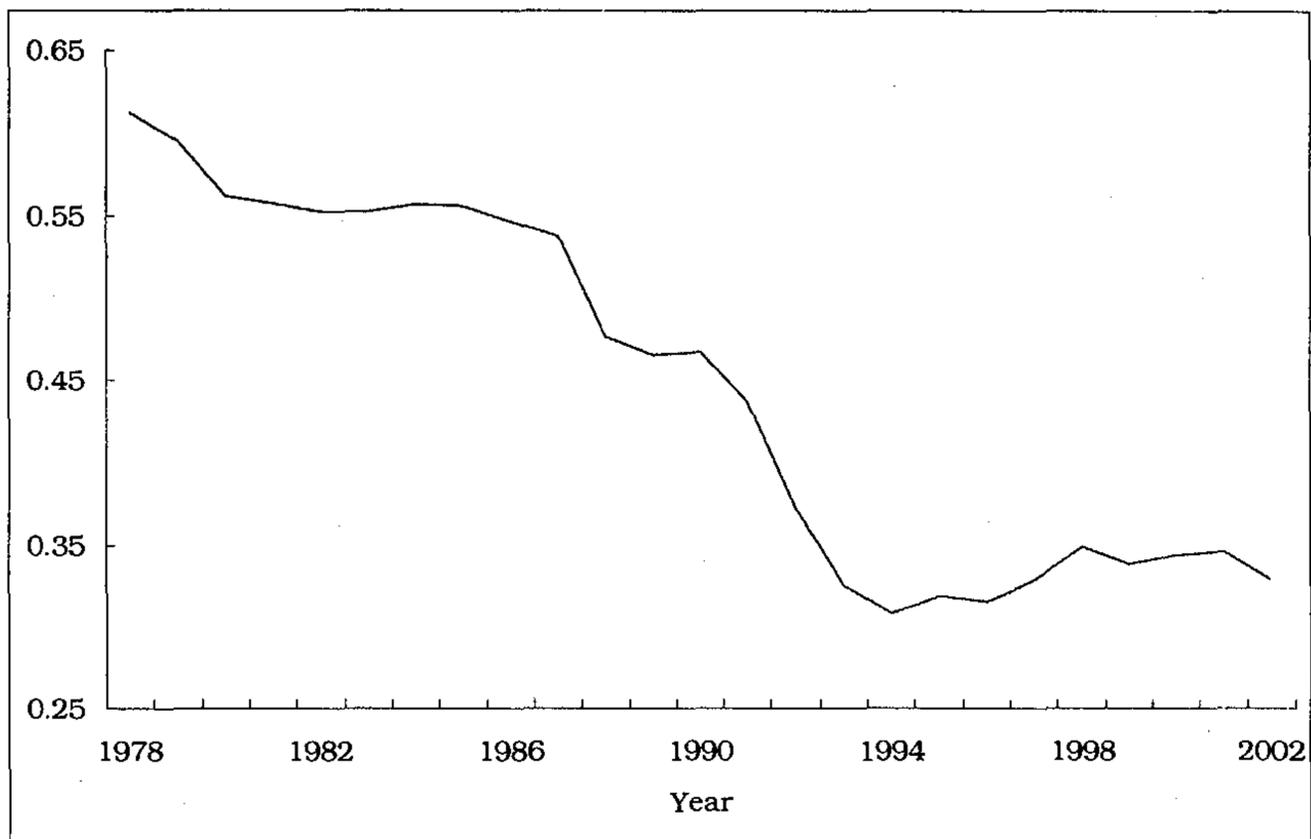
Figure 1-(B) indicates that most of the increase in college educated workers reflects that an ever-increasing share of new cohorts has attained college education. The figure plots the estimates of z_{et}^b in equation (2) in the previous section evaluated at age 35 by assigning $b+35$ to t .¹⁶ One can see in the figure that expansion of college education had become visible among those born in the early 1950s, accelerated among the baby boom cohorts born in the late 1950s and the early 1960s, and somewhat slowed down until it started to accelerate again in the 1970 cohort. As a result, 36.2% of the 1975 cohort are estimated to have attained college education by age 35, which is more than a three-fold increase from 11.8% of the 1951 cohort. The share of high-school graduates also increased substantially, from 42.6% in the 1951 cohort to 55.4% in the 1969 cohort. Since then, the share has fallen reflecting that a greater share of high-school graduates advanced to higher education.

Changes in relative wage structure in Korea during the period have been equally large. Figure 2 plots college premium defined as the log ratio of college and high-school graduates' wages among 25-54 year-old male workers, and it is evident that the premium had long been on a declining trend until the mid-1990s. The premium declined substantially between 1987 and 1994 and has slightly increased since then. As a result, college graduate men's wages were 0.55 log points (73%) higher than high-school graduates in the early 1980s but they are only 0.33 log points (39%) higher in the early 2000s.

The generally declining pattern of college premium is in accordance with increasing employment or population ratio of college graduates over high-school graduates. A simple equation as in (3) is fitted to the time-series to estimate the effect of aggregate relative supply changes on aggregate relative wages.

$$\log\left(\frac{W_{Ct}}{W_{Ht}}\right) = \alpha + \beta \log\left(\frac{N_{Ct}}{N_{Ht}}\right) + \gamma t + \varepsilon_t \quad (3)$$

¹⁶That is, the figure plots $\hat{z}_{e, b+35}^b = \hat{\alpha}_e^b + Z(35; \hat{\beta}_e)$ for each b and e .



Source: The author's calculation from the WSS.

FIGURE 2

CHANGES IN COLLEGE PREMIUM, 1978-2002

TABLE 1

ESTIMATION OF ELASTICITY OF COMPLEMENTARITY

	Model			
	(1)	(2)	(3)	(4)
Log Relative Employment	-0.430(0.082)		-0.006(0.072)	
Log Relative Population		-0.502(0.036)		-0.591(0.285)
Year			-0.014(0.002)	0.002(0.008)
Adjusted- R^2	0.529	0.888	0.861	0.884

Notes: 1) Standard errors are in the parentheses.

2) Time series of 25 years between 1978 and 2002 is used for the estimation.

Source: The author's calculation from the WWS, SEAP and PP.

W_{et} is the average real wage of education group $e=C, H$, at time t and N_{et} is the size of employment (population) with education e at time t . β in the above equation represents the elasticity of complementarity between high-school and college graduates, or the inverse of elasticity of substitution. Two types of quantity variable

are used for $N_{e,t}$ s, employment and population, and a trend variable t is included to approximate potential demand shifts. The estimation results are reported in Table 1.

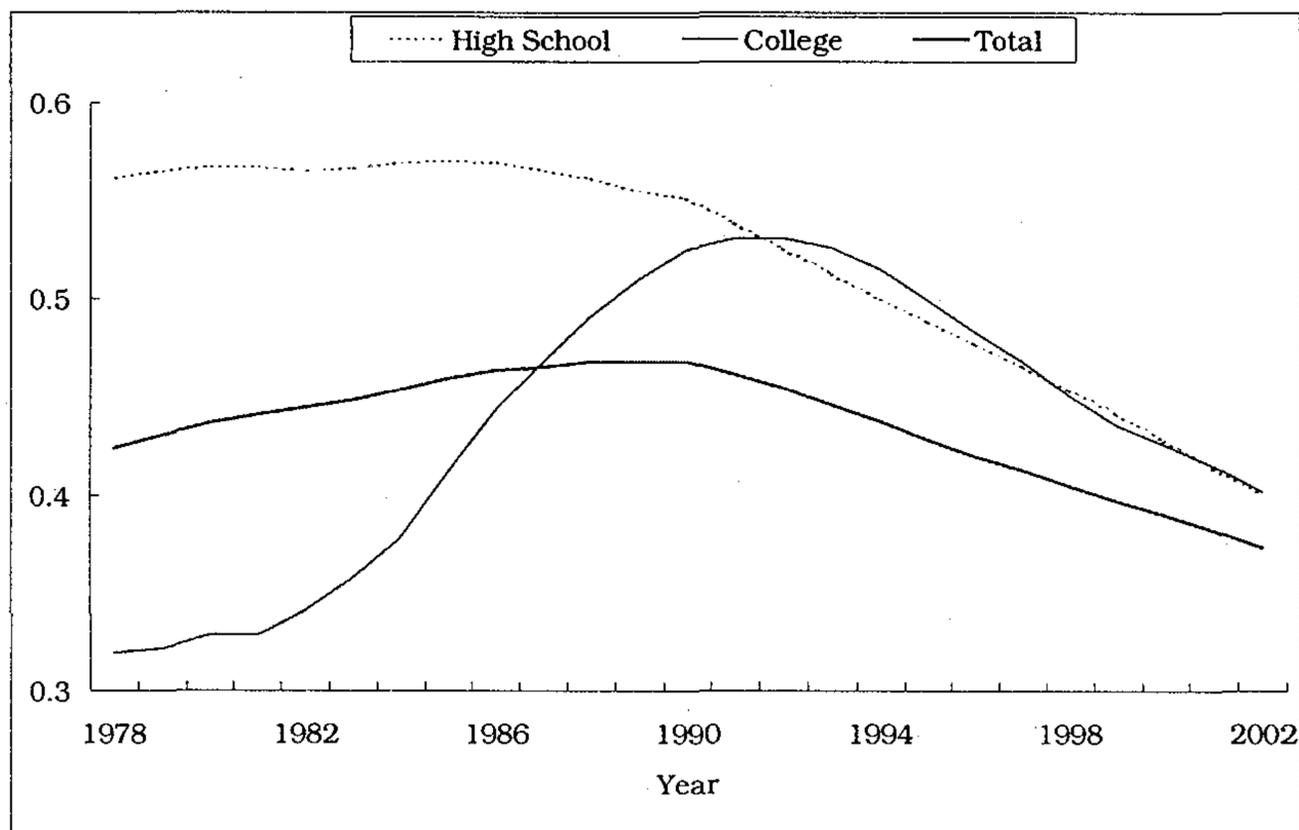
The table indicates, first of all, that using population as the quantity variable offers better fits as well as more statistically significant and robust estimates. This suggests the possibility that employment data are subject to endogeneity problem, and for this reason, I continue to use population data to instrument labor supply. The elasticity of complementarity is estimated to range between -0.6 and -0.4 except in model (3), which would imply an elasticity of substitution between 1.7 and 2.5.¹⁷ Adding the trend variable substantially reduces the coefficient on log relative employment, but that on log relative population remains quite stable.

The adjusted- R^2 is almost 0.9 when using population as the regressor, and it indicates that the aggregate time-series pattern of relative wages is mostly accounted for by exogenous changes in relative supply. There are some unexplained changes, however. During the 1987-94 period, the actual changes in college premium are a decline by 0.22 log points, but only 0.11-0.13 log points are accounted for by models (2) and (4). Also during the 1994-2002 period, the premium actually rose by 0.02 log points, while both models (2) and (4) predict a decline by 0.10 log points.

These unexplained fluctuations around the predicted series appear to reflect incomplete controls for demand shift and institutional changes. Several papers have emphasized that labor demand has shifted in favor of skilled workers including college graduates, and the trend variable is probably a poor proxy of such demand shift.¹⁸ Further, union activity was liberalized in 1987 presumably raising wages of less educated workers relative to college graduates, contributing to the decline in college premium. Unlike demand shift, however, union effect is likely to have had a one-time effect on the premium's levels, not necessarily a lasting effect on its fluctuations in the ensuing years.

¹⁷ These estimates are not very different from those reported in the US literature, though a bit larger. For example, Katz and Murphy (1992) estimated the elasticity of substitution in the US to be around 1.44.

¹⁸ For demand shift in Korea's labor market, see Choi and Jung (2002), and Kim (2004). This issue will be revisited in section D.



Source: The author's calculation from the SEAP and PP.

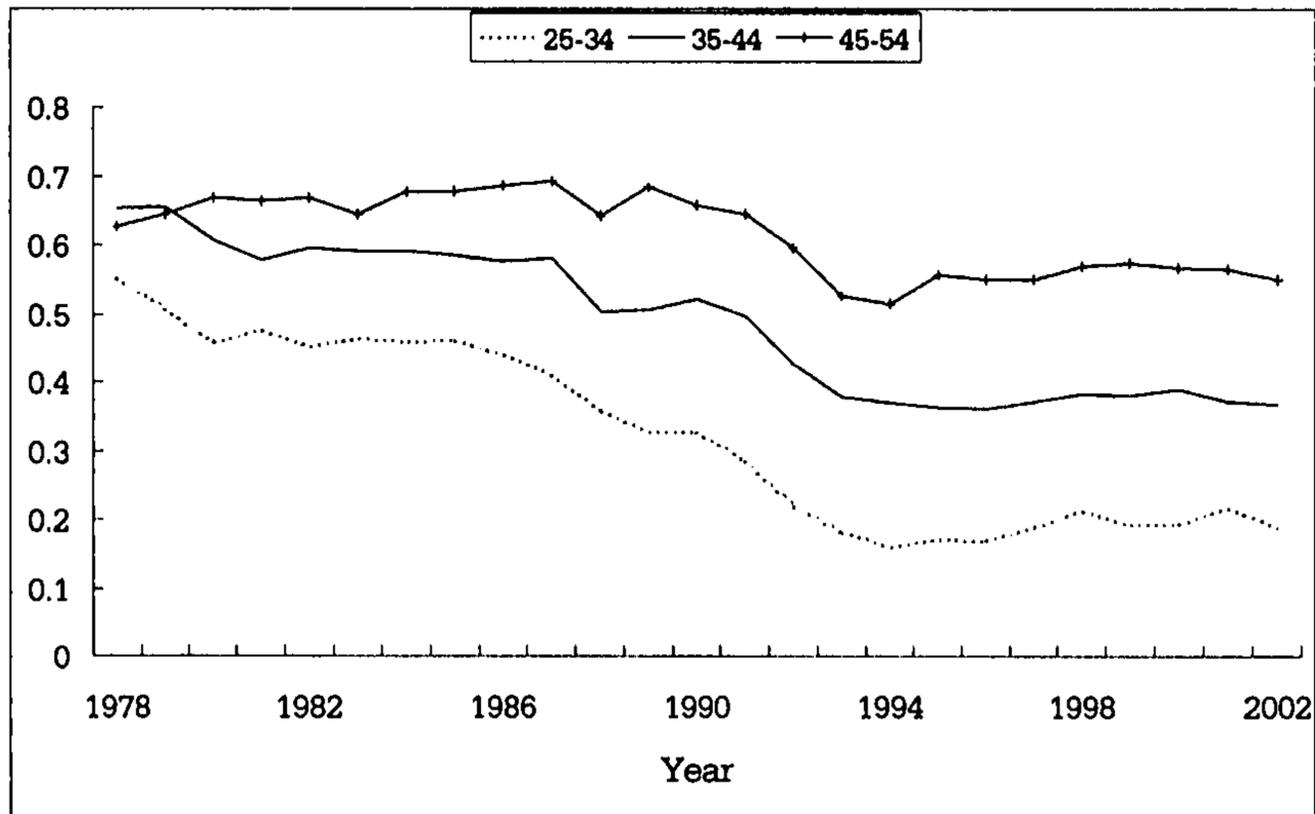
FIGURE 3

SHARE OF THE 25-34 YEARS OLD IN POPULATION, 1978-2002

B. Changes in Age Structure of Supply and Wages

Besides educational upgrading, the size of newly entering cohorts has also substantially changed over time. Figure 3 shows the magnitudes of variation in cohort sizes. As depicted in the solid line, the share of 25-34 year-old workers in the population increased from 42% in the late 1970s to 47% in the late 1980s, and then fell to 37% in the early 2000s. Jointly with varying cohort sizes, educational upgrading of newly entering cohorts have caused a non-neutral shift in age structure of labor supply among education groups, as well.¹⁹ The share of 25-34 year-old workers in high

¹⁹ Though not spelled out, one additional, and potentially very important, factor causing such non-neutrality is the difference in market-entry ages because college requires 4 additional years of education. The exact difference in market-entry age depends also on the length of military service and job placement rates. The age distribution of first-time jobs among men, estimated from the 2002 SEAP, is concentrated on the age interval [18, 25] among high-school graduate men in contrast to [23, 29] among college graduate men. Alternatively, the age at which the employment share in population reaches 90% is estimated at 28 among high-school graduate men in contrast to 30 among college graduate men.



Source: The author's calculation from the WSS.

FIGURE 4
COLLEGE PREMIUMS BY AGE GROUPS, 1978-2002

-school graduates has increased more slowly or declined faster than in total population. In contrast, the share of 25-34 year-old workers in college graduates has increased much faster in the 1980s. As a result, the young workers' share in college graduates reached a peak in 1992 while it reached a peak in 1985 and 1990 among high-school graduates and total population, respectively.

The non-neutral changes in age structure in labor supply will have differential impacts on college premiums among varying age groups to the extent that workers of varying age and education levels are imperfect substitutes with each other. Quite interestingly, however, Figure 4 shows that college premiums for three age groups (25-34, 35-44, and 45-54 year-old groups) have followed a common aggregate path, despite the apparent differences in relative supply shown in Figure 3. The only noticeable age-pattern in Figure 4, if any, is that the downward trend in college premium has been somewhat more pronounced in younger groups. The changes in college premium for these age groups are reproduced in Table 2 for three sub-periods. The table also confirms that the college premiums have moved in a similar pattern among the age groups, and that they have declined more (or increased less) in younger

TABLE 2
CHANGES IN COLLEGE PREMIUM BY AGE GROUPS

Period	Age Groups			
	All	25-34	35-44	45-54
1980-7	-0.024	-0.047	-0.027	0.024
1987-94	-0.229	-0.250	-0.212	-0.178
1994-2002	0.021	0.027	0.000	0.036

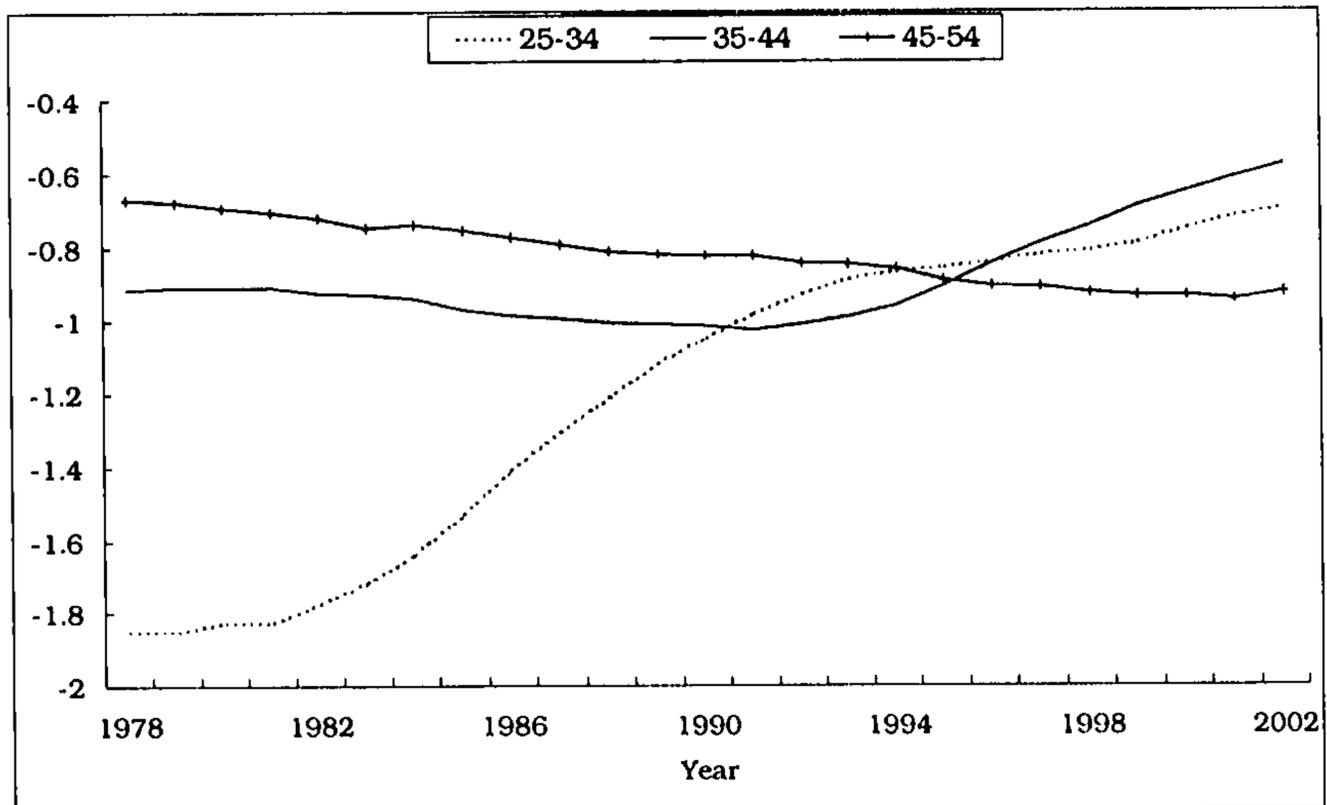
Source: The author's calculation from the WSS.

groups.

The results in Figure 4 and Table 2 contrast well to those in Figure 3. The relative prices, or college premiums, in Figure 4 and Table 2 show strong correlations among age groups, but the relative supply patterns in Figure 3 did not. The differences in time-series pattern in relative supply of college to high-school graduates among age groups are shown to be non-trivial also in Figure 5.²⁰ Log ratio of college and high-school graduates in the age 25-34 group is similar to the aggregate series previously shown in Figure 1-(A), but that in the age 35-44 group shows almost an inverse pattern, reaching a bottom around 1992. The ratio in the age 45-54 group has been continuously declining during the entire period.

The fact that relative wages (college premiums) share a common time-series pattern among various age groups despite the differences in relative supply implies that aggregate effects are a more important determinant of relative wages in age subgroups than each group's relative supply. The importance of aggregate effects implied by the common patterns in college premiums is tested below by measuring the effects of own and aggregate relative supplies on college premiums of each age group. More specifically, equation (4) is fitted against the data.

²⁰The correlation coefficients of college premiums among age groups range between 0.84 and 0.97, while those of relative supplies shown in Figure 5 range between -0.97 and 0.45.



Source: The author's calculation from the SEAP and PP.

FIGURE 5

LOG RATIO OF COLLEGE AND HIGH-SCHOOL GRADUATES BY AGE GROUPS

$$\log\left(\frac{W_{Cat}}{W_{Htat}}\right) = \alpha_a + \beta_a^I \log\left(\frac{N_{Cat}}{N_{Htat}}\right) + \beta_a^A \log\left(\frac{N_{Ct}}{N_{Ht}}\right) + \varepsilon_{at} \quad (4)$$

W_{eat} in the above is the average real wage of workers in age group a with education e at time t and N_{eat} is the quantity counterpart. Equation (4) measures the effect of each age group's own relative supply (β_a^I) and that of aggregate relative supply (β_a^A) on age-specific college premiums. The estimation results are reported in Table 3.

Model (1) in the table shows that the coefficient of own relative supply are even wrongly signed among the oldest groups, implying a weak explanatory power of own relative supply variable. Although the coefficient is correctly signed, the explanatory power is relatively low in the 35-44 year-old group as evident in the equation's low adjusted- R^2 . When regressing the premiums on aggregate relative supply (Model (2)), the adjusted- R^2 improves significantly for older groups and the coefficient estimates are all correctly signed. That is, aggregate relative supply is a much better indicator of the

TABLE 3
EFFECTS OF OWN AND AGGREGATE RELATIVE SUPPLIES
ON COLLEGE PREMIUMS

Regressors	Age								
	Model (1)			Model (2)			Model (3)		
	25-34	35-44	45-54	25-34	35-44	45-54	25-34	35-44	45-54
Own Relative Supply (β_a^I)	-0.299	-0.414	0.483				-0.241	0.105	-0.684
	(0.018)	(0.142)	(0.092)				(0.084)	(0.065)	(0.422)
Agg. Relative Supply (β_a^A)				-0.613	-0.496	-0.222	-0.124	-0.540	-0.511
				(0.044)	(0.034)	(0.036)	(0.175)	(0.042)	(0.181)
Adjusted- R^2	0.918	0.238	0.523	0.889	0.898	0.608	0.916	0.904	0.634

Notes: 1) Standard errors are in the parentheses.

2) Time series of 25 years between 1978 and 2002 is used for the estimation.

Source: The author's calculation from the WSS, SEAP and PP.

changes in age-specific college premiums. One apparent pattern is that the absolute magnitude of the estimates decreases with age, reflecting the age pattern in the changes of college premium previously shown in Figure 4. Finally when both relative supply measures are included in the equation (Model (3)), little is gained in terms of the goodness of fit, and the statistical significance of own relative supply in the 35 year-old or older groups disappears. The only exception is the youngest group, but the exception simply reflects that the aggregate and the youngest group's relative supplies are highly correlated.²¹

The importance of aggregate effects in age-specific college premiums suggests the possibility that young and old workers are highly substitutable within each education group. That is, a rapid increase of college educated workers at entry level (or among young workers), for example, commonly affects older workers' wages because they are quite substitutable for older workers. Such common effects will be suppressed if workers of varying age groups are not substitutable and own relative supplies substantially differ among them, but this is obviously not true. Instead, substitutability among age groups appears to be sufficiently strong to generate an

²¹ The correlation coefficient is 0.98.

age-neutral pattern, and the differences in own relative supplies generate only small differences in the magnitude of changes in college premiums.

Indeed, the age-differences in the magnitude of college premium changes are explained by the differences in relative supply of college to high-school graduates among age groups. To see that, I estimate the following equation.

$$\log\left(\frac{W_{eat}}{W_{et}}\right) = \alpha_{ea} + \beta_{ea} \log\left(\frac{N_{eat}}{N_{et}}\right) + \varepsilon_{eat} \quad (5)$$

Equation (5) estimates the own relative supply effect on relative wages in each age group (β_{ea}) for each education suppressing the possibility of cross-effects among age groups. A more general version of equation (5) would allow the relative supply of other age groups to affect the relative wages as well, as described below.

$$\log\left(\frac{W_{eat}}{W_{et}}\right) = \alpha_{ea} + \sum_j \beta_{ea}^j \log\left(\frac{N_{ejt}}{N_{et}}\right) + \varepsilon_{eat} \quad (6)$$

In equation (6), j represents age groups, and the coefficients (β_{ea}^j s) measure the effects on age group a 's relative wages of age group j 's relative supply within education group e . Equations (5) and (6) assume substitution among workers of varying education levels only through aggregate effects, or alternatively, they assume that the aggregate production function is separable in education groups.²² As a result, relative supplies of other education groups do not appear in them. This setup is based on the results that the aggregate, not age-specific, effects are the main determinants of college premiums in age groups. To the extent that this assumption differs from reality, the predicting power of equations (5) and (6) will be reduced. In estimating equation (6), symmetry restriction is imposed on the estimates such that $\beta_{ea}^j = \beta_{ej}^a$ for all j , a , and the

²² In particular, the separability assumes that aggregate production function is of the following type; $Y=AG(K)F(H(h_1, h_2, \dots, h_A), C(c_1, c_2, \dots, c_A))$ where K is physical capital, H and C are composite aggregate inputs of high-school and college graduates, and h_a and c_a are inputs of high-school and college graduates of age a .

TABLE 4
EFFECTS OF RELATIVE SUPPLY AMONG AGE GROUPS

		25-34 Years Old	35-44 Years Old	45-54 Years Old
Equation (5)	High-School	-0.069(0.023)	-0.063(0.023)	-0.175(0.037)
	College	-0.093(0.014)	-0.057(0.011)	-0.171(0.023)
Equation (6)	High-School			
	25-34 Years Old	-0.022(0.006)	0.040(0.012)	0.001(0.010)
	35-44 Years Old	0.040(0.012)	-0.103(0.027)	0.081(0.023)
	45-54 Years Old	0.001(0.010)	0.081(0.023)	-0.211(0.027)
	College			
	25-34 Years Old	-0.025(0.004)	0.027(0.006)	0.033(0.005)
	35-44 Years Old	0.027(0.006)	-0.046(0.010)	0.008(0.010)
	45-54 Years Old	0.033(0.005)	0.008(0.010)	-0.157(0.016)

Notes: 1) Standard errors are in the parentheses.

2) Time series of 25 years between 1978 and 2002 is used for the estimation.

Source: The author's calculation from the WSS, SEAP and PP.

results are shown in Table 4.²³

The estimated coefficients on relative supplies in Table 4 are rather small in both equations. Equation (5) shows that there is little difference in own supply effects of age groups between high-school and college graduates' samples. Equation (6) produces correctly signed own elasticities, and also many statistically significant cross elasticities, implying that the cross-effects are not trivial.

A few more patterns on the coefficients on own relative supply variables are noticeable in Table 4. First, they tend to be greater among older groups, implying that experience matters. Second, the coefficients are generally small, and even smaller in equation (6), although they are statistically significant. Small estimates imply that workers of varying ages are easily substitutable, although such substitutability may decline with age. For example, the estimates of 0.022 and 0.025 among young workers imply that there would be almost no relative wage effect.²⁴

²³ The estimates in equation (6), β^J_{ca} s are analogous to factor price elasticities.

²⁴ Comparable estimates are much greater in the U.S.. Murphy and Welch

Finally, the coefficients tend to be smaller among college graduates than among high-school graduates, which is somewhat puzzling. Welch (1979) showed that substitution among age groups was more difficult for college graduates, as their life-cycle human capital accumulation was faster. His estimates on the effects of own supply ranged between -0.261 and -0.369 among entry-level high-school graduates and between -0.665 and -0.907 among entry-level college graduates.²⁵ Although the estimates from the U.S. data cannot be directly comparable to those in Table 4, the smaller estimates among college graduates are still difficult to explain given the pattern that college graduates accumulate more human capital and see a faster wage growth over their life-cycle than high-school graduates.²⁶ Steeper human capital accumulation profile would make old college graduates less replaceable with young college graduates than old high-school graduates with young high-school graduates. This paper does not provide an answer for this puzzle, and I leave it to future research.

The coefficients in Table 4, despite their being small, reasonably well predict the age-pattern in changes in college premium. The changes in college premiums in age group a can be decomposed as below.

$$\Delta \log \left(\frac{W_{Cat}}{W_{Hat}} \right) = \Delta \left[\log \left(\frac{W_{Cat}}{W_{Ct}} \right) - \log \left(\frac{W_{Hat}}{W_{Ht}} \right) \right] + \Delta \log \left(\frac{W_{Ct}}{W_{Ht}} \right) \quad (7)$$

The first term on the right hand side is age-specific change and the second is the aggregate changes. The estimates in Table 4 are used to predict the first term, the result of which is compared to the actual values in Table 5.

It indicates that both equations (5) and (6), despite their simplicity,

(1992) report that own elasticity of complementarity is -2.1, -0.4 and -0.2 for high-school graduates workers with 1-10, 11-20, 21-30 years of experience, and -2.5, -0.3 and -0.4 for college graduate workers.

²⁵ Persistent effects were estimated also to be greater among college graduates. The elasticity ranged between -0.080 and -0.096 among high-school graduates, and between -0.194 and -0.218 among college graduates (Welch, 1979). See also Murphy and Welch (1992) for similar comparison between high-school and college graduates.

²⁶ This will be shown in Table 6 in the next section.

TABLE 5
ACTUAL AND PREDICTED CHANGES IN COLLEGE PREMIUM BY AGE GROUP

Age Groups	Periods						
	1980-7		1987-94		1994-2002		
	Actual	Predicted	Actual	Predicted	Actual	Predicted	
Based on Eqn. (5)	25-34	-0.023	-0.033	-0.021	-0.017	0.006	0.008
	35-44	-0.003	0.014	0.017	0.012	-0.022	-0.010
	45-54	0.048	0.046	0.051	0.049	0.014	0.047
Based on Eqn. (6)	25-34	-0.023	-0.017	-0.021	-0.021	0.006	0.006
	35-44	-0.003	-0.001	0.017	0.022	-0.022	-0.025
	45-54	0.048	0.068	0.051	0.035	0.014	0.044

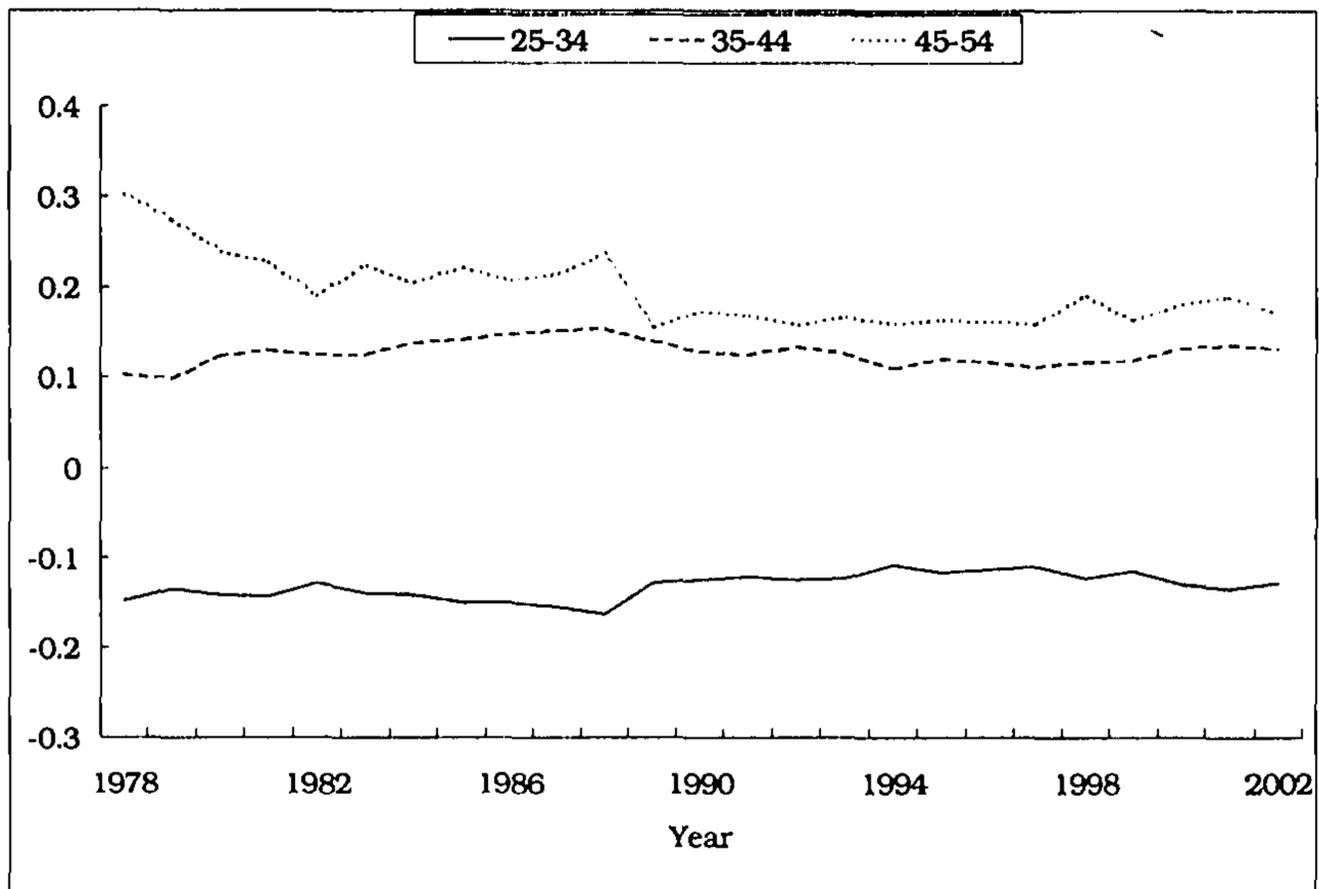
Source: The author's calculation from the WSS, SEAP and PP.

predict reasonably well the actual changes in college premiums by age groups net of the aggregate effects, or $\Delta [\log (W_{Cat}/W_{Hst}) - \log (W_{Ct}/W_{Ht})]$. Equation (6) performs slightly better, but the difference is small. Although the estimates in Table 4 indicated that cross-effects are not trivial, the similarity in predicted results from the two equations suggests that a simple model featuring only own relative supply can approximate the actual changes quite well.

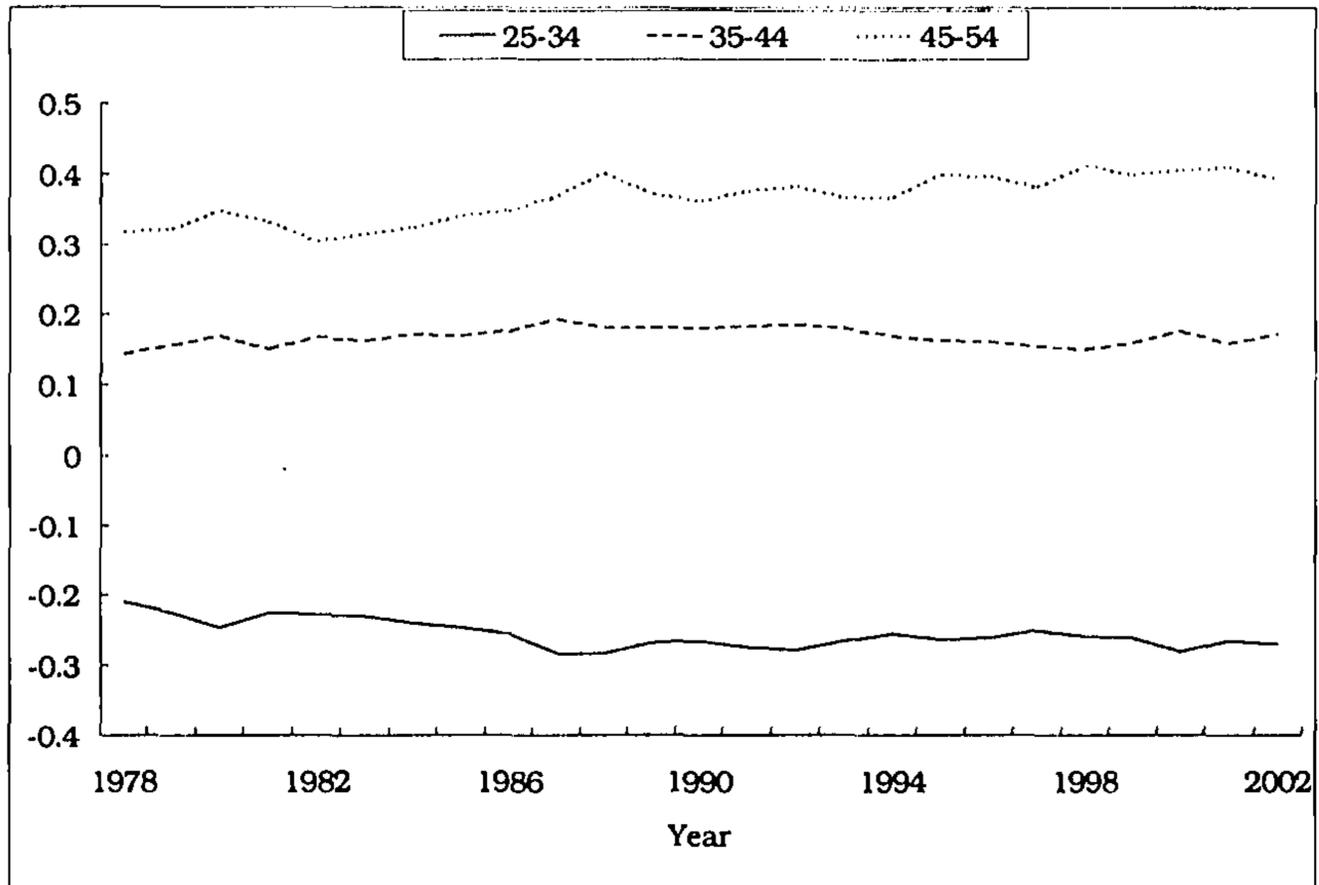
The above results indicate that cohort size can explain the relative magnitudes in changes in college premium among age groups, or the age-differences, previously depicted in Figure 4. Nevertheless, an important finding is that changes in age structure of wages is characterized by small effects of relative supplies, implying a high elasticity of substitution among age groups. This is also reflected in relatively stable age-wage structure in Korea.²⁷

²⁷ As was shown in Figure 3, the share of the 25-34 year-old among college graduates increased by 21.2% points between 1978 and 1992, and fell by 12.9% points between 1992 and 2002. The changes in relative wages were much smaller during the period; the relative wage of young college graduates to the aggregate college wages fell only by 0.067 log points, and then rose only by 0.009 log points. Among high-school graduates, the share of young workers fell by 16.0% between 1978 and 2002, which led to an increase of the group's relative wage of only 0.021 log points. Such limited changes in relative wages have led to a relatively stable age structure in wages.

(A) High-School Graduates



(B) College Graduates

**FIGURE 6**

RELATIVE WAGES OF AGE GROUPS TO THE MEAN WITHIN EDUCATION

Figure 6 depicts log ratio of an age group's wage to the mean wages, $\log(W_{eat}/W_{et})$, within each education group, $e=C, H$. Panel (A) in the figure shows that age-wage structure has been quite stable since 1980 among high-school graduates.²⁸ Among college graduates (Figure 6-(B)), there has been slight widening of age-wage structure, mostly accounted for by the relative increase in young workers. The trend is quite weak, however; the wage gap between the young (25-34 year-old) group and the old (45-54 year-old) group has expanded only by 14.2% points between 1978 and 2002, corresponding to only a 0.6% annual increase, despite the rapid increase in young college graduates.

Stable age structures of wages in Figure 6 imply that workers of varying ages are highly substitutable with each other within education, confirming the pattern previously deduced from Table 4. As a result, changes in educational distribution at entry level affect wages of all age groups through the common channel of aggregate relative supply of education groups, and this effect determines the basic time-series patterns of college premium in all age groups. The commonness in time-series patterns implies that an age-neutral single price for skills within each education can reasonably approximate the economy.

C. Decomposition of College Premiums: Role of Cohort Quality

The results in previous sections indicate that most of the changes in college premium reflect age-neutral aggregate fluctuations and that the relative supply of workers of varying ages has played a limited role in affecting the age structure of wages within education. This section looks more in detail into the decomposition of changes in college premiums into the aggregate effects and other components. In particular, I investigate the possible variation in underlying productivity (quality) among cohorts within education groups.

The possibility that productivity differs among cohorts arises because of rapid educational upgrading. Juhn, Kim, and Vella (2005) estimate the changes in cohort quality among college graduates from the U.S. data, and they find that the sudden

²⁸ There took place a one-time decrease in age premium among high-school graduates between 1988 and 1989, the cause of which is not clear. Except the year, the premium has been stable.

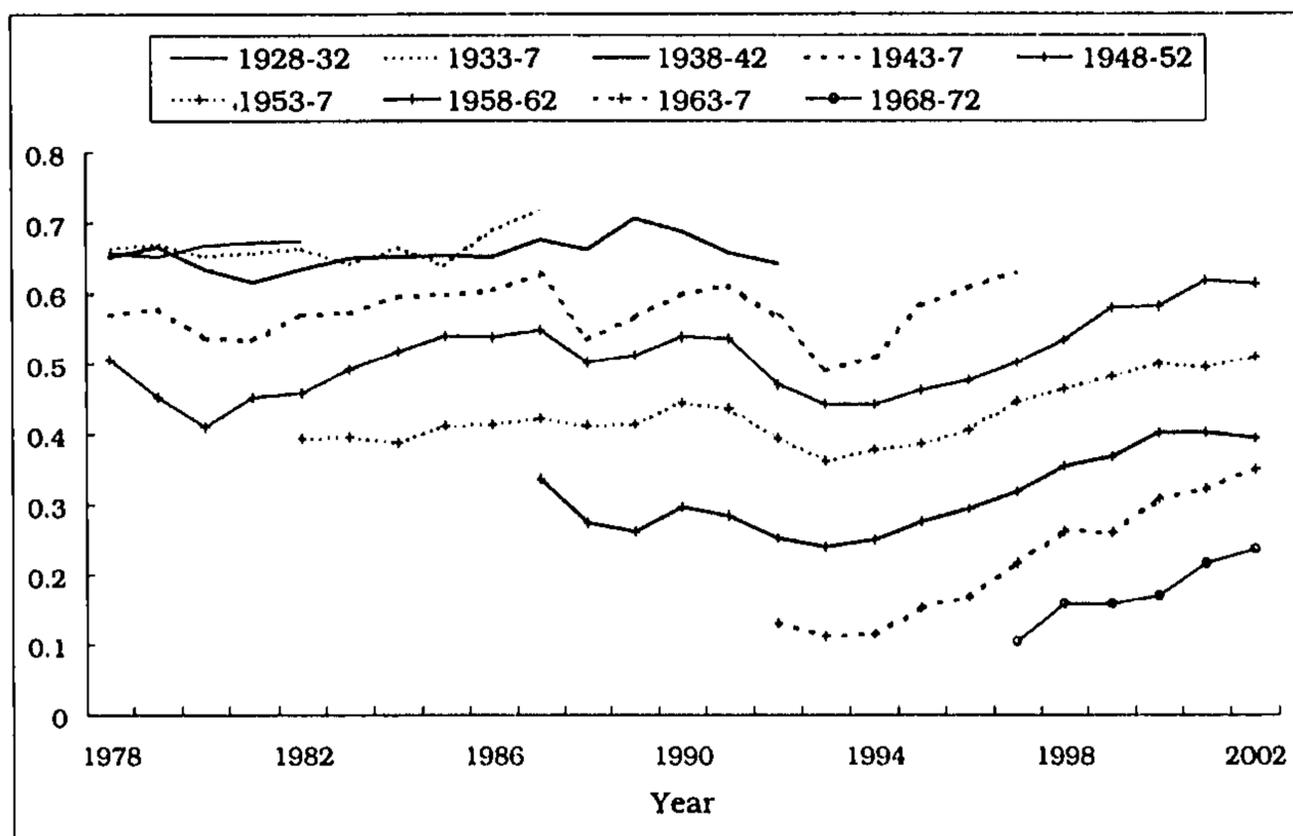


FIGURE 7

LIFE-CYCLE PATTERNS OF COLLEGE PREMIUMS BY BIRTH-YEAR COHORTS

increase in college enrollment during the Vietnam War era was associated with a weak decline in cohort quality among college graduates. Such negative association between the size of college-educated workers and their average quality may arise from fewer educational resources available per student and/or from individual heterogeneity in the population as less abler students advance to colleges.²⁹ Given the rapid educational upgrading in Korea, recent college graduates may not be as productive as their predecessors.

Figure 7 is somewhat informative on the issue. It depicts college premiums for each 5-year birth cohort over the 1978-2002 period. Two patterns are noticeable. First, college premiums fluctuate in a common pattern in all birth cohorts, indicating again the importance of aggregate effects. Second, new cohorts have started with lower college premiums in their life-cycle compared to their predecessors, and their premiums never caught up!

²⁹ There are mixed findings on the relationship between school resources and students' performances in the U.S. literature. See Card and Krueger (1996) for the survey. Juhn, Kim, and Vella (2005) considers a theoretical model based on heterogeneity that correlates student quality and the size of population educated.

The ever-decreasing entry-level college premiums among recent cohorts in Figure 7 may also reflect the aggregate effects. That is, an entering cohort's college premium is lower than that in the previous year because the aggregate effects relatively reduce the "single" price for college skills. Further, though not expected to be large, a greater share of college graduates in recent cohorts may have placed a downward pressure on their college premiums within cohorts through substitution among age groups. Thus the important question would be "how much of the ever-decreasing pattern of new cohorts' college premium reflects anything other than the common aggregate and age-specific substitution effects?"

To answer the question, the following model is employed. Real wages of workers in birth-cohort b (born in year b) with education e at time t , W_{et}^b , are modeled as below.³⁰

$$W_{et}^b = \pi_{eat} \cdot \Gamma_e(a) \cdot \mu_e^b \quad \text{where } a = t - b \quad (8)$$

In the above, π_{eat} is the market price for the unit productivity of workers of age a with education e at time t . μ_e^b measures the average productivity of cohort with education e born in b at entry, or the cohort (quality) effects. $\Gamma_e(a)$ is an education-specific function of life-cycle productivity augmentation, capturing human capital accumulation path along life-cycle among workers. Taking natural logarithm on (8) yields equation (9).

$$\log W_{et}^b = \log \pi_{eat} + \log \Gamma_e(a) + \log \mu_e^b \quad (9)$$

In equation (9), $\log \pi_{eat}$ will not vary with a if workers of varying ages are perfect substitutes for each other within education groups. That is, there exists a single-price, $\log \pi_{et}$, for skills of workers with education e . To the extent that workers of varying ages are not perfect substitutes for each other, $\log \pi_{eat}$ will vary with a , or one can write $\log \pi_{eat} = \log \pi_{et} + \rho_{eat}$. The deviation, ρ_{eat} will be negative (positive) for the age group a with greater (smaller) relative supply as it reflects substitution effects among age groups. Thus in principle, both the aggregate and age-specific substitution effects are captured in $\log \pi_{eat}$ through $\log \pi_{et}$ and ρ_{eat} , respectively.

³⁰ W_{et}^b is by definition identical to real wages of workers of age $t-b$ with education e at time t , or $W_{et(t-b)t}$.

Further in the equation, cohorts are allowed to differ in their average basic starting productivity (or ability) within education through $\log \mu_e^b$. If cohorts do not differ in their starting productivity, all the changes in real and relative wages can be explained by the aggregate (price) effects and age-specific substitution effects. Thus the cohort/education structure of $\log \mu_e^b$ would be the key to answering the main question raised above.

Finally, $\log \Gamma_e(a)$ measures the underlying age-profile of productivity (or earnings) common to all cohorts within education, which is assumed to be fixed over time independent of the changes in relative supply among age groups.³¹ The age-profile, $\log \Gamma_e(a)$, is approximated by a quadratic function of age, a . As the age-profile contains a linear age term, there takes place a singularity problem in regressors, and I follow Deaton (1997) to recover year, cohort and age effects from the estimation.

Equation (9) is estimated from the 25 years' repeated cross-section of 25-54 year-old workers at each education level between 1978 and 2002. The unit of observation is a single-year birth cohort by education, and each equation uses 25×30 year-age observations over 54 birth-year cohorts born between 1924 and 1977. The aggregate price effects, $\log \pi_{et}$, are estimated by a series of year dummy variables and the cohort effects, $\log \mu_e^b$, are estimated by a series of cohort dummy variables. The age-specific substitution effects, ρ_{eat} , are estimated by imposing $\rho_{eat} = \rho_e \log(s_{eat})$ to the equation where s_{eat} is the share of workers of age a in education group e at time t . Although cross-substitution among age groups is not rejected (see Table 4), I use this simple form to control for substitution across age groups because Table 5 suggested that there was only a small gain in allowing cross-substitution among age groups.

The estimation results of age-productivity profile and substitution effects are summarized in Table 6. Age-profile of productivity (or accumulating human capital) is steeper among college graduates; if a high-school graduate and a college graduate from a cohort earn

³¹ Substitution among age groups is captured in ρ_{eat} in this model. Another way of incorporating substitution among age groups in equation (8) is to allow the age-productivity profile to vary over time, $\Gamma_{et}(a)$ instead of $\Gamma_e(a)$, while using the common price π_{et} instead of π_{eat} . This alternative specification can be used to test the robustness of the estimates. More discussion on this is provided in the next section.

TABLE 6
AGE-PROFILE AND SUBSTITUTION EFFECTS IN REAL WAGES BY EDUCATION

	High-School	College
Age	0.119 (0.002)	0.156 (0.003)
Age ² /100	-0.130 (0.001)	-0.154 (0.003)
log(s_{eat})	-0.103 (0.014)	-0.022 (0.005)
Year & Cohort Controls	yes	yes
Adjusted- R^2	0.998	0.995

Note: Standard errors are in the parentheses.

Source: The author's calculation from the WSS, SEAP and PP.

the same wages at age 25, the latter's wages will be higher by 24.4% at age 35, by 48.0% at age 45 and by 66.7% at age 54. Further the profile reaches a peak at an older age among college graduates; the peaks are at age 45.8 among high-school graduates and at age 50.6 among college graduates. Age-specific substitution effects measured as the coefficient on $\log(s_{eat})$ are again small, though statistically significant, indicating that substitution among age groups has been merely one of many reasons why newly entering cohorts with higher education have earned relatively lower wages, but not the most important reason.

The difference in age-profile between education groups implies that college premium of a given cohort, *ceteris paribus*, must increase over time or along their career. Thus the fluctuations in college premiums within birth-year cohorts shown in Figure 7 are likely to reflect the aggregate and age-substitution effects. In particular, the rising age-profile of college premium is likely to have been countered by the falling aggregate effects.

Based on the estimates in Table 6 and the estimates on year and cohort dummies, the overall changes in college premiums can be decomposed into the aggregate effects ($\log \pi_{et}$), age-specific substitution effects (ρ_{eat}), and cohort effects ($\log \mu_e^b$). Age-profile of productivity ($\log \Gamma_e(a)$) are assumed to be stable over time for both education levels, and thus they do not affect the changes in college premium over time. To measure each component's contribution on the changes in college premium, the estimates of $\log \pi_{et}$ and $\log \mu_e^b$ among high-school and college graduates are used to construct the following series.³²

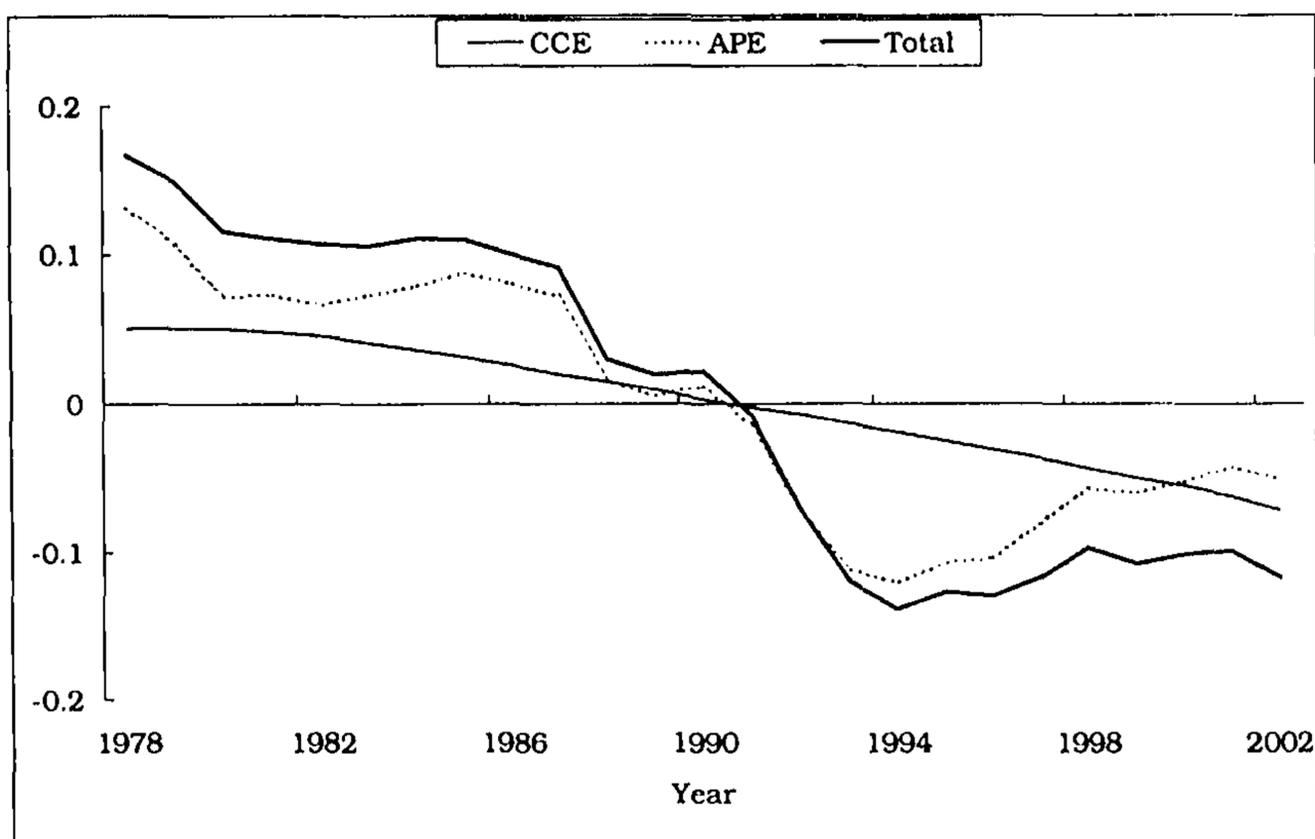


FIGURE 8
DECOMPOSITION OF CHANGES IN COLLEGE PREMIUM

TABLE 7
DECOMPOSITION OF CHANGES IN COLLEGE PREMIUM

	Total Changes	APE	CCE
1980-7	-0.024	-0.000	-0.030
1987-94	-0.229	-0.193	-0.040
1994-2002	0.021	0.071	-0.053

Note: APE represents the aggregate price effects, and CCE represents the cohort composition effects.

Source: The author's calculation from the WSS, SEAP and PP.

$$APE = \log \pi_{ct} - \log \pi_{lt} ,$$

$$CCE = \log M_{ct} - \log M_{lt} , \text{ where } M_{ct} = \sum_a s_{ca} \mu_c^{t-a} \quad (10)$$

³² The contribution of age-specific substitution is somewhat more difficult to define as it varies among single-year age groups. Thus the effects are considered as the residual effect here.

In equation (10), APE and CCE represent the aggregate price effect and cohort composition effect in college premiums, respectively. The latter would be constant (and not contributing to the changes in college premium) if there had been no changes in cohort-specific productivity (μ_e^b). Both APE and CCE are plotted in Figure 8 over time together with the actual college premiums. All series are normalized to have a zero mean over the period to facilitate their comparison. Also Table 7 compares the magnitudes of each component's changes for three sub-periods.

The implications from Figure 8 and Table 7 are quite straightforward. Year effects, reflecting the aggregate price effects determined by demand and supply, are the main determinant of the changing pattern of college premiums. They account for 76.3% of the decline in college premium between 1980 and 1994, and also indicate that net demand shift has favored college graduates since 1994. Cohort composition effects have been on a steadily declining trend, implying that productivity gap between college and high-school graduates have been narrowing. Such narrowing gaps account for 27.7% of the overall decline in college premiums between 1980 and 1994. In the post-1994 period, the narrowing gaps counteracted the favorable net demand shift toward college graduates partially offsetting the effects of higher price on college skills. The non-trivial cohort composition effects imply that the ever-decreasing college premiums among newly entering cohorts documented in Figure 7 reflected not just year (supply and demand) and substitution effects, but also narrowing productivity gaps between college and high-school graduates.

D. Discussion

The results so far have revealed a few important aspects in wage determination in the Korean labor market. Additional, but brief, discussion on a few of them appears due. First, year effects in the previous section were defined as a composite of the effects of supply and demand. The changes in relative and aggregate supplies of various types of workers have already been documented in detail, and they are shown to have placed a downward pressure on college premiums. Demand shift, however, is difficult to measure, although some imperfect estimates for it based on Katz and Murphy (1992) are available.³³ A demand shift estimate of Katz-Murphy type may

be written as below.

$$DS_{it} = \sum_j e_{jt} \Delta \log(s_{jt}) \quad (11)$$

In the above, DS_{it} is the demand shift measure for worker type i at time t . e_{jt} is sector j 's time-invariant share in total employment of worker type i , and is obtained from averaging sector j 's share in worker type i 's employment at time t , e_{jtt} , over the period (1978-2002). s_{jt} is the sector j 's share of total employment at time t . These employment shares, e_{jtt} and s_{jt} , are all measured in efficiency units by multiplying employment with average wages.³⁴ I estimate the demand shift for high-school and college graduate men by age using 19 sectors for three 7-year sub-periods, and the results are given in Table 8.³⁵

Table 8 indicates that demand shift has relatively favored college graduates throughout the period. The relative demand shift toward college graduates, measured in the difference between high-school and college graduates, varies across periods, being largest in the 1994-2001 period and smallest in the 1987-94 period. This pattern is somewhat consistent with the aggregate effects documented in Figure 8. Such relative demand shifts, jointly with the slowdown in growth of college graduates in aggregate supply, must have contributed to the turnaround of college premium into an increasing trend during the post-1994 period.³⁶

³³ For example, Choi and Jung (2002) show that labor demand has shifted toward highly educated workers, and Kim (2004) reports that demand has shifted toward more skilled (or high wage) workers.

³⁴ See Katz and Murphy (1992) for a more detailed discussion of the measure. They discuss at length on derivation of the measure and its property, and especially on endogeneity of the measure, which effectively limits its use to a descriptive analysis. In particular, a valid interpretation on the measure can be drawn when relative wages and relative demands move in the same direction. Otherwise, the actual direction of relative demand shift is rather indeterminate.

³⁵ 19 sectors are the following: (1) agriculture, fishery, forestry, and mining, (2) food and drink, (3) apparel and textile, (4) wood, paper and printing, (5) chemical, (6) non-metal, (7) metal product, (8) machinery, (9) electric and electronics, (10) vehicles, (11) other manufacturing, (12) public utility, (13) construction, (14) trades, (15) lodging and restaurants, (16) transportation, (17) communication, (18) FIRE and business service, and (19) other services.

³⁶ Aggregate effects may capture some effects of institutional factors, and

TABLE 8
ESTIMATES OF DEMAND SHIFT AMONG WORKER TYPES

Worker Types	1980-7	1987-94	1994-2001
High-School Graduates	0.037	0.062	-0.011
25-34 Years Old	0.051	0.064	0.003
35-44 Years Old	0.022	0.055	-0.024
45-54 Years Old	0.023	0.072	-0.026
College Graduates	0.095	0.094	0.079
25-34 Years Old	0.101	0.128	0.072
35-44 Years Old	0.091	0.087	0.078
45-54 Years Old	0.091	0.036	0.096

Source: The author's calculation from the WSS, SEAP and PP.

When disaggregated into 3 age groups, it appears that relative demand has shifted toward young workers in both education groups although there are some differences across periods. It is interesting to investigate how these relative demand shifts would have interacted with relative supply (documented in Figure 3) to affect relative wages among age groups because it is possible that age structure of wages may have remained stable due to the potentially offsetting effects of relative demand and supply.³⁷ Among high-school graduates, demand shift has favored workers of age 25-34 (young workers) relative to those of age 45-54 (old workers) in the 1980-7 and 1994-2001 periods, but not in the 1987-94 period. Relative supply of young workers slightly increased during the 1980-7 period, but has been decreasing since 1987. Thus both relative demand and supply have the same directional effect on relative wages of young workers during the 1980-7 (a negative effect) and 1987-94 periods (a positive effect). Only during the 1994-2001 period, relative demand and supply may have had offsetting effects on relative wages of young high-school graduates

one of the most likely factors would be the increased union activity since the second half of 1987. Recalling the changes in aggregate college premium documented in Figure 2, one can easily see that there took place a sudden drop of college premium between 1987 and 1988. No concrete evidence in this paper associates the change with increased union activity, but their association cannot be quickly dismissed. A more detailed discussion on the effect of union activity is left for future studies.

³⁷ I thank an anonymous referee for raising this possibility.

to old high-school graduates.

Among college graduates, demand shift has favored young workers to old workers in the 1980-7 and 1987-94 periods, but not in the 1994-2001 period. Relative supply of young workers increased during the 1980-7 period and also between 1987 and 1994, but it has been decreasing since 1994. As a result, both relative demand and supply have the same directional effect on relative wages of young workers in all three sub-periods - a negative effect between 1980 and 1994, and a positive effect between 1994 and 2001. That is, relative demand must have reinforced the pressure on relative wages, if any, placed by relative supply changes for most of the periods. Thus one may safely conclude that stable age structure of wages documented in the previous sections is not an artifact of offsetting effects of relative demand and supply.

Second, the extent of substitutability among age groups within education implicit in Table 4 is somewhat accountable by the pattern of job segregation among age groups. In Table 9 in which job segregation indices among various groups are reported,³⁸ jobs held by 45-54 year-old workers appear to be more different from those held by younger workers in both education groups. At the same time, job segregation indices between high-school and college graduates are estimated 0.641 during the same period, implying segregation based on age is much weaker than that based on education. This is consistent with the finding that substitutability is stronger among age groups than among education groups (Table 1 vs Table 4).

However, the age-education pattern of job segregation is not quite consistent with the finding that substitution among age groups is easier among college graduates. Table 9 indicates that jobs are more segregated between age groups among college graduates than among high-school graduates. Further the estimates in Table 6 indicated that age-profile was steeper among college graduates implying greater human capital accumulation along age. These would jointly imply that substitution among age groups should be more difficult among college graduates, but the puzzle is that there exists little evidence for it. A more detailed research is required to

³⁸ Jobs are defined as industry-occupation cells, and the segregation index between group k and q is obtained from the usual formula, $(\sum_j |s_j^k - s_j^q|/2)$, where s_j^k is the share of job cell j as a fraction of k -type workers.

TABLE 9
JOB SEGREGATION INDICES AMONG AGE GROUPS

Year	Age Groups					
	High-School			College		
	25/34 vs 35/44	35/44 vs 45/54	25/34 vs 45/54	25/34 vs 35/44	35/44 vs 45/54	25/34 vs 45/54
1985	0.330	0.394	0.504	0.424	0.405	0.603
1990	0.335	0.320	0.481	0.457	0.330	0.589
1995	0.295	0.322	0.441	0.381	0.426	0.612
2000	0.302	0.346	0.466	0.377	0.439	0.621
Average	0.316	0.346	0.473	0.410	0.400	0.606

Note: The indices are obtained from the sample of wage/salary earning men of age 25-54 in the SEAP. Further, jobs are defined as 2-digit industry by 2-digit occupation cells.

give a full account for this.

Third, the estimated cohort-specific productivity (cohort effect) indicates that there has been a non-trivial change in relative productivities among education groups. But its interpretation needs caution because, to the extent that substitution effects among age groups are incompletely controlled for in equation (9), any remaining substitution effects are likely to show up in the estimates of cohort effects causing a bias in the estimate of cohort effects, $\log \mu_e^b$.

Two methods are tried to measure the significance of such bias. First, age-specific substitution effects are allowed to have a time-specific coefficient, or $\rho_{eat} = \rho_{et} \log(s_{eat})$ in equation (6). Second, equation (9) is modified to capture age-specific substitution effects through time-specific age profile, $\Gamma_{et}(a)$, while allowing no age-variation in skill prices ($\rho_{eat} = 0$). Both methods, in principle, allow a more flexible formula for substitution effect, even risking the possibility that some genuine cohort effects are also captured into substitution effect resulting in underestimates of cohort effects. The estimates for cohort effects, $\log \mu_e^b$, from these modified models look quite different from the original estimates, but their differences among education groups, $\log \mu_c^b - \log \mu_h^b$, are found to be qualitatively quite similar to the ones used in Figure 8 and Table 7. As a result, the estimated CCE series in these modified models

also show a similarly declining trend.

The similarity suggests that the declining trend in productivity gaps among educational groups is not necessarily an artifact of incomplete controls for substitution effects. Although the bias arising from substitution effects may not be non-trivial, they are mostly canceled at least in the differences between high-school and college samples, and the declining cohort effects in college premiums are rather robust. The effects, however, are somewhat reduced under a more flexible formula for substitution effects.

IV. Concluding Remarks

This paper has investigated the changes in absolute and relative wage structures in Korea's labor market, and documented a few interesting findings. One distinct feature is that aggregate effects are the dominating factor in determining college premiums, and substitution among age groups, though not completely ignorable, appears to have played only a limited role in determining college premiums despite rapid changes in age-structure of labor supply. Cohort-specific productivity (or cohort quality) is rather a more important determinant of college premium than cohort-size effects (or age-specific substitution effects), and narrowing of such productivity gaps between high-school and college graduates has contributed non-trivially to the declining trend of college premium until recently.

The empirical findings suggest that the changes in college premium are mostly accounted for by changes in relative supply, but there still remain unaccounted variations. In particular, the increasing trend in college premium during the post-1994 period is explained neither by relative supply changes nor by cohort quality effects. The only admissible account for the rising college premium appears to be net demand shift. Continued expansion of college education among recent cohorts has not been sufficient to maintain the previous rate of new college graduates' flow into the workforce due to falling cohort size. The slowdown in growth of new college graduates must have given way to demand so that the net demand shift for college workers turned positive.

One may consider the hypothesis of net demand shift in favor of college graduates at odds with concentration of unemployment

among young college graduates in recent years. There can be a few explanations for this seemingly incompatible wage and employment outcome. First, as younger workers are more college-educated, demand shift toward college graduates is likely to be offset by a greater relative supply of young college graduates. This "congestion" effect is not expected to be large, though, given high substitutability among workers of varying ages. Second, demand shift toward college graduates may have favored older college graduates more because of "falling" relative quality (productivity) of new college graduates. Some consistent pattern of demand shift with this hypothesis was found for the 1994-2001 period in Table 8. Third, institutional factors such as employment protection for existing workers incurs additional costs on new hire, which would discourage firms from new hiring. Such effects are expected to be more pronounced if new and old workers are highly substitutable. This hypothesis, however, will be complete only with presence of certain wage rigidity.

Finding the reasons for youth unemployment is beyond the scope of this paper, and I mention them only to emphasize a general-equilibrium approach encompassing the inter-dependence of market outcomes, underlying labor market mechanisms, and institutions. For example, high substitutability among age groups is expected to reduce congestion effects and youth unemployment, but at the same time, it can serve as a reason to intensify youth unemployment under certain institutions. This paper attempts to provide a few implications that should be taken into account in such general-equilibrium models, focusing on the role of substitutability among various groups of workers. For it does not only determine relative wages but is also a key to the spreading mechanism of labor market effects from an exogenous shock in general.

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