「지방정부연구」 제6권 제1호(2002 봄) : 277~300

The Effects of Education and Literacy Skills on Wage in Five Developed Countries

- Evidence of College Premium and Adult Literacy Skills -

인적자본의 임금에 대한 영향

- 선진국들에 있어서 대학학위 프리미엄과 기술능력의 영향에 관한 경험적 증거를 중심으로 -

Kwangho Jung(Seoul National University)

최근 지식정보사회로 진입한 주요 선진국들을 중심으로 임금결정과정에서 지식(knowledge)이나 기술(skills)이 과연 얼만 만큼 큰 비중을 차지하고 있는가에 대한 관심이 높아지고 있다. 특히 지난 1990년대 이후 선진국들을 중심으로 나타나기 시작한 임금불평등(wage inequality) 현상의 심화가 임금결정에서 교육(education)이나 기술의 비중이 높아지는 것과 어느 정도 상관이 있을 것이라는 가설이 지속적으로 제기되어 있다. 그러나 그동안 기존의 연구들은 기술이나 대학과 같은 고등교육이 임금구조에 어떻게 영향을 주는가에 대한 국가간 비교연구를 자료상의 제약 때문에 효과적으로 수행하지 못하였다. 또한 그 동안 국가간 임금구조의 차이의 원인으로 노동시장의 제도적 요인들(institutional factors)이 주로 고려되었으나 한편으로는 고등교육이나 기술의 영향력이 국가에 따라 어떻게 차이가 날 것인가에 대한 연구는 이루어지지 못하였다. 본 연구는 최근 선진국들을 중심으로 조사된 국제 리터러시 자료(International Adult Literacy Survey)를 이용하여 국가간 임금결정요인들 중에서, 특히 고도의 인지기술 (cognitive skills)과 대학교라는 고등교육의 프리미엄(premium)의 영향을 미국, 독일, 영국, 스웨덴, 캐나다 등 5개 선진국들을 중심으로 살펴보고 있다. 임금연구에서 실업자가 배제됨으로써 오는 표본상의 편향(sample selection bias)문제를 극복하기 위하여 Heckman's 2 단계과정법 (Heckman's two-step procedure)을 이용하고 있으며 20퍼센타일로(20 percentile) 되어 있는 임금구조를 분석하기 위하여 순서적 프라빗(ordered probit)모형을 사용하고 있다. 본 연구의 결과 이들 다섯 선진국들에서 모두 리터러시 기술과 대학교 프리미엄이 임금결정구조에서 상당한 영향력을 행사하고 있음을 보여주고 있다. 특히 노동조합의 역할비중 때문에 임금결정구조가 매우 다른 미국이나 스웨덴의 경우에 있어서도 두 나라 모두 기술이나 고등교육의 영향력만큼은 거의 비슷한 비중을 차지하고 있음은 어느 사회에서나 임금결정에 있어서 지식이나 기술이 중요함을 예시하고 있다. 한편 독일의 경우 기술이나 대학교의 프리미엄이 남녀간의 차이에 따라 상당히 달라짐을 보여주고 있다.

주제어: 임금불평등, 인지적 기술, 대학졸업장, 국제리터러시조사, 헤크만의 두단계추정법

I. Introduction

The United States and other developed countries have experienced a rise in wage inequality since the 1980s. Wage differentials increased along a variety of

dimensions - between college-educated and less educated workers, between young and experienced workers, and within these groups. A substantial literature now documents this rise. While some papers point to the importance of skill-biased technological change as a potential explanation (Krueger 1993; Berman, Bound, and Griliches 1994) and others point to the globalization of the economy and international trade (Murphy and Welch 1992; Borjas and Ramey 1995), there is general agreement that recent developments in the wage structure reflect an increase in relative demand for skilled workers. However, previous studies have three potential weaknesses in terms of the lack of cross-national perspective, the exploration of the nature of the skill, and the lack of comparable data.

First, few studies have examined wage inequality at cross-national perspectives, while most studies have been conducted within countries, especially in the United States. Blau and Kahn (1996a, 1996b) examined international differences in male wages and found that wage setting institutions are an important determinant of international differences in wage distribution, particularly for the high relative wages of low-skilled workers in countries with centralized collective-bargaining systems.

Second, it is still unclear what types of skills are related to the wage. It is suggested that labor skills consist of three potential sources: education, cognitive skills (ability), and job experience. In recent years, many studies report that education premium in wage is related to college degree in the United States. However, the variable of college degree ignores the fact that different majors involve different levels of skills. Further, the effects of formal education on wage do not capture appropriately labor skills related to factors such as cognitive test scores and literacy skills.

Third, prior research has been hampered by the lack of data on the reading and arithmetic skills of individual in the labor market. The lack of comparable data also prevents us from identifying the extent to which literacy skills influence the distribution of the wage across developed countries with different labor market institutions.

This paper examines the wage structure in five developed countries (Canada, Germany, Sweden, the United Kingdom, and the United States), relying on International Adult Literacy Survey (IALS)[1]. This data is nationally

1) The International Adult Literacy Survey (IALS) is a nationally representative sample. The IALS provides objective and comparable measures for the economic performance of industrialized countries. Adult literacy is no longer defined merely in terms of a basic threshold of reading ability. Rather literacy is now seen as how adults use written information to function in society. Since the 1970s, the share of low-technology, low-skill, and low-wage industries in total employment has decreased in all OECD countries, while that of high-technology, high-skill, and high-wage manufacturing have expanded.

representative and comparable. Relying on the IALS data, two recent studies (Charette and Meng, 1998; Raudenbush and Kasim, 1998) found the effects of literacy on wage, but within countries, respectively in Canada and in the United States. However, these studies assume that education (i.e., years of education) has a linear effect on wage. Studies that emphasize the effects of college premium on wage suggest a non-linear effect of education on wage. Therefore, the college premium effects as well as the linearly systematic effect of education on wage should be examined in order to avoid an estimation bias such as specification errors.

This paper includes three major parts. First, this paper considers sample selection bias relying Heckman's two-step estimation procedure. Second, after examining previous studies about labor supply and wage function in five developed countries, this paper focuses on the marginal of college degree and literacy on the level of wage. And this paper attempts to predict the degree to which human capital such as college degree and adult literacy skills has a marginal effect on the wage distribution across these five developed countries. Finally, this paper provides some plausible explanations about country differences and similarities about wage structure in terms of college premium and the level of literacy skills.

Ⅱ. Literature Review

1. Labor Skills and Wage Distribution

One of the most disturbing economic trends for the last two decades has been a growing wage gap between high- and low-skilled workers in several developed countries. The labor quality hypotheses based on this skill-biased trend involve two major competing theories (Katz and Murphy, 1992; Levy and Murnane, 1992). First, technological advances have increased the demand for high-skilled and educated workers while concurrently decreasing the demand for the low-skilled and less educated worker (Berman, Bound, and Griliches, 1994). Second, expanding international trade makes low-skilled workers in industrialized countries lose ground because they must compete with low-skilled workers in developing countries (Burtless, 1995; Katz, 1996).

More recent studies (Burtless, 1995; Wood, 1998) suggest that wage inequality is more likely a function of technological change, which produces a

Employment projections for the next two decades predict a weaker demand for low-skilled jobs and an increased moderately-skilled technical and administrative workers, and highly skilled professionals (OECD, 1995).

bias towards different types of skills, rather than the globalization of the market places. This trend has been well documented in the US and UK literature (Gottschalk and Joyce, 1998). Katz (1993) showed that the dramatic increase in the wage gap in the United Kingdom in the 1980s was tempered by overall wage growth. Using a panel of 80 UK industries from 1980 to 1989, Haskel (1997) found that the average skill premium rose by roughly 13 percentage points and computer introduction explained approximately 50% of this rise. Melkas and Anker (1997) reported that Norway experienced a dramatic change in its pay distribution and wage system from 1987 to 1991 as the country's labor demand shifted to towards high skilled laborers.

There are also substantial variations across countries in terms of various interactions between market and non-market forces. Blau and Kahn (1996b) found that the US has a larger wage gap between high- and low-skilled workers than the UK, Switzerland, Germany, Italy, Sweden, Norway, and Australia. They also noticed that the US has a more heterogeneous work force with respect to skills, education, work experience, and unionization may also contribute to higher wage inequality in the US. Other factors affect countries across the globe. Gottschalk and Joyce (1998) contend that a small increase in the age premium in Sweden and Finland may reflect some institutional constraints on market forces. Some countries have found that labor market institutions and transfers to workers tend to either promote or counteract skill-biased technical change. Decentralized wage-setting mechanisms are the most persuasive explanation for the higher wage gap in the US and UK than in other countries. In contrast, a high and pervasive minimum wage and union contract extension in France prevented the wages of unskilled workers from falling significantly despite substantial employment decline.

2. Limitations of Previous Studies

No study has explored how literacy skills closely related to intelligence and knowledge affect wage in light of cross-national studies. Rather, the literature relies on education as a proxy for skills, primarily due to lack of comparable data. The college wage premium is frequently substituted for skill to capture skill-based differentials, and many empirical studies show that the recent growth in technologyintensive industries increases this premium. Recent studies have found that the college wage premium rose sharply during the 1980s in the United States (Bound and Johnson, 1992; Katz and Murphy, 1992; Murphy and Welch, 1992). This body of research is largely based on Current Population Survey (CPS) data in the United States and shows that the proportionate difference in mean wages between male college graduates and male high school

graduates grew by 15 to 30 percentage points during that decade [2].

Globally, the education premium (measured by the ratio of the number with university to non-university degree) for men in the 1980s rose sharply in the United Kingdom and the United States where overall wage inequality has increased fastest. The college wage premium in Canada and Japan in the 1980s did not grow rapidly (Levy and Murnane, 1992). Strong demand for manufactured goods in Japan during the 1980s created a strong demand for high school educated workers, keeping modest the college wage premium against the non-college wage premium (Katz and Revenga, 1989). For women, there was switch from low-skill to high-skill majors at a rate proportionately greater than for men. Grogger and Eide (1994) reported that changes in the major distribution account for 33 percent of the change in the aggregate college wage premium among women.

Previous studies suffer from measurement and specification errors because they rely heavily on formal education in order to estimate the impact[3]. Prior research has examined whether cognitive skills as distinct from formal schooling are becoming more important in wage determination. For instance, previous research in the US has relied on various measures of cognitive skills or the ability to affect labor market outcomes[4]. However, these test scores do not

2) Katz and Murphy (1992) reported that from 1979 to 1987 the wages of men with a high school education and 1-5 years of job experience fell by 20 percent while the wages of men with college degrees rose by 10 percent. The group that experienced a particularly sharp deterioration in the relative earnings were young, less educated men. Also, Grogger and Eide (1994) reported that the female college wage premium increased based on two longitudinal surveys, The National Longitudinal Study of the High School Class of 1972 and The High School and Beyond (HSB) survey in 1980.

3) Three problems occur when only formal education is considered in order to estimate the effects of skills on wages. First, job skills can be broken down into formal education, cognitive skills such as IQ and literacy scores, and job-related experiences. The education variable (measured by years of schooling) does not consider the conditions under which individuals obtained their formal schooling and the kinds of schooling pursued. In other words, the education variable ignores the quality or type of education received. Second, it is not exactly clear what is characteristic of low-or high-skilled workers. While limited evidence suggests that high-skilled workers have increased returns to their skill level, it is difficult to pinpoint what causes this and even more difficult which skills are growing demand. Third, if education and cognitive skills are positively associated, then a measure of the contribution of education to wage that ignores the literacy variable will be biased upward.

4) Historically, measurements of labor skill consist of two dimensions: micro and macro. Micro-level research focused on education and standardized test scores as a proxy for labor skill and predictor for future earnings. Benchmarks for micro-level research include education attainment (Juhn, Murphy, and Pierce, 1991; Katz and Murphy, 1992); and test such as the AFQT (Griliches and Mason, 1972) and Knowledge of the World Work (KWW) scores (Blackburn and Newmark, 1992). But these measures are limited. Quantitative measures of education (i.e., years of education and degrees obtained) inadequately capture the cognitive skills that have become decisive in the labor market

completely reflect the effects of job skills on wages. Recent studies, therefore, have suggested the importance of reading and numerical literacy skills on labor market. They have examined the effects of literacy on wages (Rivera-Batiz, 1992 ; Murnane, Willett, and Levy, 1995; Charette and Meng, 1998; Raudenbush and Kasim, 1998)[5]. However, these literacybased studies have been conducted within the US and Canada. No comparative studies have examined the effect of literacy skills on wage in other countries.

Ⅲ. Data

The empirical analysis in this study is based on the International Adult Literacy Survey for 1994 and 1998[6]. It includes data on all wages and literacy

(Raudenbush and Kasim, 1998). Similarly, scores on multiple choice tests may be inaccurate measures of the skills that matter to high wage employers.
Macro-level studies have examined the degree of importance of labor skill indirectly through various time-series and panel data. Macro-level measures include (1) the ratio of workers who use computers in their jobs (Krueger, 1993); (2) an increase in the share of non-production workers in the wage bill of US manufacturing from 1959-1989 (Berman, Bound, and Griliches, 1994); (3) the ratio of higher educated workers (Bartel and Lichtenberg, 1987); (4) investment in computers and in research and development (Mincer, 1991); and (5) classification between high- and low-skilled manufacturing industries (Brauer and Hickok, 1995). Macro research examines the link between indirect measures of labor skill and wage and productivity.

5) For instance, Rivera-Batiz (1992) showed the impact of quantitative literacy on full time employment in the US among young women. Murnane et al. (1995) found that for US women, the increase in the return to mathematics skills between 1978 and 1986 accounted for all of the increase in the wage premium associated with post-secondary education. Charette and Meng (1998) found that quantitative literacy compared to reading ability is a significant determinant of female and male wage differential in Canada. Raudenbush and Kasim (1998) studied the effect of literacy on female and male wages by searching for gaps in knowledge and skills among people with the same educational levels.

6) The IALS is the first large international effort to measure adult literacy skills using nationally representative samples of the adult population from 1994 to 1998 across various countries. First nine countries- Canada, France, Germany, Ireland, the Netherlands, Poland, Sweden, Switzerland (French and German speaking regions), and United States in 1994 and five additional countries- Australia, the Flemish Community in Belgium, Great Britain, New Zealand, and Northern Ireland in 1996 were involved in the survey. In 1998, the other nine countries and regions- Chile, the Czech Republic, Denmark, Finland, Hungary, Italy, Norway, Portugal, Slovenia, and the Italian-speaking region of Switzerland were included in the IALS data. The test was given in the common language of each country. The definition and measurement of literacy skills are the same across countries. The IALS combined the techniques of household-based surveys with those of educational testing. Each country used a probability sample to derive results representative of the civilian non-institutionalized population aged 16-65. Despite some critics on comparability problems, the IALS data is the best available source of adult literacy skills across countries.

scores. A worker is defined as working if (1) s/he is employed; and (2) his/her wage is positive. Labor force participation rates in five developed countries are reported in Table 1.

Table 1 Labor Force Participation Rates

	Wage=0(not observed)		Wage=1(observed)	
	Female	Male	Female	Male
Canada	46.4	25.54	53.6	74.46
Germany	45.92	21.18	54.08	78.82
Sweden	1.03	0.56	98.97	99.44
UK	40.03	27.46	59.97	72.54
US	32.05	19.21	67.95	80.79

Note: The estimates are based on the weighted sample of the IALS.

Except for Sweden, a significant proportion of non-working people exists in other countries, where wages are missing for non-workers. There is general agreement about the potential importance of this missing-wage problem, and it is especially important in light of the growing evidence that much of the elasticity in estimated labor supply functions come in entry and exit decisions. In order to control the sample selection bias, we use Heckman's two step procedures.

Ⅳ. An Empirical Framework and Models for Estimating Wages

Based on the empirical framework, the reduced form wage labor participation probability and wage equations to be estimated will be discussed. Definitions of variables are given in Table 2.

1) First Step Estimation: Probit Model of the Labor Force Participation

$$\text{Probability (Employed / Unemployed)} = f(\text{Education, College Dummy, Literacy, Age, Age}^2\text{, Family Size, Marital Status})$$

The first step estimation is introduced in order to take into account the sample selection bias[7]. The dependent variable in this equation is a dummy variable that takes the value one if a women works for pay, and zero otherwise.

The independent variables include age, age^2 (age-squared), education, literacy, family size, and dummy variables for marital status[8]. In particular, family size and martial status are used to instruments to estimate for the first part of Heckman's procedure. These two instruments are excluded in the second stage of wage function. The estimation is carried out for four countries including Canada[9], Germany, Sweden, the United Kingdom, and the United States.

2) Second-step Estimation - Ordered Probit Model of Wage Equation

Wage Quintile = g (Education, College Dummy, Literacy, Age, Age^2,
Industry Dummies, Firm Size Dummies, Rho(ρ))

The IALS defines literacy skills in terms of three scales: prose, document, and quantitative. Each encompasses a common set of skills relevant for diverse tasks. Different types of literacy may have different effects on wages. Several studies (Rivera-Batiz, 1992; Murnane, Willett, and Levy, 1995) have confirmed the significant effects of quantitative skills on wages. Further, Charette and Meng (1999) found that relying on Statistics Canada's Survey of Literacy Skills Used in Daily Activities, quantitative skills have more effects on labor market outcomes than reading ability. Thus, this paper estimates separately wage equation in terms of three literacy types: prose, document, and quantitative.

The second-step estimation of the wage equation includes only working women and men. The dependent variable in the analysis is the ordered quintile value of wage distribution. The independent variables include personal characteristics such as college degree, literacy score, age (a subset of the independent variables from the first-step equation), industry-specific dummy variables, and employer size dummy variables.

---

7) There are various tests for sample selection bias such as the LMtest, the conditional moment tests, and the omitted variable test. Vella (1998) suggests that this is similar to Heckman's omitted variables test for sample selection in linear regression models. Thus, we test the null hypothesis that = 0 (i.e., $\sigma_{12} = 0$). Despite the fact that λ affects the level of wage (i.e., β_λ is significant), omitting λ creates specification errors resulting from ignoring relevant variables.

8) Marital status is not available for Germany and Sweden.

9) In Canada, the equation is carried out for four age groups as a dummy variable. The model for Canada is that d = α_1 college + α_2 literacy + α_{31} aged1 + α_{32} aged2 + α_{33} aged3 + α_{34} aged4 + α_4 family size + α_6 marital status + vi, where aged2=1 if age group is 25-35, else=0; aged3=1 if age group is 36-45, else=0; aged4=1 if age group is 46-55, else=0; if aged5=1 if age group is 55 and over, else=0; Reference age group is 15-24.

Table 2 Definition of Variables in Five Countries

Name of Variables	Description
Wage	Quintiles: 1= Lowest earner quintile 2= Next to lowest earner quintile 3= Mid-level earner quintile 4= Next to highest earner quintile 5= Highest earner quintile
Literacy skills	Test score from 0 to 500 (prose, document, quantitative)
Education	Years of schooling completed
College	Dummy variable that equals 1 if people have 4-year college degree
Family Size	Number of people living in the household
Married	Dummy variable that equals 1 if people are a married couple
Age (Canada)	Dummy variable. Reference Group is 15-24 years old
Age (UK, US, Germany, Sweden)	Continuous variable
Industry	Dummy variable. Reference group is manufacturing
Size of Employer	Dummy variable. Reference group is less than 20 employed
Rho	Correlatoin between error terms in labor participation equation and in the wage equation: $\rho = [\sigma_{12}/(\sigma_{11}\sigma_{22})]$

V. Empirical Results

1. Effects of Selection Bias

Sample selection bias is said to occur when data for a variable (i.e., wage) are missing (i.e., not observed) for some cases (i.e., the unemployed) and present for others. The selection bias may emerge in using only selected cases to estimate wage equation. Table 3 shows the diversities of the selection biases across countries as well as by sex.

Table 3 Sample Selection Bias

	Canada	Germany	UK	US
Model using prose Literacy				
Rho (ρ)				
Female	.61(1.9)	-8.4(-12.4)	.45(1.2)	-.73(-8.2)
Male	-.77(-11.0)	.31(.39)	-.75(-9.9)	-.58(-2.9)
Model using document Literacy				
Female	.68(2.9)	-8.5(-12.3)	.45(1.2)	-.70(-6.7)
Male	-.76(-10.3)	.34(.49)	-.73(-9.2)	-.54(-2.4)
Model using quantitative Literacy				
Female	.63(2.1)	-8.5(-12.6)	.44(1.1)	-.69(-6.6)
Male	-.76(-10.7)	.36(.51)	-.76(-10.3)	-.58(-3.0)

Note: t values are in parentheses.

Overall, there are significant selection biases except for German male sample. The male samples in Canada, the United Kingdom, and the United States show negative selection biases, indicating that wages for women staying in their home and engaging in wage jobs are lower than expected on the basis of the observables. The United States and Germany sample for female workers show negative selection biases, while Canada and the United Kingdom do positive selection biases, indicating that wages of the Canadian and the United Kingdom female workers not currently employed are higher than the population mean conditional on the observable variables.

2. Years of Schooling and College Premium

There are no significant effects of years of schooling on the quintile wage in four countries (i.e., Canada, Germany, Sweden, and the United States) except for the United Kingdom. There are several reasons for this. First, because we use the quintile measure of wage, we may lose information about wage, compared to using continuous measure of wage. In this case, the variation of years of schooling may not capture the variation of quintile wage. Second, there may be multicollinearity between years of education and literacy score as the two have a high positive correlation[10]. However, there are little effects of

10) Raudenbush and Kasim (1998) show that years of education has a significant effect on *log* wage, even when literacy score is included in the regression.

education on the quintile wage even after excluding the literacy variable (See Table 4). Thus, multicollinearity between schooling and literacy may not be the cause of this problem. Third, the effects of education on wage are very weak after controlling for industry and firm specific effects, and schooling in these four countries may not capture the variation of the wage quintiles after controlling for industry and firm size effects.

Unlike years of schooling completed, the college dummy variable has strong effects on the wage quintiles in all five countries. This is consistent with previous studies that the college premium is one of the major factors which led to wage inequality in the 1980s in the developed countries.

Table 4 Effects of Education

	Canada	Germany	Sweden	UK	US
Wage Function (Ordered Probit Model) Index function for probability					
			(Female)		
Model 1					
Education	-.0013 (-.8)	.0003 (.79)	.0003(.19)	.1362(9.0)	-.0003(-.89)
Rho	-.3082 (-1.5)	-.7799 (-7.6)	-	.3590(.98)	-.6863(-5.6)
Model 2					
Education	-.0013 (-1.3)	.0003(.77)	.0002(.08)	.0951(6.7)	-.0003(-.76)
College	.5829 (5.8)	.1855(1.2)	.5501(5.7)	.6205(6.4)	.5865 (5.8)
Rho	-.7735(-11.1)	-.8453(-12.3)	-	.4710(1.5)	-.7236(-7.5)
			(Male)		
Model 1					
Education	-.0001 (-.23)	.0001 (.23)	-.0002(-.09)	-.0003(-.08)	.0004(.30)
Rho	-.8042(-19.7)	.5066 (1.2)	-	-.7046(-7.2)	.1119(.04)
Model 2					
Education	-.0025 (-.46)	-.00003(.06)	-.0004(-.08)	-.0006(-.12)	-.0002(-.94)
College	.6140 (6.1)	.7975(6.2)	.5255(4.2)	.5234(6.2)	.7021(7.5)
Rho	-.8029(-20.2)	.6386(2.4)	-	-.7974(-12.3)	-.7098(-6.4)

Note:
1. Model 1 (Including Education, Age, Industry Dummies, and Firm Size Dummies; Excluding College Dummy and Literacy).
2. Model 2 (Including Education, College, Age, Industry Dummies, and Firm Size Dummies; Excluding Literacy)
3. Parentheses are t ratio [(coefficient)/(standard error)].

The Figure 1 shows the marginal effects[11] of college dummy variable as well as the difference of probability within the level of wage. Since the coefficient of the college dummy is expected to be positive, the wage distribution curve is shifted to the right. Figure 1 shows that 4-year college degree decreases the area for wage=1 and wage=2. Thus, the sign of marginal effects on wage=1 and wage=2 is negative, and the marginal effects can be represented by (a-A) and (b-B), respectively. In contrast, the marginal effect for wage = 4 and wage = 5 is positive, and the marginal changes of probability can be represented by (d-D) and (e-E), respectively. The sign of marginal effect on wage = 3 depends on whether the amount of (c-C) is positive or negative. *Further, it is important to note that the total change [(a-A) + (b-B) + (c-C) + (d-D) + (e-E)] of probability reflect the extent to which the college degree variable mobilizes the level of wage.*

Table 5-1 shows the relationship between college premium and wage distribution. We can find that those with college degree are more likely to be higher wage groups, while those without the degree are more likely to be lower wage groups. However, it appears that women with college degree in the United States and Germany are less likely to be higher wage groups compared to those in Canada, Sweden, and the United Kingdom.

We estimate the marginal effects of college premium after controlling for literacy score, firm size, and industry-specific effects. We find that college premium wage exist in all five countries except for German female (See Table 5-2). Overall, there are negative marginal effects of college degree on the lowest and next lowest earner quintile, while positive effects on the highest and next highest earner quintile. Although the degree of marginal effects on the wage quintiles varies from countries, there is a clear pattern. That is, for female workers, the marginal effects of the college premium are relatively large in the lowest wage quintile (i.e., wage=1), while for male workers, those effects are large in the highest wage quintile (i.e., wage=5). For instance, Canadian male workers with college degree are more likely to fall into the highest earner quintile by 24.89 ~ 26.95 % compared to those without college degree. Canadian women with college degree are less likely to fall into the lowest earner quintile by 33.34 ~ 35.5% compared to those without college degree.

11) See Chapter 19 at Green (1999)' book for more details about ordered probit model.

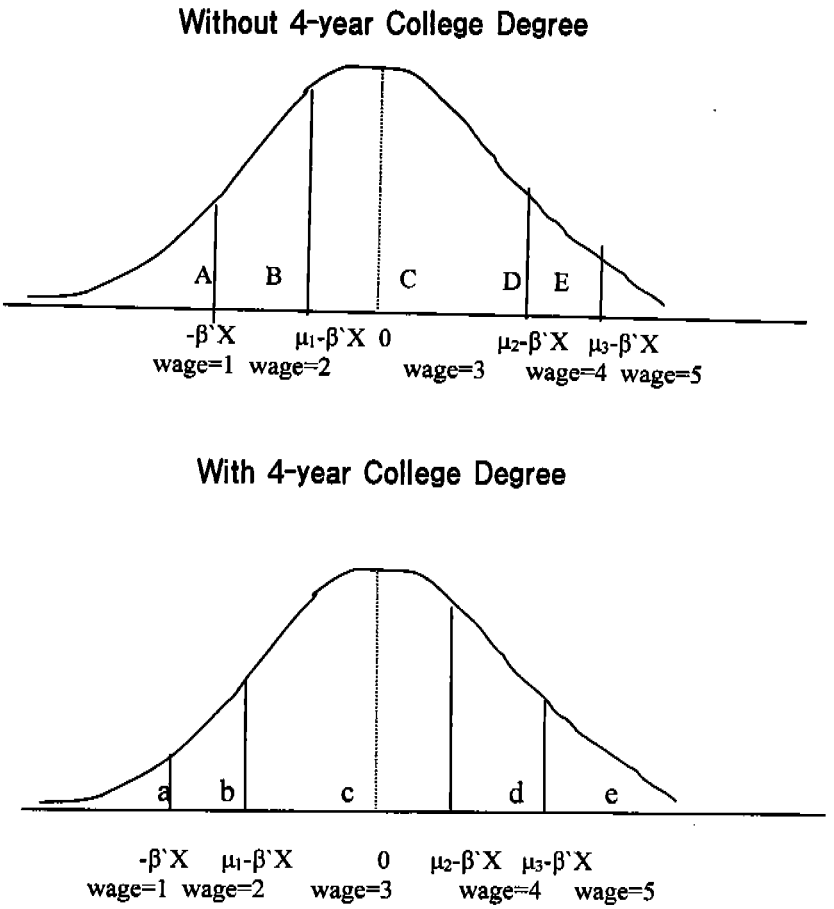

Figure 1 Distribution of Predicted Marginal Probabilities of a College Dummy Variable on the Quintile Wage

Table 5-1 College and Non-College Workers' Wage Level

	Level of Wage 0	1	2	3	4	5	Sum (%)
			(Canada)				
Non-College							
Male	27.53%	13.16%	11.91%	13.30%	15.87%	18.22%	100%
Female	48.85	16.58	15.14	10.28	7.14	2.00	100
College							
Male	14.97	7.20	5.11	4.38	27.61	40.73	100
Female	24.98	8.25	7.97	23.58	15.03	20.19	100
			(Germany)				
Non-College							
Male	22.97	5.74	13.22	17.18	23.12	17.77	100
Female	46.72	11.22	20.18	12.20	5.85	3.83	100
College							
Male	7.60	4.02	5.07	7.43	14.75	61.13	100
Female	28.80	12.54	8.12	23.67	***14.34***	***12.54***	100
			(Sweden)				
Non-College							
Male	0.48	14.03	9.06	12.71	22.45	41.28	100
Female	1.17	15.03	19.76	28.80	23.44	11.80	100
College							
Male	1.12	9.54	2.71	4.31	13.12	69.19	100
Female	0.00	13.90	9.25	10.74	24.34	41.76	100
			(UK)				
Non-College							
Male	30.11	4.91	9.64	17.23	18.31	19.81	100
Female	41.12	17.60	18.09	12.20	7.12	3.88	100
College							
Male	10.94	1.98	4.34	7.11	14.63	61.00	100
Female	19.66	9.64	7.27	11.82	23.08	28.53	100
			(US)				
Non-College							
Male	22.64	19.51	21.08	19.82	14.78	2.17	100
Female	35.60	26.74	21.65	10.79	4.22	1.00	100
College							
Male	9.57	6.46	7.48	23.68	26.83	26.09	100
Female	16.19	16.89	10.85	28.98	21.86	5.23	100

Note:
1. The estimates are based on the weighted sample of the IALS.
2. It is assumed that underlined levels of wage (Wage=4 and Wage=5) reflect college premium. College means 4-year college degree. Wage=0 means the unemployed.

Table 5-2 Marginal Effects of College Premium on Quintile Wage Controlling for Literacy Types (Changed %)

See Figure 1 —	Lowest (a-A)	Next Lowest (b-B)	Middle (c-C)	Next Highest (d-D)	Highest (e-E)
		1. Canada			
Prose					
Female	-35.5%	-3.09%	8.39%	14.38%	9.64%
Male	-13.77%	-7.76%	-4.29%	-0.21%	26.04%
Quantitative					
Female	-33.34%	-4.12%	8.14%	12.94%	8.15%
Male	-13.54%	-7.5%	- 4.03%	0.18%	24.89%
		2. Germany (Male only)			
Prose	-5.6%	-10.65%	-8.6%	3.38%	20.93%
Quantitative	-5.7%	-11.43%	-8.6%	3.59%	22.42%
		3. Sweden			
Prose					
Female	-6.42%	-7.88%	-4.17%	6.44%	12.30%
Male	-4.65%	-4.07%	-4.82%	-4.10%	17.65%
Quantitative					
Female	-4.86%	-7.36%	-5.70%	4.65%	13.27%
Male	-4.16%	-3.62%	-4.26%	-3.49%	15.52%
		4. UK			
Prose					
Female	-17.98%	-3.37%	5.12%	8.61%	7.63%
Male	-1.35%	-3.79%	-7.25%	-4.28%	16.67%
Quantitative					
Female	-17.19%	-3.14%	4.91%	8.20%	7.21%
Male	-1.30%	-3.71%	-7.10%	-4.21%	16.33%
		5. US			
Prose					
Female	-14.83%	-4.81%	5.15%	10.18%	4.31%
Male	-9.71%	-8.32%	1.94%	10.13%	5.96%
Quantitative					
Female	-14.95%	-4.59%	5.89%	10.11%	3.55%
Male	- 8.98%	-7.71%	1.88%	9.49%	5.33%

Note: Female College premium in Germany has no effects on the wage quintiles.

3. Effects of Literacy Skills

Figure 2 illustrates the marginal effects[12] of literacy on the ordered probit

12) The procedure to calculate the marginal effects of literacy score such as continuous variables is described in Green (1999).

model. Assuming β is positive holding constant, increasing X shifts the distribution of W to the right. In this case, it is clear probability (wage = 1) decreases (i.e., negative marginal effects), while probability (wage=5) increases (i.e., positive marginal effects). *The changed probability reflects the size of earnings mobility. The total change implies the degree to which an increase (decrease) of literacy mobilizes the level of wage upward (downward).* In addition, note the marginal effects sum to zero. The reason is that $(a_1 + b_1 + c_1) = (d + e_1 + f_1)$, or $(d + e_1 + f_1) - (a_1 + b_1 + c_1)$ is equal to zero.

Assuming that there is only one independent factor, the level of literacy and the coefficient of the literacy variable is positive ($\beta > 0$). Increasing the literacy score while holding β and μ constant results in shifting the distribution to the right (the solid curve → the dashed curve). In this case, the areas for wage = 1 and wage = 2 decrease, while those for wage = 4 and wage = 5 increase. For wage = 3, however, the effect is ambiguous; there may be an increase or a decrease.

We find that literacy scores have significant effects on the level of wage in all five countries as well as across all types of literacy (See Table 6). The predicted probabilities vary by country and by sex. Overall, adult literacy has significant effects on both men and women regardless of literacy types, although it has relatively small effects for Canada male and Germany female. Further, we can find that for women, the improvement of literacy score has strong effects on the lowest quintile wage groups; for men on the highest quintile wage groups except for Canada.

For instance, in Canada and the United Kingdom, the improvement of literacy score has strong effects on the lowest quintile wage groups. For the United Kingdom female workers, an increase by 100 in the literacy score reduces the area of the lowest quintile wage by approximately 0.1782 ~ 0.2032, or the amount of "a_1" is 0.1782 ~ 0.2032 in the Figure 2.

Previous studies suggest that quantitative literacy has a larger effect and prose literacy has a smaller when compared to other types of literacy (Rivera-Batiz, 1992; Charette and Meng, 1998). We find that the effect of quantitative literacy for women is larger in Canada and Germany than that of document and prose literacy. However, it is difficult to identify which type of literacy is crucial to labor market outcomes because the overall effect of literacy is strong on wage regardless of literacy types and also the size of the effect varies from countries to countries.

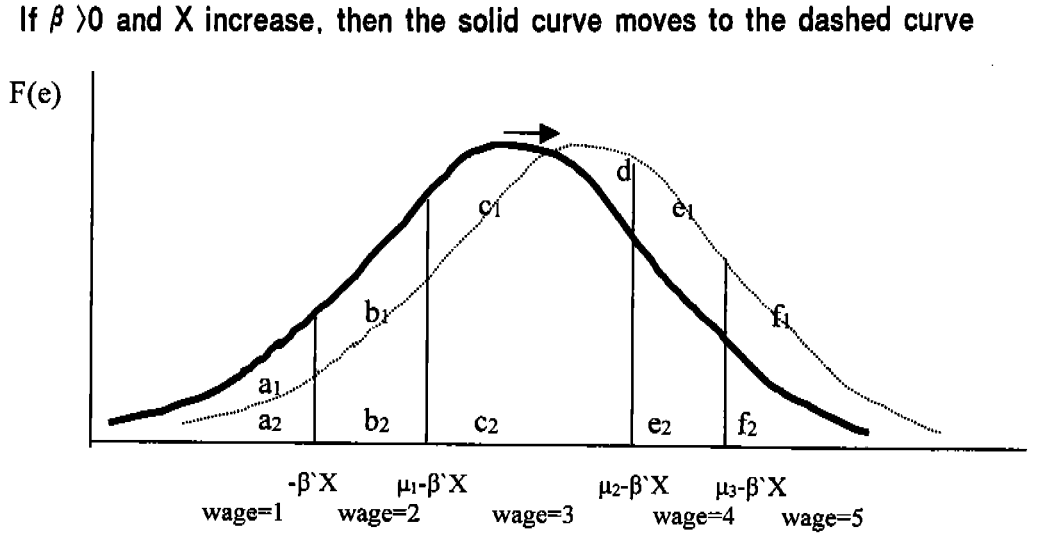

Figure 2 Effects of Change in X (continuous variables) on Predicted Marginal Probabilities

Table 6 Marginal Effects of Literacy on Quintile Wage (Changed % when one unit literacy score is 100)

		∂prob[Wage=1] / ∂Literacy	∂prob[Wage=2] / ∂Literacy	∂prob[Wage=3] / ∂Literacy	∂prob[Wage=4] / ∂Literacy	∂prob[Wage=5] / ∂Literacy
The Amount of Changed % in Figure 2		$(-a_1)$	$(-b_1)$	$(-c_1+d)$	$(+e_1)$	$(+f_1)$
(Prose Literacy)						
Canada	Female	-11.81%	3.35%	3.33%	3.69%	1.45%
	Male	-1.71	-0.66	-0.21	0.39	2.20
Germany	Female	-2.04	-1.95	-0.34	0.60	3.72
	Male	-4.46	-7.3	-3.76	4.79	10.73
Sweden	Female	-4.72	-4.63	-1.18	4.70	5.84
	Male	-2.7	-2.05	-2.13	-1.13	8.01
UK	Female	-20.32	-0.29	6.98	8.22	5.42
	Male	-1.49	-3.77	-6.34	-2.52	14.12
US	Female	-7.83	-1.57	3.22	4.61	1.57
	Male	-12.48	-8.78	3.93	11.67	5.67
(Document Literacy)						
Canada	Female	-12.96	3.92	3.64	3.91	1.5
	Male	-.74	0.29	-.01	0.17	0.95
Germany	Female	-3.6	-3.41	-0.58	1.08	6.52
	Male	-5.12	-8.06	-3.95	5.53	11.60
Sweden	Female	-6.79	-6.78	-1.74	6.94	8.38
	Male	-3.65	-2.79	-2.92	-1.55	10.91
UK	Female	-17.82	-0.24	6.08	7.20	4.79
	Male	-1.37	-3.51	-5.88	-2.22	12.98
US	Female	-8.91	-1.6	3.92	5.08	1.51
	Male	-11.65	-8.06	3.69	10.88	5.13
(Quantitative Literacy)						
Canada	Female	-17.79	5.31	4.99	5.41	2.10
	Male	-3.04	-1.16	-0.35	0.72	3.83
Germany	Female	-3.82	-3.97	-0.9	1.036	7.70
	Male	-3.48	-5.3	-2.49	3.562	7.71
Sweden	Female	-4.47	-5.57	-2.86	4.72	8.17
	Male	-4.01	-3.08	-3.22	-1.72	12.00
UK	Female	-18.43	-0.33	6.29	7.49	4.98
	Male	-1.4	-3.59	-6.05	-2.44	13.48
US	Female	-10.53	-1.91	4.73	6.01	1.70
	Male	-11.32	-9.42	4.17	12.52	5.90

VI. Marginal Effects of Human Capital on Wage

The human capital model suggests that individuals can alter their lifetime stream of earnings by making alternative sacrifices and investment decisions (Becker, 1975). If this is true, then one would anticipate that individuals experience distinctly different earnings streams over time. For instance, if human capital theories are correct in assuming that investment in one's later earnings potentials (i.e., college degree, improving literacy skills through job-training, and improving job skills through accumulated job experience) involve a sacrifice of present earnings, then one might expect to observe considerable mobility in relative earnings.

Based on the marginal effects of college premium, literacy, and age mentioned earlier, Table 7 reports cross-national differences in *predicted marginal effects of college premium and literacy* on the wage distribution. The size of the predicted marginal probability reflects the degree to which the level of earning decreases or increases.

We find that while the positive change of the relative wage distribution confirms the validity of human capital theories both country and gender differences are substantial.

First, the marginally changed percent of the female college premium is the greatest in Canada, and only mid-level in the UK, the US, and Sweden, while the marginal change for men varies little across countries. For example, if Canadian women without college degrees had degrees, approximately 67 - 71% of them would experience upward the marginal change in their wages (i.e., 67% - 71% of the aggregate wage distribution is upwardly changed (See Table 7).

The extent of earning profiles through increasing literacy scores and age premium substantially varies by sex. The marginal effect of literacy is larger for male than for female in all four countries except for Canada, where the marginal effect of literacy is larger for female than for male.

In sum, the degree of the marginal effect based on human capital is the weakest in German female workers because they have no college premium in our sample. Male workers have larger marginal advantages than female workers do in the same level of improving literacy and age.

Table 7 Predicted Marginal Effects (Marginally Moved %)

		College Premium (a)	Increasing Literacy Score (+100) (b)	Increasing Age (+10 Years) (c)	Average Size of Mobility [(a+b)/2]	Average Size of Mobility [(a+b+c)/3]
1. Using Prose Literacy in the Ordered Probit Model						
Canada	F	71.00 %	23.63 %	n.a	47.32 %	-
	M	52.07	5.17	n.a	28.62	-
Germany	F	0.00	8.65	9.26 %	4.33	5.97%
	M	49.16	31.04	32.26	40.10	37.49
Sweden	F	37.21	21.07	24.43	29.14	27.57
	M	35.29	16.02	36.37	25.66	29.23
UK	F	42.71	41.23	6.48	41.97	30.14
	M	33.34	28.24	19.68	30.79	27.09
US	F	39.28	18.80	23.05	29.04	27.04
	M	36.06	42.53	37.40	39.30	38.66
2. Using Quantitative Literacy in the Ordered Probit Model						
Canada	F	66.69 %	35.60 %	n.a	51.15	-
	M	50.14	9.10	n.a	29.62	-
Germany	F	0.00	17.43	9.54 %	8.72	8.99
	M	51.74	22.54	30.88	37.14	35.05
Sweden	F	35.84	25.79	24.83	30.82	28.82
	M	31.05	13.23	36.23	22.14	26.84
UK	F	40.65	37.52	11.48	39.09	29.88
	M	32.65	26.96	19.36	29.80	26.32
US	F	39.09	24.88	23.93	32.00	29.30
	M	33.39	33.33	37.11	33.36	34.61

Note: F = Female; M = Male. In Germany, female college premium is not significant (no effects). n.a. = "not applicable".

Ⅶ. Conclusions

This paper examined the extent to which human capital factors such as education, adult literacy skills, and age (as a proxy of job experience) have effects on the wage distribution in five developed countries with different labor market institutions. This paper shows that college premium and literacy skills have significant effects on the wage profile, after controlling for firm size and industry-specific effects. All of three literacy types have significant effects on the wage distribution, although the degree to which the effects of these human capitals on wage distribution vary across countries and by sex.

Countries with the largest increases in the wage inequality (e.g., the United States and the United Kingdom) were the countries with the most decentralized labor markets. Countries with more centralized wage-setting institutions either escaped the growing inequality, such as Germany, or experienced relatively mild increases, like Sweden. It is, therefore, hypothesized that the effects of human capital on wage distribution would be weak in countries with highly centralized wage-setting mechanisms, and market forces based on skill-biased technology may weak under a highly centralized market institution but strong under a highly decentralized market institution.

This paper provides some evidence to limit the power of the institutional hypothesis and reconfirms the effect of human capital on the wage distribution. More specifically, this paper finds that the marginal effect of human capital on the wage distribution in the United States is similar to in Sweden and less than in Canada and the United Kingdom, which rejects the non-market force hypothesis. This finding is not consistent with the expectation that the United States with the most decentralized market institution in developed countries would have larger effects of human capital on the wage distribution than other countries with relatively centralized market institutions. In addition, this paper illustrates that the distribution of wage in Germany substantially depends on gender within the same level of literacy and college premium.

Despite some advantages of cross-national findings with comparable data, it is cautious to generalize our results because our data does not consider the dynamic trend of how human capital influences the wage distribution over time. Further research should address the extent to which human capital affects wage over time. Additional studies are required to examine how the effects of human capital including education and literacy skills vary various labor market institutions across countries.

References

Bartel, Ann.P., and Frank R. Lichtenberg. (1987). The Comparative Advantage of Educated Workers in Implementing New Technology. *Review of Economics and Statistics*, 69(February): 1-11.

Becker, Gary S. (1975). *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education, 2nd ed.* University of Chicago Press.

Berman, Eli, John Bound, and Zvi Griliches. (1994). Changes in the Demand for Skilled Labor within U.S. Manufacturing Industries. *Quarterly Journal of Economics*,109 (2) (May): 367-98.

Blackburn, McKinley and David Neumark. (1992). Unobserved Ability, Efficiency Wages, and Inter-industry Wage Differentials. *The Quarterly Journal of Economics*, 107(4): 1421-1436.

Blau, Francine D., and Lawrence M. Kahn. (1996a). International Differences in Male Wage Inequality: Institutions versus Market Forces. *Journal of Political Economy*, 104(4): 791-837.

———. (1996b). Wage structure and gender earnings differentials: an international comparison. *Economica*, 63 (250) (May): S29-S62.

Borjas, George J., and Valerie A. Ramey. (1995). Foreign Competition, Market Power, and Wage Inequality. *Quarterly Journal of Economics*, 110(4) (November): 1075-1110.

Bound, John, and George Johnson. (1992). Changes in the Structure of Wages in the 1980's: An Evaluation of Alternative Explanations. *American Economic Review* 82 (June): 371-392.

Brauer, David A. and Susan Hickok.(1995). Explaining the Growing Inequality in Wages across Skill Levels. *Federal Reserve Bank of New York Economic Policy Review* 1(1) (January): 61-75.

Burtless, G. (1995). International Trade and the Rise in Earnings Inequality. *Journal of Economic Literature* 33 (2) 800-16.

Charette, Michael F. and Ronald Meng. (1998). The determinants of literacy and numeracy, and the effect of literacy and numeracy on labor market outcomes. *Canadian Journal of Economics*, 31(3): 495-517.

Goldin, Claudia and Lawrence Katz. (1996). Technology, Skill, and the Wage Structure: Insight from the Past. *American Economic Review*, 86(2) (May): 252-257.

Gottachalk, Peter and Mary Joyce. (1998). Cross-National Differences in the Rise in Earnings Inequality: Market and Institutional Factors. *Review of Economics and Statistics* LXXX(4): 489-502.

Green, William H. (1999). *Econometrics Analysis*. Prentice-Hall.

Griliches, Zvi and William M. Mason. (1972). Education, Income, and Ability. *Journal of Political Economy*, 80(3)(May-June): S74-S103.

Grogger, Jeff and Eric Eide. (1995). Changes in College Skills and the Rise in the College Wage Premium. *Journal of Human Resources*, 30(2): 280-310

Haskel, J. (1997). The Skilled Wage Premium and the Growth of Small Firms in UK Manufacturing. *Labour: The Review of Labour Economics and Industrial*

Relations, 12(2): 221-38.

Johnson, George. (1997). Changes in Earnings Inequality: The Role of Demand Shifts. *Journal of Economic Perspectives*, 11(2) (Spring): 41-54.

Juhn, Chinhui, Kevin M. Murphy, and Brooks Pierce. (1993). Wage Inequality and the Rise in Returns to Skill. *Journal of Political Economy*, 101(3) (June): 410-42.

Katz, Harry C. (1993). The Decentralization of Collective Bargaining: A Literature Review and Comparative Analysis. *Industrial and Labor Relations Review*, 47 (October): 3-22.

Katz, Lawrence and Kevin Murphy. (1992). Changes in Relative Wages, 1963-1987: Supply and Demand Factors. *Quarterly Journal of Economics*, 107(February): 35-78.

Katz, Lawrence F., and Ana L. Revenga. (1989). Changes in the Structure of Wages: The U.S. vs. Japan. *Journal of Japanese International Economies* 3(4)(December): 522-553.

Krueger, Alan. (1993). How Computers Have Changed the Wage Structure: Evidence from Microdata, 1984-89. *Quarterly Journal of Economics*, 108 (1) (February): 33-60.

Lerman, Robert I. 1997. Reassessing trends in US earnings inequality. *Monthly Labor Review*, (December): 17-25.

Levy, Frank and Richard J. Murane. (1992). U.S. Earnings Levels and Earnings Inequality: A Review of Recent Trends and Proposed Explanations. *Journal of Economic Literature*, XXX(September): 1333-1381.

Melkas, Helina and Richard Anker. (1997). Occupational segregation by sex in Nordic countries: an empirical investigation. *International Labor Review*, 136(3) (Autumn): 341-363.

Mincer, Jacob. (1991). Human Capital, Technology, and the Wage Structure: What do Time Series Show? *National Bureau of Economic Research*, Working Paper No. 3581.

Murnane, Richard J., and John B. Willet, and Frank Levy. (1995). The Growing Importance of Cognitive Skills in Wage Determination. *The Review of Economics and Statistics*, 251-265.

Murphy, Kevin M., and Finis Welch. (1992). The Structure of Wages. *Quarterly Journal of Economics*, 107(1) (February): 285-326.

OECD. (1995). *Literacy, Economy, and Society*. OECD: Paris.

Raudenbush, Stephen W., and Rafa M. Kasim. (1998). Cognitive Skill and Economic Inequality: Findings from the National Adult Literacy Survey. *Harvard Educational Review*, 68(1): 33-79.

Rivera-Batiz, Francisco L. (1992). Quantitative literacy and the likelihood of employment among young adults in the United States. *Journal of Human Resources*, 27(2) (Spring): 313-328.

Vella, Francis. (1998). Estimating Models with Sample Selection Bias: A Survey. *Journal of Human Resources*, 33(1): 127-172.

Wood, Adrian. (1995). How Trade Hurt Unskilled Workers, *Journal of Economic Perspectives*, 9(3) (Summer): 57-80.

정광호: 미국 시라큐스 대학 맥스웰 스쿨에서 2001년 12월에 The Effects of Schooling on Literacy Skills: A Cross-National Study from the International Adult Literacy Survey라는 학위논문으로 행정학 박사학위를 취득하였으며, 현재 서울대학교 행정대학원 BK 프로젝트 사업단 박사 후 연구원으로 재직하고 있다. 강의 및 연구의 주된 관심분야는 행정계량분석 및 방법론, 공공조직론 및 인적자원관리, 사회복지 및 노동정책 등이다. 주요 경력으로는 1999년 시카코에서 제 16차 미국보건학회 초청논문(invited paper) 으로 Income Inequality and Population Health among 18 Developed Countries: The Evidence from Luxembourg Income Study라는 논문을 발표를 하였다. 주요 국내논문으로는 〔IMF 경제위기가 비영리조직의 재원조달에 미친 영향: 문화예술단체를 중심으로, 한국행정학보, 제 36권 제 2호 2002 여름〕 등이 있다.