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我國不同年齡層之高階勞工勞動替代彈性之估計

Estimation of Elasticity of Substitution between College Graduate Workers in Different Experience Cohorts: the Case of Taiwan

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摘　要

台灣地區自 1980 年代末期開始進行高等教育的擴張政策。此政策造成不同年齡層之高等教育勞工的大學貼水(college premium)在 1990 年代出現不同的走勢，這種現象讓我們對不同年齡層之高等教育勞工之間在生產上之替代性問題感到興趣。依據 Card 與 Lemiux 的模型，假設不同年齡層之高等教育勞工之間在生產上為不完全替代，我們探討不同年齡層之高等教育勞工供給的改變對其薪資變化的影響，進而計算出這些不同年齡層之高等教育勞工之間的替代彈性。本文發現此替代彈性大約在 2 與 3 之間，約為美國、英國與加拿大等國的一半左右。

ABSTRACT

In the late 1980s Taiwan began expanding higher education. This policy of expansion caused the patterns of college premium of different experience groups to move to different directions since 1990. This raises a question of substitutability in production among college graduate workers with different experience levels. Following Card and Lemieux's model with the assumption of imperfect substitution between college graduate workers in different experience groups, this paper examines the effect of changes in relative supply of Taiwan college graduate workers in different experience groups on their relative wages and further investigates the elasticity of substitution between experience cohorts. We find the elasticity of substitution is in the range of 2 to 3, which is about half of those for the US, UK, and Canada.

Keywords: Expansion of higher education, Elasticity of substitution, Cohort effect, Taiwan labor market

1. Introduction

In the late 1980s, the Taiwan government expanded the availability of higher education, which in turn dramatically increased the number of highly educated workers entering the labor market each year. As shown in Lin (2002), the proportion of those with no formal education and those attending only primary schools was reduced from 58.7 per cent in 1976 to 21.4 per cent in 1999, while the proportion of those with higher education (at least a junior college degree) increased from 7.4 per cent in 1976 to 24.6 per cent in 1999. Due to the continuous expansion of college education, it would be expected that more college-educated workers would enter the labor market after 1990 mainly contributed by younger college-educated cohorts. Figure 1 shows the trends of natural log of relative supply, defined as the natural log of the relative share of college versus high school labor supplies, for two different experience groups. The trends for these two groups are relatively similar before 1990. However, after 1990 the trend for workers with less than 10 years of working experience (younger) turns upward rapidly, while the relative supply of workers with more than 10 years of working experience (older) maintain a relatively constant growth rate throughout 1982-2000.

The 1990s could be a turning point in the history of Taiwan labor market. Lin and Orazem (2001) found that the supply of young highly educated workers entering the labor market increased, which in turn leads to a decline in their wages relative to less educated workers at the same age cohorts. On the other hand, the relative wages of more experienced highly educated workers grew at a similar rate after 1990. Figure 2 shows this phenomenon in terms of college premium for these two experience groups. The college premium is defined as the difference in real wages between 4-year college graduates and senior high school graduates, holding everything else constant.[2] It appears that the expansion policy on higher education has lowered the return to college education for the young after 1990, but not for the more experienced college graduate workers. This implies these two experience groups should not be close substitutes in production. Welch (1979) used a career-phase model to describe imperfect substitution relation for workers at different phases of their career. He pointed out that a worker has different responsibilities at each phase of his/her career, and these are not perfect substitutes. With imperfect substitution between similarly educated workers at different age groups, the changes in the relative supply of highly educated workers across age groups would determine the changes in relative wages for their corresponding age groups.

However, as mentioned by Card and Lemieux (2001), most of studies analyzing the returns to higher education for various countries, including Taiwan (Gindling et al. 1995; Liu et al. 2000), have focused on the *average* returns to schooling, rather than *differences* by age or cohort. They analyzed this issue under the assumption that different age groups with the same level of education are perfect substitutes in production. Therefore, all age groups of college-educated workers belong to only one type: "college equivalent" workers. Obviously this assumption is too restrictive when explaining the changes of wage dynamics for Taiwan's labor market. Research on this topic for Taiwan's labor market could not really be found in literature. This paper shows these two different higher educated age cohorts are not homogeneous and further investigates the elasticity of substitution between them. Indeed, the results in this paper suggest the drop in earnings of younger college graduate workers relative to the more experienced ones in the 1990s for Taiwan can be largely determined by the cohort-specific college graduate relative supplies, contradicting the assumption that all college graduate workers are equivalent in their productivity. Our estimate of the elasticity of substitution between workers with college degrees in different

experience groups is in the range of 2 to 3, which is much smaller than the estimates for the US, UK, and Canada (Welch 1979; Card and Lemieux 2001). This implies Taiwan's highly skilled workers are relatively inelastic compared to the counterparts in these three countries.

The remainder of the paper is presented as follows. Section 2 presents the methodology framework used in this study. Section 3 describes the data sources and presents our estimation results. Section 4 summarizes our main findings.

2. Methodology Framework

Card and Lemieux (2001) developed a two-stage mechanism to investigate the elasticity of substitution between workers with the same education in different age groups. Since the elasticity of substitution can be obtained from both stages and the results from both stages should be the same theoretically, the first stage is used in this study. Following Card and Lemieux, the aggregate production function at time *t* is of the CES form

(1) $$y_t = f(H_t, C_t; \theta_{ht}, \theta_{ct}) = (\theta_{ht} H_t^{\rho} + \theta_{ct} C_t^{\rho})^{1/\rho},$$

where H_t and C_t are assumed to be CES subaggregate production functions of high school labor and college labor. θ_{ht} and θ_{ct} are the technological efficiency parameters associated with the respective labor.

(2) $$H_t = \left[\sum_j (\alpha_j H_{jt}^{\eta}) \right]^{1/\eta},$$

(3) $$C_t = \left[\sum_j (\beta_j C_{jt}^{\eta}) \right]^{1/\eta},$$

where α_j and β_j are efficiency parameters for age group *j*. One thing different from their setting in this paper is that we will use the experience group, rather than age group, to define cohorts. Since workers with different educational level enter the labor market at different ages, we believe it is more appropriate to use experience groups in estimation. However, Card and Lemieux (2001) obtained similar results in estimation of cohort effects from both specifications.

Based on the settings of equations (1), (2) and (3), we can calculate the elasticity of substitution between high school labor and college labor, σ_E, which equals $1/(1-\rho)$. Similarly, the elasticity of substitution between different experience groups with the same level of education,[3] σ_A, is equal to $1/(1-\eta)$.

Using the above assumption and efficiency wage theory, the relative wage of college labor to high school labor in the same experience group *j* should be equal to the ratio of marginal products for these two types of labor. Taking the natural log of this expression yields:

(4) $$\log\left(\frac{w_{jt}^c}{w_{jt}^h}\right) = \log\left(\frac{\theta_{ct}}{\theta_{ht}}\right) + \log\left(\frac{\beta_j}{\alpha_j}\right) - \left(\frac{1}{\sigma_E}\right)\log\left(\frac{C_t}{H_t}\right) - \left(\frac{1}{\sigma_A}\right)\left[\log\left(\frac{C_{jt}}{H_{jt}}\right) - \log\left(\frac{C_t}{H_t}\right)\right]$$

The major point in equation (4) is that the relative wages of college labor to high

school labor are not only determined by the aggregate relative labor supply ($\frac{C_t}{H_t}$), but also the experience–group specific relative labor supply ($\frac{C_{jt}}{H_{jt}}$). The last term of right hand side in equation (4) shows any deviation of the growth in an experience group specific relative labor supply of college labor from the growth of aggregate relative supply of college labor will lead to shifts in relative wage structure, as shown in Figures 1 and 2. This is different from the previous studies that assumed perfect substitution between different experience groups with the same educational level. When perfect substitution is imposed: $\sigma_A = \infty$, the last term of right hand side in equation (4) disappears, and the wage structure only depends on aggregate relative supply of college labor.

Simplifying equation (4) results in the following:

$$\log(\frac{w_{jt}^c}{w_{jt}^h}) = \log(\frac{\theta_{ct}}{\theta_{ht}}) + [(\frac{1}{\sigma_A}) - (\frac{1}{\sigma_E})]\log(\frac{C_t}{H_t}) + \log(\frac{\beta_j}{\alpha_j}) - (\frac{1}{\sigma_A})\log(\frac{C_{jt}}{H_{jt}}) \quad . \tag{5}$$

When implementing the estimation on σ_A, the first two terms of equation (5) can be grouped as the *year effect* and replaced with a set of time dummy variables. The year effect is common across all experience groups in that particular year *t*, representing the combination of relative technology shock favoring college labor, $\frac{\theta_{ct}}{\theta_{ht}}$, and the shift in aggregate relative supply of college labor. Similarly, adding another set of dummy variables for the third term represents the *experience effect* that is common across years. The last term, the *cohort effect*, is the primary focus in this paper. Therefore, the econometric model of equation (5) becomes

$$\log(\frac{w_{jt}^c}{w_{jt}^h}) = \sum_{i=1}^{m} a_i T_i + \sum_{j=1}^{n} b_j EXP_{jt} - (\frac{1}{\sigma_A})\log(\frac{C_{jt}}{H_{jt}}) + e_{jt} \quad , \tag{6}$$

where a_i and b_j are the coefficients on the year (T) and experience (EXP) effects respectively. e_{jt} is the disturbance term.

3. Data Source and Estimation Results

The data used for this study are from "Survey of Family Income and Expenditure",[4] which is collected each year by the Directorate-General of Budget, Accounting and Statistics (DGBAS), Executive Yuan, Taiwan. This research focuses on the waves of the survey between 1982-2000. The sample is limited to male workers between the ages of 18 and 65 to avoid any possibility of sexual discrimination on women's wages and also the less accuracy of women's potential labor market experience. The data are divided into 14 labor groups, distinguished by two educational levels (exact college graduates and high school graduates) and seven potential experience categories (less than or equal to 5, 6-10, 11-15, 16-20, 21-25, 26-30, and more than 30 years). The labor supply data is created from the sample of the surveys, including all employed, self-employed and unemployed male workers. The relative supply of college labor to high school labor for experience group *j* in year *t*, $\frac{C_{jt}}{H_{jt}}$, will then be the ratio of number of workers with college degree and experience level *j* to number of workers with high school degree and experience level *j* in

year *t*. Relative wage data, $\frac{W_{jt}^c}{W_{jt}^h}$, are similarly constructed, where W_{jt}^c (W_{jt}^h) is the average wage of the workers with college (high school) degree and experience level *j* in year *t*. However, self-employed and unemployed workers are excluded from the sample when measuring relative wage data.

The estimated results based on equation (6) are shown in Table 1. Model 1 is the OLS estimation using a set of year dummy variables for the year effect. We also replace them with a linear time trend variable in Model 2. The estimated coefficients of log college-high school relative supply on log wage gap in Models 1 and 2 are –0.482 and –0.470 respectively, implying the elasticity of substitution between different experience groups around 2.1. Considering possible heteroscedastic problem in the data, Models 1 and 2 are repeated but weighted by inverse sampling variance of college-high school wage gap in each experience group. The WLS estimations in Models 3 and 4 show similar results of elasticity of substitution around 2.6. Compared to the results by previous studies for various countries, these estimates for Taiwan are much smaller. Card and Lemeiux (2001) obtain the elasticities of substitution between different age groups for the US, UK, and Canada in the range of 4 to 6. Welch (1979) also found an elasticity of substitution near 5 for US college graduate workers. This implies Taiwan's college graduate workers are less substitutable across experience groups relative to the counterparts for those more developed countries.

The estimated coefficients of the year effect show positive returns from the combination of a technology shock favoring college graduate workers and aggregate supply changes, indicating strong demand shift toward highly educated workers in Taiwan's labor market. The demand shift is more significant over the 1990s.

The results on the experience effect show the wage gap declines as the years of working experience increase, when everything else held constant.

Now the assumption in the last section that the elasticities of substitution across experience groups are equal for college and high school workers ($\sigma_{AH} = \sigma_{AC} = \sigma_A$) is relaxed. Equation (4) then becomes 2 separate equations, one for college workers and the other for high school workers:

$$\log(W_{jt}^h) = \log(\theta_{ht}) + \log(\alpha_j) + [(\frac{1}{\sigma_{AH}}) - (\frac{1}{\sigma_E})]\log(H_t) - (\frac{1}{\sigma_{AH}})\log(H_{jt}) + e_{jt}^h \quad (7)$$

$$\log(W_{jt}^c) = \log(\theta_{ct}) + \log(\beta_j) + [(\frac{1}{\sigma_{AC}}) - (\frac{1}{\sigma_E})]\log(C_t) - (\frac{1}{\sigma_{AC}})\log(C_{jt}) + e_{jt}^c \quad . \quad (8)$$

Equations (7) and (8) can be estimated by pooling all 2 (educational levels)$\times$19 (years)$\times$7 (experience groups)=266 cohorts together. The econometric model then becomes

$$\log(W_{jt}^l) = \alpha_0 + \alpha_1 \log(C_{jt}) \times C + \alpha_2 \log(H_{jt}) \times H + \sum_{t=1}^{m} \lambda_{1t} T_t + \sum_{t=1}^{m} \lambda_{2t} T_t \times C + \sum_{i=1}^{n} \varphi_{1i} EXP_i + \sum_{i=1}^{n} \varphi_{2i} EXP_i \times C + \sum_{i=1}^{n} \sum_{t=1}^{m} \gamma_{it} T_t \times EXP_i \quad , \quad (9)$$

where *l* indicates the cohort is college or high school workers and *C* (*H*) is the dummy variable for college (high school) workers. α_i, λ_{1t}, λ_{2t} φ_{1i}, φ_{2i} , γ_{it} are the coefficients for the associated variables. The last term is the interaction of year and experience effects. It is the *fixed effect* that tries to control for unobserved factors which affect both college and high school workers in the same year, or the unobserved factors which are correlated with

the supply variables.

Table 2 shows the estimated coefficients of supply of college and high school workers on the effects of their wages. OLS regression in Model 1 has the results of –0.462 and –0.521, indicating the elasticities of substitution across experience groups for college and high school workers are 2.2 and 1.9 respectively. Model 2 is weighted by inverse sampling variance of wage gap in each experience group. The results show the elasticities of substitution are 2.9 and 2.6 respectively. Both models have consistent results that the elasticities of substitution across experience groups for college and high school workers are relatively similar, although not exactly equal. However, the estimated elasticities of substitution are in the range of 2 to 3 which is consistent with the results obtained before relaxing the assumption of $\sigma_{AH} = \sigma_{AC}$.

4. Conclusion

Taiwan's expansion policy on higher education since the late 1980s has been disproportionally increasing the relative supply of young college graduate workers. At the same time, we also observe the college premium for different experience groups have different patterns of movement. College premium for new entrants has fallen dramatically, while the premium for more experienced college graduate workers still maintains steady growth in the 1990s. This change in earnings structure challenges the traditional assumption that all college graduate workers are perfect substitutes, i.e., the elasticity of substitution across experience groups for college graduate workers is infinitely large.

Following Card and Lemieux's (2001) methodology and incorporating imperfect substitution between college graduate workers in different experience groups, we find the changes in college-high school wage gap across experience groups can be largely determined by relative cohort sizes. In particular, the estimated coefficients of experience-specific relative supply of college labor on their relative wages are significantly negative and imply the elasticity of substitution across experience groups for Taiwan college labor is in the range of 2 to 3, which is about half of those found for the US, UK, and Canada.

One question raised from the results in this paper is -- Does the decrease in the college-high school wage gap due to the expansion of higher education necessarily lead to the decline of average ability of Taiwan young college graduate workers? This future research conducted along these lines will be of particular interest to Taiwan as many policy makers and educators are concerned about the impact on schooling choice.

References

Card, David and Thomas Lemieux (2001). Can Falling Supply Explain the Rising Return to College for Younger Men? A Cohort-Based Analysis, *Quarterly Journal of Economics*, 116: 705-46.

Gindling, T. H., M. Goldfarb, and C. C. Chang (1995). Changing Returns to Education in Taiwan: 1978-1991, *World Development*, 23(2): 343-56.

Lin, Chun-Hung A. (2002). The Incidence and Wage Effects of Overeducation: The Case of Taiwan. Discussion paper, Department of Economics, Chinese Culture University.

Lin, Chung-Hung A. and Peter F. Orazem (2001). Wage Inequality and Returns to Skill in Taiwan, 1978-1996, *Journal of Development Studies*, forthcoming.

Liu, J. T., J. K. Hammitt, and C. C. J. Lin (2000). Family Background and Returns to Schooling in Taiwan, *Economics of Education Review*, 19(1): 113-25.

Welch, Finis (1979). Effects of Cohort Size on Earnings: The Baby Boom Babies' Financial Bust, *Journal of Political Economy*, 87, part 2: S65-S97.

Endnotes:

1. We use a traditional method of measuring a worker's potential working experience throughout the paper: (age – years of schooling – 6).
2. Earnings equation regressions are done separately for these two groups of workers. The explanatory variables include four educational dummies (4-year college, junior college, senior high school and junior high school), working sector, and experience and its square. We restrict the analysis only for male workers. The college premium then is obtained from the difference in coefficients between 4-year college and senior high school dummy variables.
3. We follow Card and Lemieux (2001) that first assumes the elasticities of substitution between different age groups for high school labor and college labor are equal ($\sigma_{AH} = \sigma_{AC}$), and later relax the assumption and re-estimate both of them using different regression models.
4. This survey was called "Personal Income Distribution Survey" before 1994.

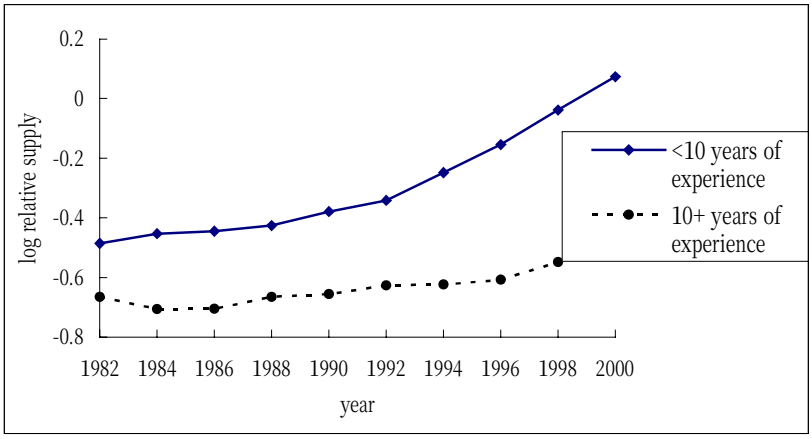

Figure 1 Relative Supplies of Different Experience Male Workers

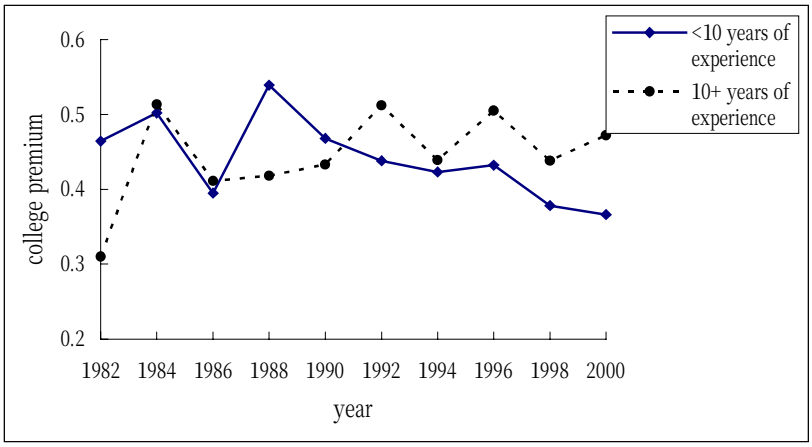

Figure 2 College Premium for Different Experience Male Workers

Table 1 Regression Analysis of log relative wage on log relative supply

variable	Model (1)	Model (2)	Model (3)	Model (4)
Constant	0.302*	-4.607*	0.800*	-31.305*
	(12.25)	(-2.45)	(9.16)	(-4.66)
$\text{Log}(\frac{C_{jt}}{H_{jt}})$	-0.482*	-0.470*	-0.376*	-0.400*
	(-6.50)	(-6.47)	(-5.19)	(-5.87)
Trend	-	0.0025*	-	0.0162*
		(2.62)		(4.81)
Yr83	0.010	-	-0.001	-
	(0.33)		(-0.01)	
Yr84	0.009	-	0.058	-
	(0.29)		(0.54)	
Yr85	0.038	-	0.149	-
	(1.27)		(1.40)	
Yr86	0.026	-	0.110	-
	(0.86)		(1.03)	
Yr87	0.017	-	0.204*	-
	(0.58)		(1.90)	
Yr88	0.003	-	0.113	-
	(0.10)		(1.05)	
Yr89	0.008	-	0.160	-
	(0.26)		(1.49)	
Yr90	0.003	-	0.133	-
	(0.10)		(1.24)	
Yr91	0.074*	-	0.428*	-
	(2.45)		(3.99)	
Yr92	0.002	-	0.154	-
	(0.08)		(1.44)	
Yr93	0.014	-	0.199*	-
	(0.46)		(1.86)	
Yr94	0.022	-	0.214*	-
	(0.74)		(2.00)	
Yr95	0.026	-	0.225*	-
	(0.88)		(2.11)	
Yr96	0.005	-	0.120	-
	(0.15)		(1.12)	
Yr97	0.056*	-	0.381*	-
	(1.81)		(3.55)	
Yr98	0.066*	-	0.316*	-
	(2.19)		(2.90)	
Yr99	0.061*	-	0.333*	-
	(2.00)		(3.06)	
Yr2000	0.059*	-	0.293*	-
	(1.93)		(2.67)	
Exp(6-10)	-0.100*	-0.098*	0.078	0.059
	(-4.40)	(-4.34)	(0.89)	(0.68)

Table 1 (continued)

Exp(11-15)	-0.147*	-0.144*	-0.103	-0.128
	(-5.85)	(-5.80)	(-1.03)	(-1.32)
Exp(16-20)	-0.135*	-0.132*	-0.066	-0.091
	(-5.28)	(-5.22)	(-0.65)	(-0.93)
Exp(21-25)	-0.141*	-0.138*	-0.121	-0.147
	(-5.35)	(-5.29)	(-1.18)	(-1.47)
Exp(26-30)	-0.156*	-0.153*	-0.237*	-0.258*
	(-6.31)	(-6.26)	(-2.56)	(-2.86)
Exp(30+)	-0.182*	-0.179*	-0.519*	-0.535*
	(-7.00)	(-6.96)	(-6.40)	(-6.69)
R^2	0.41	0.32	0.68	0.62
N	133	133	133	133

Notes: T-Statistics are in the parentheses. Models (1) and (3) use a set of year dummy variables for year effect. Models (2) and (4) use a single linear time trend variable for year effect. Considering possibility of heteroscedasticity, models (3) and (4) are weighted by inverse sampling variance of the college-high school wage gap in each experience cohort.
*: Statistically significant at 10 per cent level.

Table 2 Regression Analysis of Different Supply Effects by College and High School Workers

variable	Model (1)	Model (2)
Constant	14.586*	31.867*
	(37.73)	(35.07)
Log(C_{jt})	-0.462*	-0.338*
	(-6.37)	(-4.57)
Log(H_{jt})	-0.521*	-0.386*
	(-7.25)	(-5.26)
Year effect	Included	Included
Experience effect	Included	Included
Fixed effect	Included	Included
R^2	0.99	0.99
N	266	266

Notes: T-Statistics are in the parentheses. Both models include a set of year and experience dummy variables and their interaction terms. Model (2) is weighted by inverse sampling variance of the college-high school wage gap in each experience cohort.
*: Statistically significant at 10 per cent level.

計畫成果自評：

本計畫在估計我國不同年齡層高階勞工之勞動替代彈性。其結果大約在 2 與 3 之間，約為西方先進國家之一半左右。此結果正如作者在執行本計畫之前的預期，由於我國與西方國家勞動市場之文化不同，「年資」(seniority)仍受重視，故替代彈性較西方國家不顯著。作者對本計畫之研究成果感到滿意，期望能在期刊上發表，亦期望能基於本研究成果，在相關研究上予以延伸。最後，感謝國科會及評審委員的支持，使本研究得以執行，並獲得財務上的補助。