

# Educational Choice, Wage Determination, and Rates of Return to Education in Taiwan

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*This paper estimates educational choice, wage determination, and the rate of return to education in Taiwan using Taiwan's Manpower Utilization Survey data of 1996. As education investment is a self-selection process, this paper adopts a two-stage estimation method. First, a polychotomous ordered probit model is used to estimate the education decision. Second, the wage equations of different educational attainments are estimated by incorporating the possible selection bias obtained in the probit model. Finally, rates of return on each education level are calculated from the estimation results. (JEL I21, J24, J31)*

## Introduction

For the past fifty years since World War II, the proportion of educated people in Taiwan has been increasing tremendously. The number of students increased from 1.19 million in 1953 (18.6 percent of the population over six years of age) to 5.18 million in 1997 (26.2 percent of the population over six years of age). The enrollment rates of all education levels also surge over time: from 56.96 percent in 1953 to 90.7 percent in 1997 for senior high school and from 26.27 percent in 1953 to 56.88 percent in 1997 for college and university.<sup>1</sup> The average years of education increased from 5.5 in 1976 to 10.55 in 1997. According to the human capital theory [Becker, 1975], people forego their possible earnings (including all costs of schooling), accumulate skill and knowledge in school, and expect in return to receive higher lifetime earnings. If education is a type of investment, what are the rates of returns for different education levels? Moreover, schooling is not only an individual's decision but it is also a family decision.<sup>2</sup> That is, people self-select into appropriate educational attainment according to their talent and family resource constraints. In this regard, the observed market wages for different educational attainment are the result of self-selection. Therefore, any direct calculation of rates of educational returns, even after considering individual and job attributes, may still be subject to bias. In this paper, a two-stage selection-corrected method was adopted using Taiwan's Manpower Utilization Survey data of 1996.<sup>3</sup> The individual's educational decision is examined first by a polychotomous ordered probit model. The wage equations of different educational attainments were then estimated by incorporating the possible selection bias term obtained in the ordered probit estimation. Finally, returns on each education level are calculated from the estimation results.

The rest of the paper is organized as follows. The second section provides the theoretical background for the optimal education decision and self-selection process, and the third

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section discusses the data and estimation method employed. The fourth section summarizes the estimation results and calculates the rates of returns for each education level, and concluding remarks are made in the fifth section.

### The Theoretical Model

This section provides a theoretical model that emphasizes the self-selection process of educational choice and the need to correct the selection bias for the estimation of wage equations of different education levels. Suppose each individual maximizes the present value of his lifetime earnings, defined as:

$$V(s) = \int_s^N y(s) e^{g(t-s)} e^{-rt} dt, \quad (1)$$

where  $y(s)$  is the income for  $s$  years of education,  $N$  is the year of retirement,  $g$  is the growth rate of income, and  $r$  is the discount rate. Integrating (1) yields:

$$V(s) = \frac{y(s)}{r-g} \left[ e^{-rs} - e^{(N-s)g} e^{-rN} \right]. \quad (2)$$

Let  $N$  approach infinity. Then (2) will reduce to  $V(s) = (y(s))/(r-g) e^{-rs}$ . Thus, the first-order condition for optimal education is:

$$\frac{\partial V(s)}{\partial s} = \frac{y'(r-g) + g'y}{(r-g)^2} e^{-rs} - \frac{y}{r-g} r e^{-rs} = 0, \quad (3)$$

where:

$$y' = \frac{\partial y}{\partial s} > 0, \quad g' = \frac{\partial g}{\partial s} \geq 0, \quad \text{and} \quad V_{ss} = \frac{\partial^2 y}{\partial s^2} \leq 0.$$

The growth rate of income has the property that  $g: \Re_+ \rightarrow \Re_+$  is a strictly quasi-concave function, which satisfies  $\lim_{s \rightarrow \infty} g(s) < r$ . From (3), optimal education can be expressed as:

$$S = S(y', r, g, g'). \quad (4)$$

Let income at time  $t$  with  $s$  years of education be:

$$y(t) = y e^{g(t-s)} e^{\theta}. \quad (5)$$

As claimed in Garen [1984], the income distribution for different education levels may likely be heterogeneous. Hence, error term  $\theta$  in (5) can be specified as  $\varepsilon + \phi \cdot s$ , which satisfies  $E(\varepsilon_i + \phi_i \cdot s_j) = 0$  and  $\text{cov}(\varepsilon_i + \phi_i \cdot s_j, R_i) = 0$ , where  $R$  represents all observable factors that affect income and income growth rates. Furthermore,  $E(\varepsilon_i + \phi_i \cdot s_i)(\varepsilon_k + \phi_k \cdot s_k) = 0$  if  $i \neq k$ , and  $E(\varepsilon_i + \phi_i \cdot s_i)(\varepsilon_k + \phi_k \cdot s_k) = \sigma^2$  if  $i = k$ .

Assuming income and income growth rates are influenced by educational attainments and other factors ( $x_1$ ), they can be expressed as:

$$y = \exp [\alpha_0 + \alpha_1 \cdot s + \alpha_2 \cdot x_1 + \alpha_3 \cdot x_1 \cdot s] \quad , \quad (6)$$

and

$$g = b_0 + b_1 \cdot s + b_2 \cdot x_1 + b_3 \cdot x_1 \cdot s \quad , \quad (7)$$

where  $\alpha_0$  to  $\alpha_3$  and  $b_0$  to  $b_3$  are parameters to be estimated. Substituting (6) and (7) into (5) and taking log form on both sides yields:

$$\begin{aligned} \ln y(t) &= \alpha_0 + \alpha_1 s + \alpha_2 x_1 + \alpha_3 x_1 s + b_0 T \\ &+ b_1 s T + b_2 x_1 T + b_3 x_1 s T + \varepsilon + \phi \cdot s \quad , \end{aligned} \quad (8)$$

where  $T$  is the working experience defined as  $t - s$ . Note in the complete model of (8) and (4),  $E(\varepsilon + \phi \cdot s | s, x_1, T) \neq 0$ , which renders bias under ordinary least squares (OLS) estimation. Therefore, an intergenerational utility maximization model is provided next to show that education is not a random process but one that is strongly influenced by an individual's ability and family background. Therefore, to obtain unbiased estimators for wage equations of different education levels, an educational choice equation needs to be estimated first, then it is used to correct for the selection bias in the wage equations.

#### *Educational Choice*

The factors determining a person's educational decision are now analyzed. Considering an intergenerational utility function suggests that each generation cares about his own consumption and human capital accumulation of his children. The utility maximization problem can be expressed as:

$$\max U = U(C_p, H_c) \quad , \quad (9)$$

$$\text{subject to } P_H H_c + C_p = \alpha H_p t \quad , \quad (10)$$

where  $C_p$  is the parents' consumption level,  $H_c$  is the stock of the children's human capital,  $P_H$  is the price of the children's human capital (the price of consumption goods is taken as the

rumeraire),  $t$  is the total time available,  $\alpha$  is the parents' working ability, and  $H_p$  is the parents' human capital. The utility function has the usual properties of  $U' > 0$ ,  $U'' < 0$ . Equation (10) is the resource constraint.<sup>4</sup> The Lagrange equation for the utility maximization is:

$$L = U(C_p, H_c) + \lambda [\alpha H_p t - P_H H_c - C_p] \quad (11)$$

The first-order conditions for  $C_p$  and  $H_c$  are:

$$\frac{\partial U}{\partial C_p} = U_{C_p} - \lambda = 0 \quad , \quad (12)$$

and

$$\frac{\partial U}{\partial H_c} = U_{H_c} - \lambda P_H = 0 \quad . \quad (13)$$

Dividing (12) by (13) yields:

$$\frac{U_{C_p}}{U_{H_c}} = \frac{1}{P_H} \quad . \quad (14)$$

Equation (14) shows that the trade-off between the parents' own consumption and the children's human capital accumulation depends on the price of the children's human capital. In other words, in the intergeneration model, a parent must allocate his time between working and educating his children. Let the parent's time constraint be defined as:

$$t_h + t_w = t \quad , \quad (15)$$

where  $t_h$  is the time engaged in the children's human capital accumulation and  $t_w$  is the time spent in working activities. Furthermore, assume that the children's human capital accumulation function and the parents' consumption constraint have the following functional forms:

$$H_c = A t_h H_p^\beta \quad , \quad (16)$$

and

$$C_p = \alpha H_p t_w \quad . \quad (17)$$

Equation (16) implies that the children's human capital formation is influenced by their own ability ( $A$ ), the time that parents spent with them, and the parents' own human capital.<sup>5</sup>

Equation (17) shows that the parents' consumption availability depends on the parents' working income, which in turn depends on the parents' ability, their stock of human capital, and the time they work. Substituting (15) and (17) into (9) and differentiating with respect to  $t_w$  yields:

$$\frac{U_{C_p}}{U_{H_c}} = \frac{A}{\alpha} H_p^{\beta-1} . \quad (18)$$

From (14) and (18):<sup>6</sup>

$$\frac{U_{C_p}}{U_{H_c}} = \frac{1}{P_H} = \frac{A}{\alpha} H_p^{\beta-1} . \quad (19)$$

From (19), it is apparent that under intergenerational utility maximization, the children's human capital depends on their individual factor as well as their family background such as their own ability, their parents' ability, and their parents' human capital. Therefore, the individual education choice function (E) can be defined as:

$$E = f(A, \alpha, H_p, \beta) \quad (20)$$

In short, an individual's attributes as well as family background influence an individual's educational choice.

### Estimation Method and Data Description

The empirical study is conducted in three steps. First, an ordered probit model is used to estimate the educational choice decision according to (20). Second, the wage equations of different educational attainments are estimated by incorporating the possible selection bias obtained in the ordered probit model. Finally, the returns on each education level are calculated from the estimation results.

Let the wage equations for each education level be:

$$W_{ij} = r_{oj} + r_{ij}' X_{ij} + v_{ij}, \quad i = 1, 2, 3, \dots, n \quad \text{and} \quad j = 1, 2, 3, \dots, m, \quad (21)$$

where  $i$  and  $j$  are indices for the  $i$ th individual and  $j$ th education level, respectively,  $W$  is the wage rate,  $X$  represents all observable factors that affect wage, and  $v$  represents all unobservable variables. Observable factors include individual attributes such as work experiences and its squared term, tenure and its squared term, professional field, and marital status, as well as exogenous variables such as occupation and firm size.

If education is a self-selection process under utility maximization, then the data observed will be a truncated nonrandom sample. In this case, direct OLS estimation of (21) will be biased. To cope with this problem, Heckman's [1979] two-stage method is used.

#### *Two-Stage Estimation Method*

First, an ordered probit model is adopted to estimate the educational choice equation. Assuming  $n$  workers and  $m$  types of education level, the choice function of the optimal level of education for each individual is expressed as:

$$E_i = \beta' H_i + u_i, \quad i = 1, 2, 3, \dots, n, \quad (22)$$

where  $E_i$  is the educational preference of the  $i$ th worker,  $H$  is factors affecting educational choice, and  $u_i \sim N(0, 1)$  is an error term. From the second section,  $H$  includes individual and family attributes. In the literature, family background includes parents' education, mother's working hours, number of children in the family, religion, race, and living amenity [Willis and Rosen, 1979; Garen, 1984; Falaris, 1996; Joseph and Thomas, 1996; Glewwe, 1996; Arjun and Gaston, 1997]. Individual attributes include intelligence, health condition, and test scores. In fact,  $E_i$  is a latent and unobservable variable. In reality, the observed educational choice is represented by a dummy variable,  $Z_{ij}$ , and  $\alpha_1, \dots, \alpha_n$  are cut-off points for the different education levels, where  $\alpha_1 < \alpha_2 < \dots < \alpha_n$ ,  $\alpha_0 = -\infty$ , and  $\alpha_n = \infty$  for  $i = 1, 2, \dots, n$  and  $j = 1, 2, \dots, m$ . If  $\alpha_{j-1} \leq S_i < \alpha_j$ , then  $Z_{ij} = 1$  and  $i$ th worker chooses  $j$ th level of education, otherwise  $Z_{ij} = 0$ . The probability of having education  $j$  becomes:

$$\text{prob}(Z_{ij} = 1) = \Phi(\alpha_j - \beta' H_i) - \Phi(\alpha_{j-1} - \beta' H_i), \quad (23)$$

where  $\Phi$  is a standard normal cumulative density function. Since under self-selection the samples observed would be a truncated normal distribution, estimation of  $r_{oj}$  and  $r_{ij}$  in (21) by OLS will be biased and inconsistent.

Let  $\psi_{ij} = \sigma_{uv} / \sigma_u$  be the covariance matrix of error terms between educational choice and wage equations, and:

$$\lambda_{ij} = E \left( \frac{u}{\sigma_u} \middle| \frac{\alpha_{j-1} - \beta' H_i}{\sigma_u} < \frac{u_i}{\sigma_u} < \frac{\alpha_j - \beta' H_i}{\sigma_u} \right),$$

is the expected value of the correction term. Then (21) can be rewritten as:

$$W_{ij} = r_{oj} + r_{ij}' X_{ij} + \psi_{ij} \lambda + e_{ij}. \quad (24)$$

That is:

$$\begin{aligned}
& E(W_{ij} | X_{ij}, Z_{ij} = 1) \\
&= \gamma_{0j} + \gamma_{ij}' X_{ij} + E(v_i | X_{ij}, Z_{ij} = 1) \\
&= \gamma_{0j} + \gamma_{ij}' X_{ij} + E(v_i | \alpha_{j-1} - \beta' H_i < u_i < \alpha_j - \beta' H_i) \\
&= \gamma_{0j} + \gamma_{ij}' X_{ij} + E \left[ E(v_i | \alpha_{j-1} - \beta' H_i < u_i < \alpha_j - \beta' H_i, u_i) \right. \\
&\quad \left. | \alpha_{j-1} - \beta' H_i < u_i < \alpha_j - \beta' H_i \right] \\
&= \gamma_{0j} + \gamma_{ij}' X_{ij} + \frac{\sigma_{uv}}{\sigma_u^2} E(u | \alpha_{j-1} - \beta' H_i < u_i < \alpha_j - \beta' H_i) \\
&= \gamma_{0j} + \gamma_{ij}' X_{ij} + \frac{\sigma_{uv}}{\sigma_u} E \left( \frac{u}{\sigma_u} \middle| \frac{\alpha_{j-1} - \beta' H_i}{\sigma_u} < \frac{u_i}{\sigma_u} < \frac{\alpha_j - \beta' H_i}{\sigma_u} \right) .
\end{aligned}$$

Empirically, the maximum likelihood estimation method can be used to estimate (23), then use  $\hat{\alpha}$  and  $\hat{\beta}$  to calculate the standard normal cumulative density function ( $\Phi$ ) and probability density function ( $\phi$ ) among  $j = 1$ ,  $1 < j < m$ , and  $j = m$ , respectively. Except for the cases  $j = 1$  and  $j = m$  which are single truncated, all other cases are double truncated. According to Maddala [1983], the expected values of truncated correction terms can be expressed as:

$$\lambda_{i1} = E \left( \frac{u}{\sigma_u} \middle| \frac{\alpha_0 - \beta' H_i}{\sigma_u} < \frac{u_i}{\sigma_u} < \frac{\alpha_1 - \beta' H_i}{\sigma_u} \right) = \frac{-\phi \left( \frac{\alpha_1 - \beta' H_i}{\sigma_u} \right)}{\Phi \left( \frac{\alpha_1 - \beta' H_i}{\sigma_u} \right)}, \quad j = 1, \quad (25)$$

$$\begin{aligned}
\lambda_{ij} &= E \left( \frac{u}{\sigma_u} \middle| \frac{\alpha_{j-1} - \beta' H_i}{\sigma_u} < \frac{u_i}{\sigma_u} < \frac{\alpha_j - \beta' H_i}{\sigma_u} \right) \\
&= \frac{\phi \left( \frac{\alpha_{j-1} - \beta' H_i}{\sigma_u} \right) - \phi \left( \frac{\alpha_j - \beta' H_i}{\sigma_u} \right)}{\Phi \left( \frac{\alpha_j - \beta' H_i}{\sigma_u} \right) - \Phi \left( \frac{\alpha_{j-1} - \beta' H_i}{\sigma_u} \right)}, \quad 1 < j < m, \quad (26)
\end{aligned}$$

and

$$\lambda_{im} = E \left( \frac{u}{\sigma_u} \middle| \frac{\alpha_{m-1} - \beta' H_i}{\sigma_u} < \frac{u_i}{\sigma_u} < \frac{\alpha_m - \beta' H_i}{\sigma_u} \right)$$

$$= \frac{\phi \left( \frac{\alpha_m - \beta' H_i}{\sigma_u} \right)}{1 - \Phi \left( \frac{\alpha_m - \beta' H_i}{\sigma_u} \right)}, \quad j = m. \quad (27)$$

In the second stage, substituting the sample selection-corrected terms,  $\lambda$ , into (24) and using OLS estimation will solve the problem of sample selection bias, in this case  $E(e_{ij} | X_{ij}, Z_{ij} = 1) = 0$ .

#### Returns to Education

The estimation results obtained from the selection-corrected wage equations are used to calculate the rates of return for each education level. The annual rate of return for each education level is defined as:

$$R \equiv \frac{\left[ \frac{E(W(ij)) - E(W(jj))}{E(W(jj))} + \frac{E(W(ji)) - E(W(ii))}{E(W(ii))} \right] \div 2}{S(j) - S(i)}, \quad (28)$$

where  $E(W(ij))$  is the expected wage of  $j$ th education level for workers with  $i$ th educational attainment,  $E(W(jj))$  is the average wage of workers with  $j$ th educational attainment,  $E(W(ji))$  is the expected wage of  $i$ th education level for workers with  $j$ th educational attainment, and  $E(W(ii))$  is the average wage of workers with  $i$ th educational attainment. The calculation of returns to education requires the estimation of the expected wage received if the workers choose not to have the current educational attainment. For example, for a college graduate worker, estimate the expected wage with high school education if he chooses to receive only high school education instead of going further for college. For a high school graduate, calculate his expected wage with college education, provided he chooses to go to college. As the expected wage computation involves these two types of workers, use the average of the two as the rates of return, as shown in (28). In addition, although only one type of calculation is performed, the results are quite similar.

#### Data Description

This study utilizes Taiwan's Manpower Utilization Survey data of 1996, obtained from the directorate general of budget, accounting, and statistics, Executive Yuan. Data with complete information on intergenerational properties are employed, including parents' education, occupation, and marital status. For the first-stage selection equation, there were 19,455 samples, with 61.9 percent male and 38.1 percent female. For the second-stage wage



equation, there were 8,485 samples, with 55 percent male and 45 percent female. As shown in Table 1, the average years of schooling for parents and children are 6.79 and 11.89 years, respectively, and the correlation coefficient of the two variables is 0.23. On average, the worker's age is 26 years, tenure is 2.63 years, in which the male's tenure (3.05) in general is greater than the female's (1.96), and the years of other experience is 5.8 years, in which the male's (7.07) is about twice the female's (3.53). Tables A1 through A3 in the Appendix shows the basic properties of the wage equation samples. In this study, due to limited data, information on an individual's ability is not available. However, some family background data can be obtained which include parents' education, occupation, and marital status, as well as the number of siblings. Factors that affect wage rate include tenure, work experience, industry, occupation, firm size, skill level, gender, and marital status. The definitions of all the variables used in this paper are summarized in Table A4.

**TABLE 1**  
**Basic Statistics of Variables in Wage Equations**

Variables	Full Sample Mean	Male Sample Mean	Female Sample Mean
Age	25.88 (5.57)	27.23 (5.76)	23.58 (4.36)
Years of education	11.89 (2.31)	11.49 (2.34)	12.56 (2.10)
Tenure	2.63 (3.11)	3.05 (3.44)	1.96 (2.26)
Other work experience	5.80 (4.73)	7.07 (4.86)	3.53 (3.46)
Parents' education	6.79 (2.89)	6.47 (2.70)	7.33 (3.12)
Number of siblings	1.67 (2.01)	1.82 (2.05)	1.42 (2.10)
Observations	8,485	4,676	3,809

Notes: Standard deviations are in parentheses.

## Estimation Results

Table 2 presents the maximum likelihood estimation results of the ordered probit educational choice equation. For all the full, male, and female samples, the Pearson  $\chi^2$  tests for models' goodness of fit are all significant at the 1 percent level. For the full sample, all coefficients are significant at the 5 percent level. The negative sign of parents' education implies the higher the parents' education levels, the greater the probability of education for their children. The parents' occupations with probability of receiving more education are in the following order: government administrators and business managers, technicians and associate professionals, service or sales workers, clerks, machine operators and assemblers, production laborers, and agricultural workers. For parents working in the public sector, their

children tend to attain higher education. This is mainly because these parents receive an education subsidy for their children from the government, therefore reducing their children's cost of education. Children whose parents are living together also tend to receive more education.<sup>7</sup> However, the larger the number of siblings, the smaller the chance of receiving an education. This is consistent with Becker's [1975] argument that altruistic parents trade off between quantity and quality of their children. When separated into male and female subgroups, except for the variables *PPUB*, *EXE&GOVP*, and *TEC&PROP*, the coefficients of all variables show that males tend to have a higher probability of receiving more education than females. These results suggest that family background factors are essential in determining the children's education level. Moreover, in Taiwan or any society deeply rooted in traditional Chinese culture, family preference is significantly biased toward the male along with education.

**TABLE 2**  
**Ordered Probit Model of Educational Choice**

Variables	Full Sample		Male Sample		Female Sample	
Constant	-1.914	(283.90)*	-1.639	(159.73)*	-2.140	(75.23)*
<b>Family Background</b>						
<i>PEDU</i>	-0.070	(92.30)*	-0.090	(84.61)*	-0.040	(14.91)*
<i>PPUB</i>	-0.175	(38.70)*	-0.159	(17.96)*	-0.196	(20.54)*
<i>PMARR</i>	-0.239	(4.77)*	-0.302	(5.81)*	-0.050	(0.04)**
<i>CHILD</i>	0.011	(5.45)*	0.018	(7.73)*	0.003	(16.23)*
<b>Parents' Occupation</b>						
<i>EXE&amp;GOVP</i>	-0.375	(92.32)*	-0.354	(37.95)*	-0.396	(35.66)*
<i>TEC&amp;PROP</i>	-0.223	(26.65)*	-0.217	(14.20)*	-0.224	(11.21)*
<i>CLERKP</i>	-0.175	(13.97)*	-0.214	(11.67)*	-0.117	(2.59)***
<i>SER&amp;SALEP</i>	-0.201	(41.24)*	-0.228	(28.46)*	-0.179	(11.93)*
<i>AGR&amp;FISHP</i>	0.180	(32.53)*	0.212	(27.01)*	0.089	(2.89)***
<i>OPR&amp;ASSEP</i>	-0.040	(2.07)*	-0.09	(4.96)*	0.027	(0.33)
<b>Personal Characteristics</b>						
<i>GENDER</i>	0.192	(144.90)*				
$\alpha_2$	1.364		1.412		1.272	
$\alpha_3$	1.829		1.849		1.799	
$\alpha_4$	2.819		2.796		2.856	

TABLE 2 (CONT.)

Variables	Full Sample	Male Sample	Female Sample
$\alpha_5$	3.425	3.385	3.484
Log Likelihood	-30,040.580	-18,323.850	-11,642.800
Pearson $\chi^2$	73,067.800*	40,019.640*	27,922.400*
Observations	19,470	11,800	7,670

Notes: \*, \*\*, and \*\*\* denote statistically significant at the 1, 5, and 10 percent levels, respectively. The reference group for occupation is production laborers. Negative coefficients imply a higher probability for receiving an education. The  $\chi^2$  statistics are in parentheses.

Tables 3 through 5 show the estimation results of the second-stage selection-corrected wage equations of each education level for the full, male, and female samples. The main findings are as follows. First, occupations have a positive effect on wages. Government administrators, business executives and managers, and professionals receive the highest wage. For males, they are significant across different education levels except for primary school level, but for females, it is most significant at the junior college and university levels. Second, a positive firm-size or public sector effect is only present at higher education levels. Third, the industries that pay higher wages are transportation, storage, communication, and public utilities, which are especially significant for senior high, vocational school, and junior college. The agriculture sector, in general, pays lower wages, especially at the junior high level for females and at the vocational school and university levels for males.

Fourth, as for the subject studied, for vocational school graduates, the medicine majors receive the highest wage for males but the lowest wage for females. For junior college graduates, the science, humanities, and agriculture majors receive the lower wage. For university graduates, the medicine majors receive the highest wage for both males and females. However, science majors receive a significantly lower wage for females. Fifth, tenure and work experience have a significant and positive effect on wages. Tenure has a positive and significant effect on wages for all education levels except primary school. Work experience has a positive and significant effect for junior high, vocational school, and junior college. The negative effects of their squared terms imply that the effects of tenure and work experience diminish over time. Moreover, the effect of tenure is more important than work experience for both male and female groups. This result may imply the relative importance of specific training over general training in determining workers' wages. Sixth, workers who are married and living with their spouses receive higher wages. Seventh, males receive higher wages than females, especially at the vocational school level. However, the wage gap shrinks as the education level increases.

**TABLE 3**  
**Wage Regression by Educational Attainment: Full Sample**

Variables	Primary School	Junior High	Senior High	Vocational School	Junior College	University
Constant	12.39 (19.90)*	12.11 (87.10)*	12.18 (152.00)*	12.18 (355.00)*	12.32 (293.00)*	12.63 (138.00)*
<b>Occupation</b>						
<i>EXE&amp;GOV</i>	0.68 (2.04)*	0.43 (4.06)*	0.21 (2.75)*	0.26 (7.04)*	0.22 (7.62)*	0.23 (5.12)*
<i>TEC&amp;PRO</i>	—	0.06 (0.76)	0.09 (2.40)*	0.05 (2.78)*	0.07 (3.79)*	0.07 (2.01)**
<i>CLERK</i>	0.40 (1.60)	0.11 (1.58)	0.07 (2.05)**	0.04 (2.21)*	0.12 (3.69)*	0.23 (2.89)*
<i>SER&amp;SALE</i>	0.22 (0.67)	-0.13 (1.48)	-0.25 (1.83)***	-0.21 (3.37)*	0.11 (0.45)	0.49 (1.57)***
<i>AGR&amp;FISH</i>	0.50 (1.86)***	0.09 (1.26)	-0.02 (0.73)	-0.02 (1.09)	0.02 (0.87)	0.11 (1.22)
<i>OPR&amp;ASSE</i>	0.17 (0.63)	0.04 (0.63)	-0.05 (0.95)	-0.12 (3.73)*	-0.15 (2.27)**	0.16 (0.53)
<b>Firm Size</b>						
<i>FS2</i>	0.24 (1.16)	0.04 (0.99)	-0.10 (2.21)**	0.01 (0.71)	0.02 (1.04)	0.09 (1.81)***
<i>FS3</i>	-0.09 (0.44)	0.12 (2.70)*	-0.01 (0.28)	0.02 (0.86)	0.08 (3.01)***	0.20 (4.99)*
<i>FS4</i>	-0.29 (1.22)	0.05 (0.93)	-0.05 (1.11)	0.05 (2.22)**	0.04 (1.85)***	0.17 (3.65)*
<i>PUB</i>	-0.05 (0.12)	-0.00 (0.10)	0.10 (1.95)***	-0.01 (0.46)	0.06 (2.36)**	0.20 (5.10)*
<b>Industry</b>						
<i>AGR</i>	-0.05 (0.42)	-0.18 (1.98)***	0.05 (0.78)	-0.11 (2.99)*	0.01 (0.32)	-0.22 (2.78)*
<i>MFG</i>	—	-0.09 (1.11)	0.08 (1.24)	-0.04 (1.12)	-0.00 (0.21)	-0.12 (1.90)***
<i>ELE</i>	0.08 (1.02)	0.00 (0.11)	0.13 (1.74)***	0.07 (1.90)***	0.05 (1.34)	0.09 (1.02)

TABLE 3 (CONT.)

Variables	Primary School	Junior High	Senior High	Vocational School	Junior College	University
<i>CON</i>	0.09 (0.63)	-0.11 (1.29)	0.05 (0.80)	-0.01 (0.57)	-0.00 (0.25)	-0.03 (0.50)
<i>TRA</i>	0.21 (1.02)	0.01 (0.17)	0.17 (2.40)**	0.06 (1.68)***	0.08 (2.46)**	0.03 (0.62)
<i>FIN</i>	0.17 (1.20)	-0.04 (0.55)	0.10 (1.56)	-0.07 (2.29)*	0.00 (0.07)	-0.14 (2.26)**
<i>SER</i>	-0.04 (0.08)	-0.28 (1.05)	0.06 (0.68)	0.09 (1.68)***	0.06 (1.22)	-0.05 (0.66)
<b>Academic Specialty</b>						
<i>HUM</i>	—	—	—	0.08 (0.38)	-0.11 (1.62)***	-0.00 (0.15)
<i>LAW</i>	—	—	—	—	—	0.01 (0.26)
<i>SCI</i>	—	—	—	—	-0.17 (1.90)***	-0.03 (0.55)
<i>TEC</i>	—	—	—	-0.01 (0.75)	-0.03 (1.55)	-0.01 (0.44)
<i>AGR</i>	—	—	—	-0.03 (1.32)	-0.10 (2.15)**	0.05 (0.84)
<i>MED</i>	—	—	—	0.18 (3.79)*	0.01 (0.39)	0.42 (7.13)*
<i>EDU</i>	—	—	—	0.01 (0.10)	0.04 (0.73)	0.03 (0.72)
<i>OTH</i>	—	—	—	-0.01 (0.60)	0.06 (1.75)***	0.11 (1.57)
<i>TENURE</i>	0.01 (0.87)	0.07 (11.20)*	0.06 (7.34)*	0.06 (12.80)*	0.05 (8.89)*	0.05 (5.40)*
<i>TENUSQ</i>	-0.00 (0.68)	-0.00 (7.52)*	-0.00 (4.88)*	-0.00 (5.67)*	-0.00 (4.41)*	-0.00 (2.08)**
<i>WEXPER</i>	-0.02 (1.41)	0.05 (1.62)***	0.00 (1.00)	0.03 (8.32)*	0.04 (6.53)*	0.01 (1.02)
<i>WEXPSQ</i>	0.00 (1.51)	-0.00 (8.92)*	-0.00 (1.13)	-0.00 (5.57)*	-0.00 (4.10)*	0.00 (1.15)

TABLE 3 (CONT.)

Variables	Primary School	Junior High	Senior High	Vocational School	Junior College	University
<i>MARR</i>	0.19 (2.42)*	0.06 (3.25)*	0.19 (6.03)*	0.07 (4.30)*	0.05 (2.42)*	0.02 (0.65)
<i>GENDER</i>	0.25 (2.56)*	0.17 (7.02)*	0.18 (6.13)*	0.28 (14.40)*	0.18 (9.16)*	0.11 (3.63)*
$\lambda$	0.20 (0.80)	0.07 (1.00)	-0.03 (0.56)	-0.10 (2.72)*	-0.04 (1.50)	-0.10 (2.16)**
$R^2$	0.18	0.35	0.38	0.42	0.38	0.43
SSE	35.06	299.34	94.12	416.78	146.42	98.69
Observations	185	1,741	1,711	2,761	1,367	634

Notes: \*, \*\*, and \*\*\* denote statistically significant at the 1, 5, and 10 percent levels, respectively. SSE denotes sum of squared errors. The reference groups are production laborers for occupation, 1 to 99 persons for firm size, business for academic specialty, and commerce for industry.

TABLE 4  
Wage Regression by Educational Attainment: Male Sample

Variables	Primary School	Junior High	Senior High	Vocational School	Junior College	University
Constant	13.23 (17.4)*	12.12 (58.90)*	12.32 (71.50)*	12.47 (163.00)**	12.49 (142.00)*	12.83 (80.80)*
<b>Occupation</b>						
<i>EXE&amp;GOV</i>	-0.10 (0.22)	0.59 (3.71)*	0.18 (1.87)***	0.53 (7.95)*	0.21 (4.48)*	0.18 (2.26)**
<i>TEC&amp;PRO</i>	—	0.10 (0.73)	0.04 (0.60)	0.07 (1.62)***	0.10 (2.70)*	0.05 (0.77)
<i>CLERK</i>	-0.46 (1.08)	0.16 (1.19)	0.02 (0.36)	0.14 (3.06)*	0.26 (4.73)*	0.32 (2.19)**
<i>SER&amp;SALE</i>	-0.49 (1.07)	-0.08 (0.58)	-0.09 (0.57)	-0.21 (2.74)*	0.05 (0.18)	0.53 (1.54)

TABLE 4 (CONT.)

Variables	Primary School	Junior High	Senior High	Vocational School	Junior College	University
<i>AGR&amp;FISH</i>	-0.26 (0.62)	0.15 (1.13)	-0.05 (0.92)	0.01 (0.32)	0.03 (0.81)	0.12 (0.98)
<i>OPR&amp;ASSE</i>	-0.74 (1.72)	0.09 (0.69)	-0.09 (1.07)	-0.12 (2.36)**	-0.12 (1.45)	0.12 (0.37)
<b>Firm Size</b>						
<i>FS2</i>	—	0.06 (1.10)	-0.10 (1.47)	-0.00 (0.24)	0.01 (0.37)	0.04 (0.59)
<i>FS3</i>	-0.10 (0.50)	0.13 (1.99)***	-0.03 (0.36)	-0.01 (0.36)	0.06 (1.69)***	0.18 (3.05)*
<i>FS4</i>	-0.16 (0.56)	0.07 (0.93)	-0.06 (0.82)	0.01 (0.30)	0.02 (0.87)	0.21 (3.04)*
<i>PUB</i>	-0.17 (0.37)	-0.00 (0.10)	0.10 (1.62)***	-0.06 (1.45)	0.09 (2.07)**	0.15 (2.40)**
<b>Industry</b>						
<i>AGR</i>	-0.10 (0.72)	-0.14 (1.31)	0.21 (1.34)	-0.19 (3.07)*	-0.01 (0.25)	-0.24 (2.02)**
<i>MFG</i>	—	-0.09 (0.84)	0.21 (1.38)	-0.11 (1.83)***	-0.02 (0.39)	-0.07 (0.74)
<i>ELE</i>	0.06 (0.74)	0.02 (0.23)	0.25 (1.63)***	-0.00 (0.01)	0.04 (0.58)	0.11 (0.78)
<i>CON</i>	0.06 (0.40)	-0.08 (0.76)	0.17 (1.13)	-0.12 (2.13)**	-0.03 (0.52)	0.01 (0.16)
<i>TRA</i>	0.22 (1.06)	0.02 (0.23)	0.31 (2.01)***	-0.00 (0.09)	0.00 (0.10)	0.08 (0.81)
<i>FIN</i>	0.08 (0.52)	-0.02 (0.19)	0.20 (1.30)	-0.12 (2.09)***	0.02 (0.31)	-0.06 (0.65)
<i>SER</i>	0.03 (0.05)	-0.27 (0.98)	0.23 (1.30)	0.07 (0.87)	-0.07 (0.87)	-0.05 (0.44)
<b>Academic Specialty</b>						
<i>HUM</i>	—	—	—	—	-0.13 (1.23)	-0.03 (0.56)
<i>LAW</i>	—	—	—	—	—	0.14 (1.18)

TABLE 4 (CONT.)

Variables	Primary School	Junior High	Senior High	Vocational School	Junior College	University
<i>SCI</i>	—	—	—	—	-0.28 (1.83) <sup>***</sup>	0.01 (0.16)
<i>TEC</i>	—	—	—	-0.00 (0.28)	-0.04 (1.39)	-0.00 (0.08)
<i>AGR</i>	—	—	—	-0.01 (0.35)	-0.04 (0.63)	0.05 (0.56)
<i>MED</i>	—	—	—	-0.29 (1.69) <sup>***</sup>	-0.07 (1.18)	0.47 (5.47) <sup>*</sup>
<i>EDU</i>	—	—	—	—	-0.00 (0.01)	-0.01 (0.18)
<i>OTH</i>	—	—	—	0.00 (0.09)	0.05 (0.88)	0.24 (1.81) <sup>***</sup>
<i>TENURE</i>	0.00 (0.18)	0.07 (9.16) <sup>*</sup>	0.06 (6.59) <sup>*</sup>	0.06 (9.87) <sup>*</sup>	0.05 (6.12) <sup>*</sup>	0.04 (3.08) <sup>*</sup>
<i>TENUSQ</i>	0.00 (0.01)	-0.00 (6.16) <sup>*</sup>	-0.00 (4.89) <sup>*</sup>	-0.00 (4.87) <sup>*</sup>	-0.00 (3.01) <sup>*</sup>	-0.00 (0.94)
<i>WEXPER</i>	-0.01 (0.45)	0.06 (11.50) <sup>*</sup>	0.01 (1.38)	0.04 (6.80) <sup>*</sup>	0.03 (3.91) <sup>*</sup>	-0.00 (0.39)
<i>WEXPSQ</i>	0.00 (0.66)	-0.00 (9.10) <sup>***</sup>	-0.00 (1.45)	-0.00 (5.00) <sup>*</sup>	-0.00 (2.70) <sup>*</sup>	0.00 (1.58) <sup>***</sup>
<i>MARR</i>	0.14 (1.72) <sup>***</sup>	0.06 (2.83)	0.17 (5.04) <sup>*</sup>	0.06 (3.28) <sup>*</sup>	0.04 (1.76) <sup>***</sup>	0.03 (0.70)
$\lambda$	0.13 (0.51)	0.02 (0.34)	0.08 (0.93)	-0.01 (0.29)	0.01 (0.35)	-0.12 (1.70) <sup>***</sup>
$R^2$	0.16	0.29	0.30	0.29	0.26	0.44
SSE	26.32	232.76	52.18	205.21	69.85	49.22
Observations	149	1,402	423	1,605	741	311

Notes: See notes in Table 3.



**TABLE 5**  
**Wage Regression by Educational Attainment: Female Sample**

Variables	Primary School	Junior High	Senior High	Vocational School	Junior College	University
Constant	13.82 (5.27)*	12.22 (48.40)*	12.13 (126.00)*	12.13 (310.00)*	12.32 (231.00)*	12.63 (106.00)*
<b>Occupation</b>						
<i>EXE&amp;GOV</i>	—	-0.51 (2.22)**	0.13 (0.80)	0.05 (1.04)	0.25 (5.88)*	0.24 (4.13)*
<i>TEC&amp;PRO</i>	—	-0.03 (0.36)	0.15 (2.97)*	0.09 (3.68)*	0.08 (3.52)*	0.06 (1.59)***
<i>CLERK</i>	1.04 (4.33)*	0.00 (0.10)	0.10 (2.06)*	-0.00 (0.21)	0.01 (0.32)	0.02 (0.25)
<i>SER&amp;SALE</i>	—	—	-1.19 (3.62)*	0.16 (0.84)	—	—
<i>AGR&amp;FISH</i>	1.28 (2.09)**	0.14 (1.23)	-0.04 (0.74)	-0.05 (1.55)	0.09 (1.54)	—
<i>OPR&amp;ASSE</i>	1.50 (2.85)*	0.01 (0.16)	-0.09 (0.90)	0.01 (0.28)	-0.26 (1.91)***	—
<b>Firm Size</b>						
<i>FS2</i>	0.17 (0.83)	0.01 (0.21)	-0.08 (1.40)	0.04 (1.46)	0.05 (1.40)	0.21 (2.76)*
<i>FS3</i>	—	0.11 (2.16)**	-0.00 (0.07)	0.06 (1.92)***	0.12 (3.01)*	0.23 (3.92)*
<i>FS4</i>	-1.39 (1.24)	-0.00 (0.03)	-0.05 (0.92)	0.11 (3.42)*	0.05 (1.59)	0.14 (1.99)***
<i>PUB</i>	—	-0.02 (0.11)	0.10 (0.89)	0.12 (2.02)**	0.06 (1.58)	0.27 (5.31)*
<b>Industry</b>						
<i>AGR</i>	0.36 (2.04)	-0.27 (1.68)***	0.00 (0.10)	-0.04 (0.99)	0.03 (0.68)	0.02 (0.20)
<i>MFG</i>	—	-0.15 (0.94)	0.06 (0.74)	0.00 (0.09)	-0.01 (0.33)	-0.25 (2.66)*
<i>ELE</i>	-2.76 (1.21)	0.29 (1.67)***	0.01 (0.08)	0.07 (1.11)	0.02 (0.49)	0.04 (0.41)

TABLE 5 (CONT.)

Variables	Primary School	Junior High	Senior High	Vocational School	Junior College	University
<i>CON</i>	0.97 (2.16)**	-0.06 (0.45)	0.04 (0.53)	0.07 (1.73)***	0.00 (0.01)	-0.10 (1.38)
<i>TRA</i>	—	0.51 (1.30)	0.11 (1.26)	0.12 (2.43)**	0.16 (3.83)*	-0.00 (0.00)
<i>FIN</i>	0.61 (1.02)	0.00 (0.04)	0.08 (1.02)	-0.01 (0.47)	-0.03 (0.76)	-0.21 (2.71)*
<i>SER</i>	—	—	-0.03 (0.22)	-0.08 (1.01)	0.07 (1.16)	-0.15 (1.48)
<b>Academic Specialty</b>						
<i>HUM</i>	—	—	—	0.29 (1.46)	-0.06 (0.72)	0.01 (0.46)
<i>LAW</i>	—	—	—	—	—	-0.12 (1.55)
<i>SCI</i>	—	—	—	—	-0.09 (0.84)	-0.23 (1.62)***
<i>TEC</i>	—	—	—	-0.01 (0.45)	-0.01 (0.41)	-0.01 (0.18)
<i>AGR</i>	—	—	—	-0.03 (0.89)	-0.13 (1.85)***	0.08 (0.87)
<i>MED</i>	—	—	—	0.31 (6.04)*	0.05 (1.30)	0.22 (2.30)**
<i>EDU</i>	—	—	—	0.03 (0.33)	0.07 (1.00)	0.03 (0.53)
<i>OTH</i>	—	—	—	-0.00 (0.25)	0.04 (0.99)	-0.01 (0.11)
<i>TENURE</i>	-0.00 (0.10)	0.09 (7.07)*	0.04 (2.00)**	0.06 (7.99)*	0.05 (6.72)*	0.10 (5.23)*
<i>TENUSQ</i>	-0.00 (0.04)	-0.00 (4.47)*	-0.00 (0.11)	-0.00 (2.84)*	-0.00 (3.71)*	-0.00 (3.75)*
<i>WEXPER</i>	-0.15 (2.02)***	0.03 (3.38)*	-0.00 (0.01)	0.03 (5.13)*	0.04 (5.26)*	0.02 (1.47)
<i>WEXPSQ</i>	0.00 (1.53)	-0.00 (2.70)**	-0.00 (0.10)	-0.00 (3.32)*	-0.00 (2.77)*	-0.00 (0.03)

TABLE 5 (CONT.)

Variables	Primary School	Junior High	Senior High	Vocational School	Junior College	University
<i>MARR</i>	0.49 (1.50)	-0.14 (0.96)	0.27 (1.94)***	0.19 (1.95)***	0.24 (2.71)*	0.09 (0.74)
$\lambda$	1.04 (0.92)	0.08 (0.55)	-0.20 (2.31)**	-0.19 (3.88)*	-0.09 (1.89)***	-0.10 (1.68)***
$R^2$	0.56	0.23	0.16	0.25	0.34	0.35
SSE	6.01	36.97	24.61	116.71	54.77	37.07
Observations	36	339	289	1,156	626	323

Notes: See notes in Table 3.

As for the coefficients of selection bias term, significant coefficients are found for educational attainment at the university level for males and at all education levels above junior high for females. These results strongly suggest that sample selection bias is presented in the data. This also justifies the need for the two-stage estimation method. Table 6 shows the values of selection bias by multiplying the correction terms with the estimated coefficients. For example, for females, positive selection bias exists for senior high school (0.146) and negative selection bias is present for vocational school (-0.007), junior college (-0.065), and university (-0.149). These results imply that the observed wages of workers with junior high school attainment are biased upward, while those of workers with educational attainment above vocational school are biased downward.

Finally, the rates of return on education are computed for different education levels according to (28). The results are shown in Table 7. The estimated annual rate of return is -3.57 percent for junior high school, -2.32 percent for males, and -11.3 percent for females;<sup>8</sup> 2.30 percent for senior high school, 1.83 percent for males, and 3.28 percent for females; 3.98 percent for vocational school, 3.40 percent for males, and 4.40 percent for females;<sup>9</sup> 4.58 percent for junior college, 4.20 percent for males, and 6.09 percent for females; 8.20 to 12.41 percent for university, 7.23 to 10.57 percent for males, and 8.82 to 18.77 percent for females.

In summary, the annual rate of return for secondary school education is 3 percent, 2.8 percent for males, and 4.1 percent for females, while that for higher education is 12.2 percent,<sup>10</sup> 10.3 percent for males, and 18.1 percent for females. Therefore, in Taiwan, the return rate of education is higher for higher education than for secondary education. Moreover, rates for females are also greater than rates for males at all education levels except for the junior high school level. The findings of this paper are consistent with those of most studies conducted in developing countries.<sup>11</sup>

**TABLE 6**  
**Estimation of Selection Bias ( $\lambda * \psi$ ) by Educational Attainment**

Education	Full Sample	Male Sample	Female Sample
Primary School	-0.451	-0.307	-2.334
Junior High	-0.095	-0.037	-0.114
Senior High	0.026	-0.062	0.146**
Vocational School	-0.004*	-0.001	-0.007*
Junior College	-0.040	0.012	-0.065**
University	-0.145**	-0.182***	-0.149***

Notes: \*, \*\*, and \*\*\* denote statistically significant at the 1, 5, and 10 percent levels, respectively. Positive (negative) selection implies observed values are overestimated (underestimated).

**TABLE 7**  
**Estimated Returns on Education by Educational Attainment**

Education	Full Sample	Male Sample	Female Sample
Junior High	-3.57	-2.32	-11.03
Senior High	2.30	1.83	3.28
Vocational School	3.98	3.40	4.40
Junior College	4.58	4.20	6.09
From senior high to university	12.41	10.57	18.77
From vocational school to university	12.33	8.96	14.74
From junior college to university	8.20	7.23	8.82

### Concluding Remarks

This paper estimates educational choice, wage determination, and the rate of return to education in Taiwan using Taiwan's Manpower Utilization Survey data of 1996. Since

education investment is a self-selection process, this paper adopts a two-stage estimation method. First, a polychotomous ordered probit model is used to estimate the education decision. Second, the wage equations of different educational attainments are estimated by incorporating the possible selection bias that was obtained in the ordered probit model. Finally, the rates of return on each education level are calculated from the estimation results.

The main findings of this paper are as follows. First, family factors significantly affect a person's selection of education level. For example, the larger the number of children in the family, the lower the educational attainment of the children; the higher the parents' education and work position, the higher their children's education; and children from single-parent families tend to attain a lower level of education. Second, significant negative selection bias is found in the male group for the university level and in the female group for vocational school, junior college, and university. On the other hand, in the female group, significant positive bias is only found for senior high school. Third, the estimated annual rate of return to schooling is 2.30 percent for senior high school, 3.98 percent for vocational school, 4.58 percent for junior college, and 12.20 percent for university. In general and consistent with the literature, it is found that females have a higher return rate to education than males for most education levels.

Due to limited data on the measurement of an individual's talent, the results of our educational choice estimation may likely understate the extent of the selection biases that were identified. Nevertheless, the findings of this paper clearly support the fact that people in Taiwan are in favor of a higher education study, and this is conducive to human capital accumulation.

## APPENDIX

**Table A1**  
**Summary Properties of Full Sample (in Percentages)**

Age		Marital Status		Education		Occupation		Firm Size	
15-25	14.7	Never Married	26.9	Primary School	2.20	Professionals/Managers	7.4	1-49	74.9
26-35	30.1	Married/Cohabited	67.8	Junior High	20.50	Technicians	16.1	50-99	5.0
36-45	28.8	Separated/Divorced	3.0	Senior High	20.20	Clerks	13.5	100-499	5.1
46-55	16.2	Widowed	2.3	Vocational School	32.50	Service	16.3	500+	6.3
56-65	9.0			Junior College	16.10	Agricultural	6.1	Public	8.6
65+	0.2			University	7.47	Skilled Production	36.4 4.2		

**Table A2**  
**Summary Properties of Male Sample (in Percentages)**

Age		Marital Status		Education		Occupation		Firm Size	
15-25	11.3	Never Married	25.1	Primary School	3.2	Professionals/Managers	5.7	1-49	78.1
26-35	30.4	Married/ Cohabited	70.9	Junior High	30.0	Technicians	14.5	50-99	4.4
36-45	29.0	Separated/ Divorced	2.8	Senior High	9.0	Clerks	3.9	100-499	4.1
46-55	16.8	Widowed	1.2	Vocational School	34.3	Service	12.2	500+	5.6
56-65	10.4			Junior College	15.8	Agricultural	8.9	Public	7.9
65+	2.1			University	6.7	Skilled Production	49.7 5.1		

**Table A3**  
**Summary Properties of Female Sample (in Percentages)**

Age		Marital Status		Education		Occupation		Firm Size	
15-25	20.3	Never Married	29.8	Primary School	0.1	Professionals/Managers	10.4	1-49	69.5
26-35	29.6	Married/ Cohabited	62.8	Junior High	8.9	Technicians	18.7	50-99	6.2
36-45	28.3	Separated/ Divorced	3.3	Senior High	7.6	Clerks	29.8	100-499	6.7
46-55	14.3	Widowed	4.1	Vocational School	30.3	Service	23.3	500+	7.6
56-65	6.7			Junior College	16.4	Agricultural	1.3	Public	10.0
65+	0.8			University	8.5	Skilled Production	13.8 2.7		

**TABLE A4**  
**Variable Definitions**

Variables	Definitions
<i>LNWAGE</i>	Log of yearly wage rate.
<b>Worker's Attibutes</b>	
<i>EDUC</i>	Years of formal education. There are six educational categories: primary school (6 years), junior high school (3 years), senior high school (3 years), vocational school (3 years), junior college (5 years), and university (4 years).
<i>TENURE</i>	Years of employment with current employer.
<i>TENUSQ</i>	Squared term of <i>TENURE</i> .
<i>WEXPER</i>	Years of other work experience (defined as <i>AGE-TENURE-EDU-6</i> ).
<i>WEXPSQ</i>	Squared term of <i>WEXPER</i> .
<i>GENDER</i>	Dummy equals 1 if male.
<i>MARR</i>	Dummy equals 1 if married with spouse present.
<b>Field of Major</b>	
<i>HUM</i>	The reference group is business.
<i>LAW</i>	Field of major dummy equals 1 if humanities.
<i>SCI</i>	Field of major dummy equals 1 if law.
<i>TEC</i>	Field of major dummy equals 1 if science.
<i>AGR</i>	Field of major dummy equals 1 if technology.
<i>MED</i>	Field of major dummy equals 1 if agriculture.
<i>EDU</i>	Field of major dummy equals 1 if medicine.
<i>OTH</i>	Field of major dummy equals 1 if education.
<b>Family Background</b>	
<i>CHILD</i>	Field of major dummy equals 1 if others.
<i>PEDUC</i>	Number of siblings.
<i>PMARR</i>	Parents' education. Same definition as <i>EDUC</i> .
<i>PPUB</i>	Dummy equals 1 if respondent's parents are married with spouse present.
<b>Parent's Occupation</b>	
<i>EXE&amp;GOVP</i>	Dummy equals 1 if respondent's parents work in public sector.
<i>TEC&amp;PROP</i>	The reference group is production laborers.
	Parents' occupation dummy equals 1 if working as legislators, government administrators, business executives and managers, and professionals.
	Parents' occupation dummy equals 1 if working as technicians and associate professionals.

TABLE A4 (CONT.)

Variables	Definitions
<i>CLERKP</i>	Parents' occupation dummy equals 1 if working as clerks.
<i>SER&amp;SALEP</i>	Parents' occupation dummy equals 1 if working as service workers and shop and market sales assistants.
<i>AGR&amp;FISHP</i>	Parents' occupation dummy equals 1 if working as agriculture, animal husbandry, forestry, and fishing workers.
<i>OPR&amp;ASSEP</i>	Parents' occupation dummy equals 1 if working as plant and machine operators and assemblers.
<b>Industry</b>	The reference group is commerce.
<i>AGR</i>	Industry dummy equals 1 if agriculture, forestry, fishing, animal husbandry, and mining.
<i>MFG</i>	Industry dummy equals 1 if manufacturing.
<i>ELE</i>	Industry dummy equals 1 if electricity, gas, and water.
<i>CON</i>	Industry dummy equals 1 if construction.
<i>TRA</i>	Industry dummy equals 1 if transportation, storage, and communication.
<i>FIN</i>	Industry dummy equals 1 if finance, insurance, and real estate.
<i>SER</i>	Industry dummy equals 1 if services.
<b>Occupation</b>	The reference group is production laborers.
<i>EXE&amp;GOV</i>	Occupational dummy equals 1 if working as legislators, government administrators, business executives and managers, and professionals.
<i>TEC&amp;PRO</i>	Occupational dummy equals 1 if working as technicians and associate professionals.
<i>CLERK</i>	Parents' occupational dummy equals 1 if working as clerks.
<i>SER&amp;SALE</i>	Occupational dummy equals 1 if working as service workers and shop and market sales assistants.
<i>AGR&amp;FISH</i>	Occupational dummy equals 1 if working as agriculture, animal husbandry, forestry, and fishing workers.
<i>OPR&amp;ASSE</i>	Occupational dummy equals 1 if working as plant and machine operators and assemblers.
<i>FS2, FS3, and FS4</i>	Firm-size dummy equals 1 if working in a plant size of 50-99, 100-499, and 500 or more employees, respectively. The reference group is 1-49 persons.
<i>PUB</i>	Dummy equals 1 if respondent works in the public sector.

### Footnotes

1. A nine-year compulsory education policy was implemented in 1968.



2. Education may also be a content of intergenerational transfer. For example, see Kotlijiöff and Summers [1986], Cox and Jappelli [1993], Altig and Davis [1993], and Chu and Koo [1995] among others.
3. The use of a probit model and selection-corrected wage equations for estimating returns of education can be found in Willis and Rosen [1979].
4. The right-hand side of the equation is actually the parents' full income.
5. Note that  $\beta = 1$  implies positive income effect and no substitution effect,  $\beta < 1$  implies a positive income effect and a negative substitution effect, and  $\beta > 1$  implies both income and substitution effects are positive. Therefore,  $\beta \geq 1$  implies that the higher the parents' human capital, the larger the effect on children's human capital accumulation.
6. This can also be obtained by substituting (15) and (17) into (10), for example:

$$P_H = \frac{\alpha H_p t - \alpha H_p t_w}{A t_h H_p^\beta} = \frac{\alpha H_p t_h}{A t_h H_p^\beta} = \frac{\alpha}{A} H_p^{1-\beta}.$$

7. Mincer [1996] points out that the rise in income increases the devotion rate, which in turn results in many single-parent families that destroy household division of labor and generate a family's instability, which in turn decreases the possibility of their children receiving more education.
8. The negative rates of return for junior high school education may be due to the small sample size. However, the reasons may be that the jobs available for primary and junior high school graduates are similar and the knowledge of primary school education is quite enough for the jobs. That is, junior high school graduates are overqualified, resulting in negative returns for junior high school. This may also justify the nine-year compulsory education policy introduced by the Taiwanese government in 1968 for upgrading labor quality from the social viewpoint.
9. As the rates of return for senior high and vocational schools are also relatively low, the reason why people are willing to receive these education levels may be partly due to the high return rates for the university, provided they may enter the university in future.
10. The rates of return for higher education is a weighted average of returns for entering the university from senior high, vocational school, and junior college.
11. Cross-country studies by Psacharopoulos [1981, 1985] find that private rates of return on education are greater in developing than in developed countries. In the developing countries, the rate is higher for higher education than for secondary school. Country-specific studies also show that rates of educational return increase with education level. For example, see Garen [1984] and Ganderton and Griffin [1993] for the U.S., Bedi and Born [1995] for Honduras, and Ryoo et al. [1993] for Korea. Literature covering the fact that return rates are higher for females than for males are Alba-Ramirez and San-Segundo [1995] for Spain, Duraisamy [1993] for India, Deolalikar [1995] for Indonesia, Vijverberg [1995] for the Ivory Coast, and Johnson and Chow [1997] for China.

## References

- Alba-Ramirez, A.; San-Segundo, M. J. "The Returns to Education in Spain," *Economics of Education Review*, 14, 2, 1995, pp. 155-66.
- Altig, D.; Davis, S. J. "Borrowing Constraints and Two-Sided Altruism with an Application to Social Security," *Journal of Economic Dynamics and Control*, 17, 3, 1993, pp. 467-94.

- Arjun, B. S.; Gaston, N. "Returns to Endogenous Education: The Case of Honduras," *Applied Economics*, 29, 4, 1997, pp. 519-28.
- Becker, G. S. *Human Capital*, New York, NY: National Bureau of Economic Research, 1975.
- Bedi, A. S.; Born, J. "Wage Determinants in Honduras: Credentials versus Human Capital," *Social and Economic Studies*, 44, 1, 1995, pp. 145-63
- Chu, C. Y.; Koo, H. W. "Bequest Division and Income Inequality: Comparative Dynamics and Markov Branching Processes," *Economica*, 63, 248, 1995, pp. 423-40.
- Cox, D.; Jappelli, J. "The Effect of Borrowing Constraints on Consumer Liabilities," *Journal of Money Credit and Banking*, 25, 2, 1993, pp. 197-213.
- Deolalikar, A. B. "Gender Differences in the Returns to Schooling and in School Enrollment Rates in Indonesia," in T. P. Schultz, ed., *Investment in Women's Human Capital*, Chicago, IL: University of Chicago Press, 1995, pp. 273-303.
- Duraisamy, M. "Women's Choice of Work and Fertility in Urban Tamil Nadu, India," discussion paper, Yale Economic Growth Center, 1993, pp. 695-28.
- Falaris, E. M. "The Role of Selectivity Bias in Estimates of the Rate of Return to Schooling: The Case of Married Women in Venezuela," *Economic Development and Cultural Change*, 43, 2, 1996, pp. 333-50.
- Ganderton, P.; Griffin, P. "Impact of Child Quality on Earnings: The Productivity-of-Schooling Hypothesis," *Contemporary Policy Issues*, 11, 3, 1993, pp. 39-47.
- Garen, J. E. "The Return to Schooling: A Selectivity Bias Approach with a Continuous Choice Variable," *Econometrica*, 52, 1984, pp. 1199-218.
- Glewwe, P. "The Relevance of Standard Estimates of Rate of Return to Schooling for Education Policy: A Critical Assessment," *Journal of Development Economics*, 51, 2, 1996, pp. 267-90.
- Heckman, J. "Sample Selection Bias as a Specification Error," *Econometrica*, 47, 1, 1979, pp. 153-62.
- Johnson, E. N.; Chow, G. C. "Rates of Return to Schooling in China," *Pacific Economic Review*, 2, 2, 1997, pp. 101-13.
- Joseph, A. G.; Thomas, D. A. "The Effects of Family Characteristics on the Return to Education," *Review of Economics and Statistics*, 78, 4, 1996, pp. 692-704.
- Kotlikoff, L. J.; Summers, L. H. "The Contribution of Intergenerational Transfers to Total Wealth: A Reply," working paper, 1827, National Bureau of Economic Research, 1986.
- Maddala, G. S. *Limited Dependent and Qualitative Variables in Econometrics*, New York, NY: Cambridge University Press, 1983.
- Mincer, J. "Economic Development, Growth of Human Capital, and the Dynamics of the Wage Structure," *Journal of Economic Growth*, 1, 1, 1996, pp. 29-48.
- Psacharopoulos, G. "Returns to Education: An Updated International Comparison," *Comparative Education*, 17, 1981, pp. 321-41.
- . "Returns to Education: A Further International Update and Implications," *Journal of Human Resources*, 20, 4, 1985, pp. 583-604.
- Ryoo, J. K.; Nam, Y. S.; Carnoy, M. "Changing Rates of Return to Education over Time: A Korean Case Study," *Economics of Education Review*, 12, 1, 1993, pp. 71-80.
- Vijverberg, W. M. "Educational Investment and Returns for Women and Men in Cote d'Ivoire," in T. P. Schultz, ed., *Investment in Women's Human Capital*, Chicago, IL: University of Chicago Press, 1995, pp. 304-42.
- Willis, R.; Rosen, S. "Education and Self-Selection," *Journal of Political Economy*, 87, 5, 1979, pp. S1-S36.