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Abstract:

This study establishes a life-cycle model that a representative agent chooses optimal time of education to maximize his/her life earning, which implies that there may exist nonlinear relation between education and earning. Using the data of Chinese off-farm wage employment, we find that the duration of schooling years will increase by 1.7 years with 1 percent increase in rate of return to education. The empirical results also indicate that controversies about return to education might arise from model misspecification without consideration of nonlinearity and sample selection.

Key words: return to schooling, life-cycle model, rational expectation, China.

Jel classifications: I20, J43, Q01.

Introduction

Since Jacob Mincer published his theory of human capital earning in 1957 and 1958, there has been a recognition that the key feature of the labor market is its linking between market wage and the unobserved quantity of skills owned by an individual (Rosen, 1992). The most widely used form of Mincer (1974) earning equation, in which logarithmic earnings are modeled as the sum of a linear function of years of education and a quadratic function of years of potential experience, has been applied to a large amount of empirical studies for different countries. For instance, a meta analysis by Liu (2008) has comprehensively reviewed 125 estimates from 25 primary studies of return to schooling even for China, and finds the variance of the return to education is very large which can be attributed to a lot of factors, such as samples and methods. Heckman, Lochner and Todd (2003) also have a comprehensive review of the methodological issues for Mincer earning equation.

With its strong policy implication that high education premium supports more favorable investment on education, the Mincer models are popular for the sake of comparability in the contexts of a large number of empirical studies for different countries and time periods. With certain extensions and modifications several approaches have been developed to improve the estimation to acquire consistent estimators by correcting potential bias due to omitted variables, such as instrumental-variable estimations (Angrist and Krueger ,1991). In addition, Levhari and Weiss (1974) and Hogan and Walker(2002) found that investment in human capital declines due to increase in uncertainty regarding the return to human capital investment. Their conclusions have been mirrored by Palacios-Huerta (2003) that returns to human capital include a substantial risk premium to a larger extent of the pertained uncertain returns to human capital.

An implicit assumption for Mincer wage equation is that education is exogenous. The fact of heterogeneous schooling years makes this assumption too strong to truly evaluate the return to education. For a rational person, there is a decision of a life-time allocation between human capital accumulation and working time is subject to learning ability and conditions of the exogenous labor market (Lucas, 2004) . On the one side, duration of schooling is well documented as an investment on human capital, in turn, return rate to education is internal rate of return to human capital, which will equal to marginal productivity of workers in the competitive labor market, Usually, the more education laborers obtained, the higher premium he/she will obtain, vice verse. On the other side, education, which is not always free, incurs forgone-earning cost of investment. Furthermore, the longer they stay in school, the shorter they work in a life time, vice verse. Trading off between the potential benefit from education and costs incured per se, agent chooses optimal schooling to maximize their life-time utility (Becker ,1962; Heckman ,1976).

Furthermore, nonlinearity in the return to schooling has been evolved in the recent studies in order to have a better fit. This more flexible specification is based on the hypothesis that in the presence of " education credential” or “sheepskin” effects, one more year of education at different level, for example, at primary school or at university, or same years of education but with or without a diploma, does deserve to the different return (Jaeger and Page, 1996). Relaxation of linearity in schooling by adding indicator for each year of schooling caused substantial differences in rate of return to schooling, especially for schooling level with degree completion year (Heckman, Lochner and Todd 2003). Furthermore, there is an obvious increase over time in the marginal return to education (Zhang, et al.,2005). Using data from 12 countries, Trostel (2005) proved that a Mincer wage equation with polynomial terms of shcooling performs better than the one only with first-order term by likelihood ratio tests. Thus, the conclusion is reached that marginal rate of return is increasing at low level of schooling while decreasing at high level above (Trostel,2005).

However, the nonlinearity of education can also be explained by the endogeneity of education. If education is endogenous, schooling will be a function of expected return to education, so that schooling and the return to education are consequently correlated in a usual Mincer wage equation with linear schooling, and the estimated coefficient for schooling is hence biased and not a “real” return. In addition, this correlation between schooling and return also possibly creates a nonlinear relation in the reduced form of Mincer wage equation.

In order to identify the real return to education, following Lucas (2004) we establish a life-cycle model that an agent chooses optimal time of human capital accumulation to maximize his/her whole life utility, given the expected return to education. After identifying the relation between education and its return, we reach a reduced form of Mincer wage Equation to estimate.

In addition, a dataset of off-farm employment wage from China is used as an empirical example to examine the theoretical framework. In a country where fast economic growth has lasted for more than 30 years, off-farm employment is being one of most important income sources for farmers. Particularly, there are a lot of controversies about the return to education in China in the current literature (de Brauw and Rozelle 2008; Liu 2008). Hopefully, the theoretical model and the findings in this study can also contribute to reconciliation of the controversies specifically from a methodological perspective.

The paper is organized as follows: Section 2 presents a theoretical framework and the related empirical specifications to explain the nonlinearity in rate of return to education subject to a rational expectation. Section 3 gives the descriptive statistics of the data collected in the three provinces in rural China for the year of 2004. In section 4 we present the empirical results and its policy implications. The last section concludes.

Theoretical framework and econometric model

Theoretical framework

Following Lucas (2004), suppose a rational agent make a decision to allocate his life into two periods: human capital accumulation and working. Different from Lucas’ assumption (2004) of infinite life horizon, the life before the retirement of an agent is fixed, and standardized. Assuming that the time for human capital accumulation is t, the time for working is $1-t$. Human capital function is assumed to be

(1) $H = At$

where H is accumulated human capital, and A captures ability of learning or heterogeneities in human capital accumulation . We also assume wage w in the second period is fixed as it only depends on accumulated human capital in the first period. By original Mincer Wage equation,

(2) $w = w_0 e^{\beta H}$

where w_0 is base wage for this person, and β is the expected return to human capital.

Substituting equation (1) into (2) and assuming the discount rate is r, gives the life earning W_0, and

$$(3)\quad W_0 = w_0 e^{\beta At}\int_t^1 e^{-rs}ds = \frac{w_0}{r}(e^{\beta At-rt} - e^{\beta At-r})$$

In order to maximize the life earning W_0, the first-Order condition with respect to t for equation (3) shows

$$(4)\qquad t_0 = 1 - \frac{1}{r}\ln\frac{\beta A}{\beta A - r}$$

which gives an solution to the optimal time for human capital accumulation., and it is a function of the return to human capital β, the ability of human capital accumulation A, and the discounting rate r. Obviously, the return to education and education time are correlated which should be mirrored in empirical models. Equation (4) also indicates that the sufficient condition for existence of an interior solution is that $\frac{1}{r}\ln\frac{\beta A}{\beta A - r} < 1$, to which the solution is

$$(5)\qquad \beta A > \frac{e^r r}{e^r - 1}$$

Equation (5) shows the conditions for education participation. If the return to education β is given, and the accumulation speed of human capital A is very low, specifically $A \le \frac{e^r r}{\beta(e^r - 1)}$, this person will not accumulate any human capital, and consequently only obtains the base wage in his whole life. Similarly, If A is given, and the return to education is very low, specifically $\beta \le \frac{e^r r}{A(e^r - 1)}$; neither will this person participate in education.

Furthermore, taking first-order derivative respectively with respect to β, A and r in equation (4), shows that

$$(6.a)\qquad \frac{\partial t_0}{\partial \beta} = \frac{1}{\beta(\beta A - r)} > 0 \quad \text{and}$$

$$(6.b)\qquad \frac{\partial t_0}{\partial A} = \frac{1}{A(\beta A - r)} > 0 \quad .$$

In addition, when r is relatively small,

$$(6.c)\ \frac{\partial t_0}{\partial r} = \frac{1}{r^2}(\ln\frac{\beta A}{\beta A - r} - \frac{r}{\beta A - r}) \approx \frac{1}{r}(\frac{1}{\beta A} - \frac{1}{\beta A - r}) < 0$$

.

The results indicate that the optimal time of human capital accumulation increases in the return to human capital and the speed of human capital accumulation, but decreases in the discounting rate.

Econometric Model

We start from a classical Mincer wage equation to estimate the return to education,

$$(7)\qquad \ln w = \beta E + X\gamma \quad ,$$

where E is the years of education; X is a vector of other variables, and γ is a vector of the corresponding coefficients.

However, Equation (4) and (6.a) show that education time is a function of the return rate to human capital, and particularly they are positively correlated. If we simply estimate Equation (7), the results might be biased. Following the above-mentioned theoretical model, specifically Equation (4) and (6.a), in order to study the return to education of migrants, we nevertheless simply assume

$$(8.a)\qquad E = \alpha_0 + \alpha_1\beta ,$$

where α_0 denotes threshold education which is needed for compensating the costs for education and $\alpha_0 > 0$. If one's education is lower than α_0 education, the return from education in the future cannot compensate her\his opportunity cost. It is the main reason that many countries introduce compulsory education; and α_1 is the marginal impact of return to education on education year and $\alpha_1 > 0$ which is supported by Equation (6.a). Rewriting Equation (8.a) shows

$$(8.b)\qquad \beta_{\text{int}} = -\frac{\alpha_0}{\alpha_1} + \frac{1}{\alpha_1}E$$

which is the internal rate of return to education. Substituting Equation (8.b) into (7), we have

$$(9)\qquad \ln w = \hat{\alpha}_0 E + \hat{\alpha}_1 E^2 + X\gamma$$

where $\hat{\alpha}_0 = -\frac{\alpha_0}{\alpha_1}$ and $\hat{\alpha}_1 = \frac{1}{\alpha_1}$.

Then equation (9) shows that logarithm of wage is a quadratic function of education if rational decision of education is considered. It is easy to conclude that $\hat{\alpha}_0$ is negative while $\hat{\alpha}_1$ is positive. Thus, it builds up a theoretical foundation for the nonlinear return to education. In addition, the coefficient for the second-order term of education is exactly the inverse of the marginal return to education on education year.

Furthermore, equation (9) shows the external rate of return to education is

$$(10) \qquad \beta_{ext} = \frac{d \ln w}{dE} = -\frac{\alpha_0}{\alpha_1} + 2\frac{1}{\alpha_1}E$$

In sum, the key assumption in our model is that individual has rational expectation of return to education. If people allocate life time between schooling and working according to expected reward to schooling, nonlinearity in marginal return to education inherently will be supported. This has been proven by our model, and consistent with the current literature (Trostel, 2004). We will give empirical evidence from job market of rural migrant in China in the next sections.

Data description

This study uses fixed-point rural survey data series from Zhejiang, Hubei and Yunnan provinces conducted by the Research Center for Rural Economy, Ministry of Agriculture, China in 2004. The sample is based on a multistage, random-cluster process. Counties, which are below province-level administrative units, were stratified by income level and selected based on a weighted sampling scheme. Then, the villages within the counties were randomly chosen according to geographic characteristics (plain, hilly, or mountainous area), location (suburb of city or not), and economic features defined as mainly agriculture, forestry, husbandry, fishery or others (Benjamin, 1992). Subsequently, the households are randomly selected from the respective villages. Within each household, the survey records the detailed information of each laborer.

The survey consists of around 7,800 individuals from 1,887 households over 30 villages in the surveyed provinces. Migrant is defined as the rural labourer, who temporarily or permanently migrates outsides the home village to conduct various kinds of economic activities with monetary return (Taylor, Rozelle and de Brauw 2003; Zhang, de Brauw and Rozelle 2004). With the omission of the rural labor employed in the locality in the employment of either on or off-farm, there are 1453 agricultural migrants in the final estimations (Table 1).

The three provinces chosen in this study are representative according to the geographic location and migrant status. Table 1 presents occupation structure of rural labor force. In Zhejiang-a developed coastal province, around 47 percent of rural labor takes the off-farm employment away from the hometown is much more than that in Hubei and Yunnan located in mid and western China, respectively.

Table 2 presents the statistical description of the migrant laborers. The dependent variable-daily wage is computed by dividing the monetary earning over the year by the working days of all of the employed activities. The dependent variable is daily wage, which is taken as earning measure. Average daily wage earned by migrant farmer is roughly 32 Yuan/day with a large variation within group (standard error 39.6) (Column 5, row 4). Migrant workers are more educated, younger and healthier than those who work on farm (de Brauw et al., 2002). Migrant workers averagely take 7.38 schooling years of education, around 1.75 years longer than that of farmers (Column 10, row 4). With respect to the education attainment level, the percentage of migrant workers who finished high school education (8 percent, Column 12, row 4) is double than that of farm counterpart (4 percent, Column 12, row 3) .

Experience contributes to increase of income, which is proxied by age. The average age of migrant worker is 33.5 years old, which is about 8.5 years younger than that of farmers. Other variables, which might create wage premium for individuals, are also added in the equation. Dummy of gender, health status and occupation are all controlled by eliminating premium effect on wage. The share of the men in the migrant sector is 62 percent while that in the farm sector is 45 percent. Majority of migrant workers (26 percent) are employed in manufacture sector while 18 percent are working in service sector. Almost all of the migrant workers reported that he/she is healthy. Farmers who lived in wealthier village proxied by net income per capita at village level prefer to work as migrants (bottom row).

Empirical results

Our main econometric model explicitly asserts that logarithmic earning are modelled as a quadratic function of schooling years (Equation 9) when a rational agent makes the optimal time allocation of schooling in a fixed life-time horizon. To conduct the empirical estimations, we used a fixed effect model, in which village dummies are used to control heterogeneity among villages. If we just estimate Equation (9) using OLS, a sample selection problem arise since people with shadow or reservation wage higher than offered wage are not observable (Heckman 1976). In rural China, those people, who are not qualified for urban employment, are also excluded from job market. Consequently, if there is no correction for this selection problem, biased estimators incur. To account for this possible bias, a Heckman selection model is applied to incorporate choice of migration job.

The empirical results are reported in Table 3. Fixed-effects models with and without controlling for sample selection are first applied to the Mincer equation under the assumption of the linearity in return to education (model 1 and 2). To deeply investigate the return to education we then conducted the OLS regressions considering the appearance of sample selection bias without or with village fixed-effects (model 3 and 4). Likelihood ratio test indicates that the resulting Chi-square statistics of 502 with 26 degrees of freedom strongly rejects the OLS model (model 3) at the 1 percent significance level, suggesting that fixed-effects model (model 4) is preferred in empirical explanation. Different from de Brauw and Rozelle (2008) who use two-step approach to incorporate determination of off-farm employment into wage equation, we estimate selection function and wage function simultaneously to obtain more efficient results. Estimations of relation between earning-schooling are reported in the upper part of Table 3 while the results of off-farm employment selection equation are shown in the low part of Table 3.

First, the likelihood ratio tests strongly reject the hypothesis that there is no sample selection in wage equation, indicating that choice of off-farm job is systematically related with some attributes of farmers. This result is consistent with the study by de Brauw and Rozelle (2008) and implies that the previous studies without considering the sample selection bias is not sufficient to explain the return rate to education for the migrant laborers in rural China. Coefficients of variables of interest in the sample selection equation and wage equation are of expected sign and statistically significant at the traditional accepted levels.

Years of schooling and its squared term are respectively -0.071 and 0.006, and statistically significant both at 1 percent level (rows 1 and 2) in model 4. The empirical evidence indicates that there exists the nonlinearity of return to education, which is consistent with our theoretical framework (Equation 9).

As indicated in Equation (8.a) and Equation (9), the coefficient for the second-order term of education is inverse of the marginal return to education on education year. Therefore, the threshold education α_0 is about 11.83 years, and the marginal return to education on education year α_1 is 1.67. That is, if the return to education increases by 0.01, a migrant would like to receive 1.67 years of education.

By equation (8.b), the internal rate of return to education is $\bar{\beta}_{\text{int}}$ = -0.071+0.006 E_{mean} =-0.027 (E_{mean} =7.38), which indicates that the average education is still too low to reach the threshold education level., and the return to education still cannot compensate the opportunity costs of education. It supports the necessity of compulsory education.

Furthermore, by Equation (10), we have the external return to education for off-farmers, β_{ext} = -0.071+2*0.006* E_{mean} =0.0176 (E_{mean} =7.38). This rate is lower in some extent than those in other studies, where the average rate of return across six studies using standard Mincerian model (calculated by de Brauw and Rozelle, 2008) is about 4 percent.

Our study can provide evidences to review the controversies about comparatively low return to education in China. Other studies show that return to education in China ranged from 1 percent to 11 in the first two decades of the reform (Zhang et al.,2005). de Brauw and Rozelle (2008) found, timing of data and methodology can explain gap among studies. Since most of models specify linear relation between logarithmic wage and schooling, the formulations without consideration of non-linearity are not sufficient to estimate the rate of return to education, given the nonlinearity in rate of return to schooling.

Education, measured by schooling year, not only affects earning in job market, it also has a significantly positive effect on the tendency to enter off-farm job market. Selection equation in table 3 accounts for the propensity of farmers to pursue on- or off-farm employment. The coefficient of schooling is 0.064, suggesting that at the mean level of education in the whole sample, with one more year of schooling, the probability of working as off-farm migrant increase 6.4 percent. This result is consistent with the studies by Zhang et al. (2008) and Smyth, Zhai and Li (2009). They found that more education positively affects turnover intention or off-farm participation. Since education is associated with daily wage and migration decision, formulations without correcting for sample selection might be another pitfall for estimating the effect of schooling on logarithmic earning (Heckman et al., 2003).

Conclusion

In previous researches on return to education with Mincer model, non-convexity in schooling to earning is neglected theoretically and empirically. This study presents a life-cycle model that a representative agent chooses optimal time of education to maximize his/her whole life earning. Theoretical derivations show that, if agents invest on education according to their expected rate of return to education, schooling year would be squared function of return to education. These conclusions are verified by empirical results using a representative data about off-farm employment in China. The external return to education for off-farmers is 0.0176. In addition, marginal return to education on education year is 1.67.

The empirical results also present new perspective to review ongoing debate on low rate of return in China. Since most of models assume linear relation between logarithmic wage and schooling, these specifications without consideration of non-linearity might be a source for inappropriate estimation of return to education. Furthermore, models without sample selection procedure might dampen return to education because farmers tend to select off-farm job according to their human capital, especially education stock.

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Table 1. Distribution of Migrants and Non-migrants by Provinces, 2004

	Total	Migrant		Non-migrant	
	No.	No.	(%)	No.	(%)
Total	3692	1453	39	2239	61
Zhejiang	765	356	47	409	53
Hubei	1801	817	45	984	55
Yunnan	1126	280	25	846	75

Table 2. Descriptive Statistics of Samples by Migration Status

Variables	Symbol	All	Migrants	Non-migrants
		Mean	Mean	Mean
No. of observation		3692	1453	2239
Dependent variable				
Wage (Yuan/day)	Wage	11.99	31.59	0.00
		(28.81)	(39.60)	0.00
Log of wage	Lg(wage)	3.09	3.09	---
		(0.79)	(0.79)	---
Individual Characteristics				
Years of schooling	Schooling	6.28	7.38	5.61
		(3.18)	(2.89)	(3.17)
High school graduates(1=yes;0=no)	Highs	0.05	0.08	0.04
		(0.22)	(0.27)	(0.18)
Age (Year)	Age	38.89	33.53	42.17
		(11.93)	(11.04)	(11.25)
Gender (1=male;0=female)	Gender	0.52	0.62	0.45
		(0.50)	(0.49)	(0.50)
Dummy of health[a] (1=good; 0=otherwise)	Health	0.48	0.56	0.43
		(0.50)	(0.50)	(0.50)
Sector dummy[b] (%)	Agri	---	No report	---
Household characteristics				
Number of laborers	Labor	3.20	3.26	3.16
		(1.11)	(1.09)	(1.12)
Number of seniors (age>65)	Senior	0.17	0.18	0.17
		(0.44)	(0.45)	(0.44)
Number of Children (age<7)	Children	0.27	0.27	0.27
		(0.50)	(0.50)	(0.50)
Village characteristics				
Average net income per capita (Yuan/Capita)	Income	3790	4363	3439
		(4594)	(5359)	(4016)

Note: standard deviation in parentheses. .

a. Health status is self-reported by the family members, which has been categorized into five scales: excellent, good, medium, bad and disable. Disable person does not account as the laborers, and thus being dropped from this study. For this study, the dummy variable of health is defined as 1 with being excellent in health, 0 otherwise.

b. Agriculture here means off-farm job related to agriculture, for example, repairing agricultural machinery. Limited by space, they are not reported here.

Table 3. Empirical Results of Mincer Model

	Linear return model		Non-linear return model	
	Model 1	Model 2	Model 3	Model 4
Individual Characteristics				
Schooling	0.021	0.002	-0.046	-0.071
	(3.267)***	(0.243)	(-2.285)**	(-3.050)***
Schooling^^{2}	-------		0.004	0.006
			(2.526)**	(3.798)***
Age	0.071	0.077	0.078	0.086
	(7.368)***	(8.134)***	(8.207)***	(7.691)***
Age^^{2}	-0.001	-0.001	-0.001	-0.001
	(-6.623)***	(-6.071)***	(-6.108)***	(-4.817)***
Gender	0.219	0.075	0.079	0.027
	(6.418)***	(1.934)*	(2.048)**	(0.595)
Health	0.101	0.112	0.115	0.168
	(2.727)***	(2.859)***	(2.945)***	(3.995)***
Manu[a]	-0.081	-0.089	-0.092	0.172
	(-1.473)	(-1.676)*	(-1.731)*	(3.293)***
Construct	-0.062	-0.079	-0.084	-0.073
	(-0.901)	(-1.183)	(-1.252)	(-1.011)
Transport	0.166	0.174	0.182	0.590
	(2.083)**	(2.219)**	(2.324)**	(6.812)***
Service	-0.080	-0.079	-0.085	0.222
	(-1.306)	(-1.337)	(-1.427)	(3.635)***
Other	-0.183	-0.172	-0.175	0.018
	(-3.039)***	(-2.970)***	(-3.013)***	(0.295)
Constant	1.936	2.218	2.331	1.525
	(9.558)***	(10.992)***	(11.292)***	(6.990)***
Village Dummy	no report	no report	---	no report
Observations	1,453	1453	1453	1453
R-squared	0.414		------	
Selection Equ.				
Individual Characteristics				
Schooling		0.062	0.065	0.064
		(7.578)***	(7.882)***	(7.754)***
Highs		-0.091	-0.167	-0.193
		(-0.935)	(-1.643)	(-1.922)*
Age		-0.040	-0.040	-0.041
		(-18.906)***	(-18.901)***	(-19.199)***
Gender		0.488	0.487	0.490
		(10.675)***	(10.666)***	(10.702)***
Health		-0.012	-0.012	-0.028
		(-0.259)	(-0.261)	(-0.609)
Household characteristics				
Labor		-0.042	-0.041	-0.047
		(-2.109)**	(-2.063)**	(-2.354)**
Senior		-0.042	-0.039	-0.048
		(-0.950)	(-0.886)	(-1.082)
Children		-0.096	-0.096	-0.107
		(-2.232)**	(-2.224)**	(-2.483)**
Village characteristics				
Income		0.000	0.000	0.000

	(6.623)***	(6.613)***	(9.104)***
Constant	0.671	0.649	0.666
	(5.076)***	(4.893)***	(5.026)***
Observations	3,692	3,692	3,692
Log likelihood	-3360	-3357	-3608
Wald chi^^{2}	Chi^^{2}(36) =1018	Chi^^{2}(37) =1024	Chi^^{2}(11) =319
Model diagnostics			
1. Sample selection bias test (Likelihood ratio test)			
H0:model has no sample selection bias			
Chi^^{2}	Chi^^{2}(1)=17.5	Chi^^{2}(1)=20.52	Chi^^{2}(1)=50.4
P-value	<0.001	<0.001	<0.001

Note: t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

a. For the dummies of employment, agriculture is taken as reference.