ECONOMICS BULLETIN

Alternative measure for education variable in an empirical economic growth model: Is primary education less important?

Tin-Chun Lin
Indiana University - Northwest

Abstract

In this paper, an alternative measure of the education variable is proposed in an empirical economic growth model. Taiwan from 1964-2000 is selected as a case study. The main innovation of this paper is the weighting of education inputs by schooling level as an additional input into the application of production. Results reveal that primary education carries the greatest credits in Taiwan's economic development, which suggests that educators and policy makers value the importance of the foundation (i.e., primary education).

I would like to thank John Riew for his advice on this paper.
Citation: Lin, Tin-Chun, (2006) "Alternative measure for education variable in an empirical economic growth model: Is primary education less important?." *Economics Bulletin*, Vol. 15, No. 15 pp. 1-6
Submitted: November 14, 2006. **Accepted:** December 29, 2006.
URL: http://economicsbulletin.vanderbilt.edu/2006/volume15/EB-06O00056A.pdf

Alternative measure for education variable in an empirical economic growth model: Is primary education less important?

Abstract

In this paper, an alternative measure of the education variable is proposed in an empirical economic growth model. Taiwan from 1964-2000 is selected as a case study. The main innovation of this paper is the weighting of education inputs by schooling level as an additional input into the application of production. Results reveal that primary education carries the greatest credits in Taiwan's economic development, which suggests that educators and policy makers value the importance of the foundation (i.e., primary education).

1. Introduction

Since 1990, empirical researchers have begun to acknowledge the importance of education's effects on economic growth, and are now considering it in an empirical growth model. Therefore, identifying the most effective methods for measuring a proxy for the education variable in an empirical economic growth model has become an important issue. For example, both Liu and Armer (1993) and Tallman and Wang (1994) measured the education variable as the number of people in a population who have completed different levels of schooling. Liu and Armer (1993) investigated the effects of education on economic growth in Taiwan and employed four distinct levels of education achievement as proxies for human capital over the period 1953–1985. They found that both primary and junior-high achievement variables add explanatory power to a Cobb-Douglas growth regression; but senior-high and college education did not exert any significant effects on growth. In contrast, the education proxy used in Tallman and Wang (1994) imposed strong prior restrictions about the relative productivity of educational attainment in Taiwan from 1965–1989, which conflicts with results in Liu and Armer. Their findings showed that higher education exerts a greater effect on economic growth than do primary and secondary education.

In reviewing their studies (both Liu-Armer and Tallman-Wang), my main concern is their measure for the education variable. They separate education stock into three or four different independent categories of education level: workers with a primary education, secondary education (junior and senior high school), and higher education (college and university). However, human capital is accumulated, which means that it cannot be precisely separated into three or four different independent categories. Workers who have a university degree must have completed primary and secondary levels of education. Based upon Tallman and Wang's (1994) conclusion, my question is this: if a worker with a university degree provides a positive and significant effect on economic growth, can we attribute this contribution only to higher education? If the worker did not receive a good primary and secondary education, would the worker succeed in a university? Thus, their measures could reveal some bias and lead the government to focus more resources on higher education than on primary education.

In addition, both Liu-Armer and Tallman-Wang investigated the effects of education on Taiwan's economic growth, but came up with opposite results. For that reason, I reemployed

Taiwan time-series data for 1964–2000, reconstructed an alternative measure for human capital, applied a general form of a structural earnings function to a measure of human capital, and used a transcendental production function in the model. Hence, the education variable is measured as the average number of years of formal education per person in the labor force, rather than the number of people in a population who have completed different levels of schooling. More importantly, the main contribution of the alternative measure for the education variable is the creation of four indices of educational achievement.

This paper is organized as follows. First, I describe the methodology and data measurement. Then, I present the empirical analysis and results. Finally, I offer conclusions and remarks.

2. Methodology and data measurement

Using the Cobb-Douglas production function, output is modeled as follows:

$$Y_t = \left(A_0 e^{\xi t}\right) K_t^{\alpha} \left(L_t H_t\right)^{\beta}, \qquad (1)$$

where *Y* stands for real output, *K* stands for physical capital, *L* stands for raw labor input, *H* stands for the quality of human capital, $(L \cdot H)$ stands for effective labor, ($A_0 e^{\xi t}$) is an exogenous knowledge and technological factor, α and β are the physical capital and effective labor shares, respectively, and *t* is time trend.

Assume that an individual's income depends on his human capital, which is a function of schooling. Hence, the individual's income is given by:

$$I = wH(E), \qquad (2)$$

where *I* stands for the individual's income, *w* stands for the wage per unit of human capital, and *H*(.) stands for the quality of human capital as a function of schooling which is denoted by *E*. Hence, the estimated general form of the structural earnings function can be specified as:

$$\ln I = \Psi + g\,(E). \qquad (3)$$

where Ψ is a constant term.

Equations (2) and (3) imply that human capital will be given by:

$$H = e^{g(E)}, \qquad (4)$$

while the constant term in equation (3) corresponds to ln(*w*). The standard assumptions about the *g*(*E*) are that $g' > 0, g'' \leq 0$ (Wills, 1986). For the sake of simplicity, assume that $g(E_t) = \gamma E_t$, where γ is a constant parameter, and then substitute equation (4) into equation (1). Thus, the production function can be re-expressed as follows:

$$Y_t = \left(A_0 e^{\xi t}\right) K_t^{\alpha} \left(L_t e^{\gamma E_t}\right)^{\beta}. \qquad (5)$$

Taking natural logarithms of both sides of equation (5), the production function becomes linear:

$$\ln Y_t = \ln A_0 + \xi t + \alpha \ln K_t + \beta \ln L_t + \gamma\beta E_t. \qquad (6)$$

The Taiwan data for 1964-2000 that are used in this study include annual measures of economic output, physical capital input, labor input, and educational stock compiled mainly from *Statistical Yearbooks of the Republic of China*, *Statistical Abstract of National Income in Taiwan Area*, *Monthly Bulletin of Manpower Statistics in Taiwan Area*, *Education Statistics of The Republic of China*, and *Quarterly National Economic Trends in Taiwan Area*.

Output (*Y*) is defined as gross domestic product. The value of this variable is measured in millions of New Taiwan dollars (NT$) at 1996 constant prices. Physical capital (*K*) is defined as real capital stock, which includes gross fixed capital formation and increases in stocks (e.g., buildings, equipment, and other construction) in the domestic economy, and is also measured in millions of New Taiwan dollars at 1996 constant prices. Labor (L) is measured as the number of people in the economically active population of the employed. This variable is reported in thousands of employed people. Human capital (E) is measured as the average number of years of formal education per person among employed people [i.e., the average number of years of formal education per person = (primary stock x 6 + junior stock x 9 + senior stock x 12 + college stock x 16) / total employed people].[1] In order to take full advantage of more complete information on educational data and ascertain the differential effects of education level on economic growth, I develop four indices of educational achievement, which respectively employs each component of education level. They are shown as follows.

Index 1. This index is designed to ascertain the impact of primary education on economic growth. I attach a weight of 1 to all workers who have completed elementary education, and 0.5 to others (i.e., junior-high, senior-high, and college). The average number of years of formal education per person = {(primary stock x 6 x 1 + junior stock x (6 x 1 + 3 x 0.5) + senior stock x (6 x 1 + 3 x 0.5 + 3 x 0.5) + college stock x (6 x 1 + 3 x 0.5 + 3 x 0.5 + 4 x 0.5)}/ total employed people.

Index 2. This index is designed to ascertain the impact of junior-high education on economic growth. I attach a weight of 1 to all workers who have completed junior-high education, and 0.5 to others (i.e., primary, senior-high, and college). The average number of years of formal education per person = {(primary stock x 6 x 0.5 + junior stock x (6 x 0.5 + 3 x 1) + senior stock x (6 x 0.5 + 3 x 1 + 3 x 0.5) + college stock x (6 x 0.5 + 3 x 1 + 3 x 0.5 + 4 x 0.5)}/ total employed people.

Index 3. The purpose of this index is to ascertain the impact of senior-high education on economic growth. I attach a weight of 1 to all workers who have completed senior-high education, and 0.5 to others (i.e., primary, junior-high, and college). The average number of years of formal education per person = {(primary stock x 6 x 0.5 + junior stock x (6 x 0.5 + 3 x 0.5) + senior stock x (6 x 0.5 + 3 x 0.5 + 3 x 1) + college stock x (6 x 0.5 + 3 x 0.5 + 3 x 1 + 4 x 0.5)}/ total employed people.

Index 4. The purpose of this index is to ascertain the impact of college education on economic growth. I attach a weight of 1 to all workers who have completed college education, and 0.5 to others (i.e., primary, junior-high, and senior-high). The average number of years of formal education per person = {(primary stock x 6 x 0.5 + junior stock x (6 x 0.5 + 3 x 0.5) + senior stock x (6 x 0.5 + 3 x 0.5 + 3 x 0.5) + college stock x (6 x 0.5 + 3 x 0.5 + 3 x 0.5 + 4 x 1)}/ total employed people.

3. Empirical analysis and results

Based upon the production function in the previous section and to avoid the presence of serial correlation, I take a first difference and add two dummy variables ($D1_t$ and $D2_t$) as control

---

[1] "*Primary stock* refers to all employed people who have completed primary school but not higher levels. *Junior stock* refers to all employed people who have completed junior high school but not higher levels. *Senior stock* refers to all employed people who have completed senior high school but not higher levels. *College stock* refers to all employed people who have completed college, university or higher education." See p. 309 in Liu and Armer's (1993) article. Education consists of 6 years of primary school, 3 years of junior high school, 3 years of senior high school and 4 years of college or university.

variables to capture the effects of the two oil crises of 1973–1975 and 1979–1982 (indicated as $D1_t$) and the Asian financial crises of 1997–1998 (indicated as $D2_t$). Thus, the econometric model can be specified as:

$$\ln Y_t - \ln Y_{t-1} = C_0 + b_K\left(\ln K_t - \ln K_{t-1}\right) + b_L\left(\ln L_t - \ln L_{t-1}\right) + b_E\left(E_t - E_{t-1}\right) + b_{D1}D1_t + b_{D2}D2_t + u_t\,, \qquad (7)$$

where u_t is stochastic disturbance terms, assuming a mean 0 and a variance σ^2.

The results of estimation with no-indexed and four variants of indexed education variables from equation (7) are presented in Table 1. I begin the empirical analysis by testing the hypothesis that education has no bearing. The results show that the null hypothesis is rejected, meaning that education matters. The estimated effect on the output of the no-indexed education variable is 0.1985 and is statistically significant at the 1% level. Thus, one additional year of average education is estimated to increase real output by approximately 0.1985%. The effects of education are shown to be even more potent when indexed (weighted) education variables are used, and they are all statistically significant at the 1% level. One additional year of average education, when indices 1 – 4 are used, is estimated to increase real output growth by approximately 0.4009%, 0.2932%, 0.2896%, and 0.2759%, respectively. In addition, if we take a closer look at those estimated coefficients of education in indices 1 – 4, we find that the largest is in index 1, followed by index 2, index 3, and then index 4. Specifically, the coefficient in index 1 (i.e., 0.4009) is much larger than the others (i.e., 0.2932, 0.2896, and 0.2759). The results imply that elementary education carried the largest weight in Taiwan's economic development. The evidence also confirms my initial hypothesis that elementary education, which enables people to read, write, and articulate in arithmetic has a more direct bearing on labor productivity. A worker who has secondary and/or higher education must have completed elementary education. In other words, high-quality primary education training will significantly improve an individual's productivity, and lead to successful completion of secondary and even higher education training. That is, successful secondary and/or higher education training should be partly attributed to successful primary education training.

Moreover, dummy variable 1 exerted a negative and significant effect on real output growth in both the no-indexed and indexed equations, which implies that the oil crises in 1973–1975 and 1979–1982 did hurt Taiwan's economy. In 1973, the first oil crisis resulted in an economic recession and inflation throughout the world. In Taiwan, commodity prices soared, as shortages of food and industrial raw materials added fuel to the fire. Although commodity prices did not increase as much during the second oil crisis in 1979, the increases still created an adverse impact on economic growth. Dummy variable 2 also exerted a negative effect on real output growth, but the effect is not statistically significant at the 5% or 10% levels, which implies that the Asian financial crisis did not seriously damage Taiwan's economy compared with those in other Asian countries, such as South Korea, the Philippines, Indonesia, Malaysia, and Thailand, which seriously suffered from abrupt currency and banking crises (Barro, 2001; Park and Lee, 2001). The reasons were that Taiwan had excellent economic fundamentals, no foreign debt, a low percentage of bad loans in financial institutions, no blind or excessive investments, strong adaptability by small- and medium-sized enterprises, and appropriate government countermeasures.

Furthermore, the estimates for labor shares of output growth in all equations in Table 1 are around 70%, and the estimated effects are statistically significant at the 1% level. Capital shares are estimated by around 13%, and the effects are also statistically significant at the 1% level. Moreover, the estimates of constant terms (i.e., technical progress) are estimated by around 2.9%, and the effects are statistically significant at the 5% level.

Finally, the R-squares in no-index and indices 1 – 4 are around 0.62, which means that 62% of the variation in the dependent variable can be explained by the variation in independent variables in the regression. In addition, according to the *F* statistics, the null hypothesis that all coefficients are zero is rejected, and the LM test does not reject the null hypothesis of zero autocorrelation, meaning that autocorrelation does not exist in the model.

Conclusion

The key contribution of this paper is the proposal of an alternative measure for the education variable in the empirical growth model, which stems from four indices of educational achievement. The weighting of educational inputs allows us to test the hypothesis that the impact of education on growth per unit of education differs at different levels of schooling. As a result, the analysis shows that elementary education has played a remarkable role in Taiwan's economic development in the past four decades. Thus, these findings suggest that educators and policy makers value the importance of a strong education foundation (i.e., elementary education). Without a solid foundation, how can we build a magnificent imperial tower? This study suggests that the government not only needs to enhance the quality of higher education training, but also needs to improve the quality of primary and secondary education training.

Referrences

Barro, R. (2001) "Economic Growth in East Asia Before and After the Financial Crisis." NBER Working Paper 8330.

Liu, C., and M. Armer. (1993) "Education's Effect on Economic Growth in Taiwan." *Comparative Education Review* **37(3)**, 304-321.

Park, Y. and J. Lee. (2001) "Recovery and Sustainability in East Asia." NBER Working Paper 8373.

Tallman, E. and P. Wang. (1994) "Human Capital and Endogenous Growth: Evidence from Taiwan." *Journal of Monetary Economics* **34**, 101-124.

Willis, R. (1986) "Wage Determinants: A Survey and Reinterpretation of Human Capital Earnings Function." *Handbook of Labor Economics*, 1A, (North-Holland, Amsterdam).

TABLE 1

Estimates of $\ln Y_t - \ln Y_{t-1}$

Explanatory Variables	No-Index	Index 1 (More weight on primary)	Index 2 (More weight on junior-high)	Index 3 (More Weight on senior-high)	Index 4 (More weight on college)
Constant	0.02919** (2.47)	0.02888** (2.44)	0.02856** (2.48)	0.02904** (2.42)	0.02923** (2.43)
$\ln K_t - \ln K_{t-1}$	0.12659*** (3.43)	0.12754*** (3.46)	0.12307*** (3.39)	0.12987*** (3.49)	0.13016*** (3.48)
$\ln L_t - \ln L_{t-1}$	0.7010*** (4.40)	0.7003*** (4.42)	0.6946*** (4.50)	0.7008*** (4.37)	0.7006*** (4.36)
$E_t - E_{t-1}$	0.19857*** (3.44)	0.4009*** (3.47)	0.29325*** (3.61)	0.28961*** (3.39)	0.27590*** (3.37)
$D1_t$	-0.03106*** (-3.68)	-0.030998*** (-3.68)	-0.032685*** (-3.88)	-0.030679*** (-3.63)	-0.030343*** (-3.59)
$D2_t$	-0.02216 (-1.55)	-0.0222 (-1.55)	-0.01999 (-1.41)	-0.02146 (-1.49)	-0.02220 (-1.54)
R^2	0.620	0.621	0.630	0.617	0.615
$\overline{R}^2$ (adjusted)	0.556	0.558	0.569	0.553	0.551
F-Statistic	9.77	9.84	10.23	9.65	9.59
Durbin-Watson	1.78	1.77	1.77	1.78	1.77
Autocorrelation (LM Test)	No	No	No	No	No

(*t*-value) ***denotes statistical significance of the *t*-statistic at the 0.001 level, **denotes statistical significance of the *t*-statistic at the 0.05 level.