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Education, technical progress, and economic growth: the case of Taiwan

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Abstract

This paper investigates the effect of education and the role of technical progress on economic growth in Taiwan over the 1965–2000 period. A structural earnings function and indicator for average schooling years are applied to a measure of education, and a transcendental production function is used in the model. Findings reveal that education has a positive and significant effect on growth, but the role of technical progress does not appear to be extraordinarily important. According to the complementarity test, no markedly significant relationships exist between capital and education, or between education and technical progress. [*JEL classification*: O40, J24, I20] © 2002 Elsevier Science Ltd. All rights reserved.

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1. Introduction

This study examines the effect of education and the role of technical progress on Taiwan's economic growth during the period 1965–2000. The main innovation of the paper is the application of a human capital measure as an additional input into the production function.

A number of recent empirical studies have investigated the effects of education on economic growth, such as Armer and Liu (1993); Lau, Jamison, Liu and Rivkin (1993); Tallman and Wang (1994); and McMahon (1998). Armer and Liu employed annual data from Taiwan during the period 1953–1985. The proxies of human capital in their model were measured as the number of people in a population who have completed different levels of schooling. They found that only primary and junior high education had strong and positive effects on economic growth. Lau, Jamison, Liu, and Rivkin employed cross-state data from Brazil in 1970 and 1980. In their model, the proxy of human capital was measured as the

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average number of years of formal education per person in the labor force. Their results indicated that average education has a large, positive, and statistically significant effect on real output. Tallman and Wang also employed annual data from Taiwan during the period 1965-1989. They incorporated human capital proxies and labor to form an effective labor input. The proxies for human capital in their empirical model were measured as the number of people in a population who have completed different levels of schooling. They showed that the performance of the growth model in Taiwan is amended by combining a labor quality index into labor input. McMahon employed cross-country panel data in East Asia. The proxy of investment in human capital in his model was measured as gross enrollment rates. He found that secondary and higher education expenditure are more significant after primary enrollments are universal.

Based upon the previous studies, the proxy of human capital is a key issue in the empirical growth model. An appropriate proxy of human capital would improve the performance of the growth model. Therefore, I apply a general form of a structural earnings function to a measure of human capital and use a transcendental production function. The quality of human capital is a function of schooling, and the educational variable is measured as the average number of years of formal education per person in the labor force.

In addition, the role of technical progress in economic growth is another important issue in this study. Productivity growth, which has played a key role in the increasing output in developed countries, such as the USA, is the subject of the current controversy surrounding the basis for the spectacular growth in newly industrializing countries, particularly in East Asia (i.e., Hong Kong, Singapore, South Korea, and Taiwan). Some economists have concluded that this growth is based on high growth rates for productivity and exports (Page, 1994;World Bank, 1993); others have claimed that the extraordinary rate of output growth is due to rapid rates of factor accumulation, with little due to technological progress (Young, 1994 and 1995; Krugman, 1994; Kim and Lau, 1994; Rodrik, 1995; and McMahon, 1998).1 However, Hsieh (1999) used an alternative approach (the Dual Approach to Growth Accounting²) to re-estimate the growth of total factor productivity for newly industrializing countries in East Asia. He found that the growth of total factor productivity is larger based on the Dual Approach than on the Primal Approach. Thus, Young (1994) may have underestimated growth in total factor productivity for East Asian countries, leading Hsieh to conclude that both technological progress and factor accumulation play important roles in growth of output in East Asian countries.

This paper is organized as follows. A brief overview of Taiwan's economic development during the post-war period may be found in Sect. 2. Section 3 describes the model and data measurement. The empirical analysis and results are presented in Sect. 4. I decompose the sources of Taiwan's output growth in Sect. 5. Finally, conclusions may be found in Sect. 6.

2. A brief overview of Taiwan's economic development

Taiwan has worked hard to overcome very poor economic conditions, overpopulation, a small domestic market, scarce resources, and violent inflation. Until the 1950s, Taiwan was still a less developed country. In 1951, agriculture contributed 32% to total output, while industries contributed only 21%. Since the 1960s, Taiwan has been transformed into one of the few newly industrializing countries in the world. The contribution of industries to output has improved over time, averaging 32% in the 1960s, 42% in the 1970s, and 45% in the 1980s. On the other hand, the proportion of agricultural output has dropped over time, averaging 22% in the 1960s, 12% in the 1970s, 6% in the 1980s, and 3% in the 1990s. Real growth in industrial output has also risen faster than agriculture and services. In the meantime, annual growth in total domestic product during the 1960s increased to more than 10%. Nominal gross domestic product per capita has improved from approximately US\$160 in 1962 to US\$15,000 in 2000. Taiwan's economic structure has shifted emphasis from agricultural to industrial production in less than three decades.

Manufacturing has shown the largest percentage distribution of capital investment among all activities since the 1960s, averaging almost 29%, and 33% in 1970s. The investment rate was only 14% in 1951 but has risen rapidly since the 1960s, averaging 22%, and 30% in the 1970s. Hence, Taiwan has created an "economic miracle" in the international environment in the 1960s, 1970s, and 1980s.

Foreign investment and US aid have played important roles in Taiwan's economy. Foreign investment, mostly from overseas (China, the United States, Japan, and Western Europe), helped introduce modern and laborintensive technology to the island in the 1960s. The emphasis has changed from production of light-industry consumer goods for export to more sophisticated heavy industry and technology-intensive products. During the Korean War, Taiwan benefited from the US aid program. More than US\$1.4 billion was appropriated in 1951– 1965. In the early 1950s, US aid played a key role in helping to control inflation. Without this aid, Taiwan's trade gap would have been a serious limiting factor in its economic development in that period.

In the 1970s, there were two oil shocks — one in late 1973 and one in 1979. During the recession following the 1973 oil embargo, Taiwan managed to overcome the slump in demand for its industrial exports by adopting a successful economic stabilization program. Ten major infrastructure projects were launched to stimulate economic activity. After the second oil shock, Taiwan's economy continued to grow in the 1980s, based on a shift in industrial structure toward one that is more capitalintensive and more energy-efficient.

Foreign trade has also been a major factor in Taiwan's rapid growth. The value of exports grew fast during the 1960s, averaging almost 23%. The value of trade roughly tripled in each five-year period and increased nearly sixfold between 1975 and 1990. Taiwan's exports are now nearly 90% industrial goods. Imports are dominated by raw materials and capital goods.

Moreover, education in Taiwan expanded promptly so

¹ Both Kim and Lau (1994) and McMahon (1998) find significant education effects on growth, but technology effects are not significant on growth (zero in Kim and Lau) in East Asian countries.

² The Dual Approach to Growth Accounting can be readily derived from the basic national income that national output is equal to factor incomes" (Hsieh, 1999, p. 134).

that several economists have claimed that the rapid economic growth was significantly derived from increased education. The average number of years of formal education per person of employed people appears to have improved over time, averaging 7.18 years in the 1960s, 7.85 years in the 1970s, 9.28 years in the 1980s, and 10.7 years in the 1990s. Thus, the quality of the labor force has also improved. In 1964, the population of workers with a college degree or above was only 3%. The largest population was people who completed a primary school education only (82%). However, the population of workers with a senior high school and college degree has risen steadily over time. By 2000, more than 60% of workers had at least a senior high school degree, and nearly 27% had been awarded a college degree. Hence, human capital has improved since the 1960s.

It should be pointed out that the Taiwan government first required nine years of mandatory education for boys and girls in 1968 so that the number of graduates from junior high school increased significantly in the 1970s. The government also introduced a science and technology development program in 1979 and focused on high-level technologies. Thus, the population of engineering and science majors has grown more rapidly than other majors.

In short, Taiwan's economic development relied on numerous government policies, especially on the accumulation of human capital in the labor force. Several questions remain: What processes accounted for the educational effects on Taiwan's economic growth? Due to sufficient human capital accumulation, did factor accumulation lead to a high rate of productivity growth? What role did technical progress play in Taiwan's economic development?

3. The model and data measurement

3.1. The model

Economic output is modeled as a function of labor and capital input and of the measures of educational stock using the multiplicative Cobb–Douglas production function. The production function is expressed as:

$$Y_t = A K^{\alpha}_t L^{\beta}_t H^{\gamma}_t, \tag{1}$$

where Y is real output, K is physical capital, L is raw labor input, H is the quality of human capital, A is an exogenous knowledge and technological factor, and α , β , and γ are the physical capital, labor, and human capital shares, respectively, and t is time trend.

I assume that individuals invest in education at the beginning of their lives, and then work until they retire or die. Their earnings depend on their human capital, which is a function of schooling. The only cost of schooling is the foregone earnings. Hence, the earnings of an individual who is no longer in school are given by:

$$I = wH(E), \tag{2}$$

where I is the earnings of an individual, w is the wage per unit of human capital, and H(.) is the quality of human capital as a function of schooling, which is denoted by E. According to the analysis of labor literature, an estimated form of the structural earnings function can be specified as:

$$\ln I = constant + f(E). \tag{3}$$

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

$$H = e^{f(E)},\tag{4}$$

while the constant term in eq. (3) will correspond to $\ln(w)$. The standard assumptions about the f(E) function (Willis, 1986) are that $f_E > 0, f_{EE} \le 0$. To simplify the model, I assume that $f(E_i) = E_i$, and then substitute eq. (4) into eq. (1). Thus, the production can be re-expressed as follows:

$$Y_t = AK_t^{\alpha} L_t^{\beta} e^{\gamma E_t}.$$
(5)

The parameters to be estimated are A, α , β , and γ . Eq. (5) is known as the transcendental production function, a generalization of the Cobb–Douglas production function. Taking natural logarithms of both sides of eq. (5), the production function becomes linear:

$$\ln Y_t = \ln A + \alpha \ln K_t + \beta \ln L_t + \gamma E_t.$$
(6)

The model involves an implicit assumption in the functional form that output growth is linear in the number of years of schooling. The additional one year of average schooling from 6 to 7 in the 1960s and the early 1970s may have different output implications than the additional one year of average schooling from 10 to 11 in the 1980s and the 1990s. The relevant implications regarding this assumption may be found in the previous section (e.g., the Taiwan government's support for engineering and science education). In the early stage of the 1960s, Taiwan's economy was still focusing on labor-intensive and non-technical production so that lesseducated workers were still desirable. However, since the Taiwan government supported a science and technology development program in 1979, and since Taiwan's economic structure has transformed into high-technology and knowledge-intensive production, highly educated workers were essentially desirable. While in both periods a year of schooling was added, the output implications behind this addition definitely differ.

3.2. Data measurement

The Taiwan data over the period 1964–2000 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*. Note that the data series in the 1950s and early 1960s are not quite sufficient, so the data begin in 1964. Table 1 presents summary statistics that describe the growth experiences of Taiwan.

Economic output (Y). This measure is defined as gross domestic product, or the value of all final goods and services produced in the domestic economy. The value of this variable is measured in millions of New Taiwan dollars (NT\$) at 1996 constant prices.

Physical capital input (K). This variable 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. This series is also measured in millions of New Taiwan dollars at 1996 constant prices.

Labor input (L). Labor is measured as the number of people in the economically active population of employment status (see Note 1). Based on the definition from the *Statistical Yearbook of the Republic of China*, the measure of employed individuals represents all persons age 15 or older who worked for pay or profit, or who worked 15 hours or more per week as unpaid family member in a profit-seeking establishment operated by family members, during the reference week each year. Hence, this variable does not cover unemployed people, but it covers own-account (non-wage) workers and *invisible* workers. This variable is reported in thousands of employed people.

Human capital or educational stock (E). Human capital is measured as the average number of years of formal education per person of employed people (see Note 2). Thus, the index of this variable is reported in number of years. As Fig. 1 shows, the average number of years of formal education per person appears to have increased over time mostly from 1964 (6.95) to 2000 (11.39), with the average of 8.98 as a whole over the 1964–2000 period. The information implies that the quality of human capital in Taiwan has been upgraded over time.

Time (*t*). This variable is measured in terms of annual chronology with year 1964 set at 1, and year 2000 at 37.

In addition, the annual rates of growth of real output,



Fig. 1. Average years of education per person among employed people (1964–2000).

physical capital, labor, and annual change of average education are presented in Figs. 2–5.

4. Empirical analysis and results

According to the production function eq. (6), the econometric model is specified as:

$$\ln Y_{t} - \ln Y_{t-1} = C_{0} + a_{K} (\ln K_{t} - \ln K_{t-1}) + a_{L} (\ln L_{t}$$
(7)
$$-\ln L_{t-1}) + a_{E} (E_{t} - E_{t-1}) + \varepsilon_{t},$$

where ε_t is stochastic disturbance terms and is assumed with a mean of 0 and a variance of σ^2 . It is assumed that the independent variables — the first differences of



Fig. 2. Annual growth rate for real GDP in Taiwan (1965–2000).

Table 1								
Summary	statistics	elements	of	growth	for	Taiwan	(1965-	-2000)

	Growth rate of GDP (%)	Growth rate of capital (%)	Growth rate of labor (%)	Annual change of average education (Year)
Mean	8.42	11.12	2.68	0.123



Fig. 3. Annual growth rate for capital in Taiwan (1965–2000).



Fig. 4. Annual growth rate for labor in Taiwan (1965–2000).



Fig. 5. Annual change for average education in Taiwan (1965–2000).

quantities of physical capital, labor, and human capital — are uncorrelated with the stochastic disturbance terms.

Most time series are nonstationary because they usually have a linear or exponential time trend. The Dickey– Fuller test was used to examine stationarity. According to the study described here, the original series of each log-variable is integrated of order 1 (eq. (1)). Since the type of the model to be estimated might depend on whether a dependent variable may be cointegrated with an independent variable, it is important to test whether two or more variables are cointegrated. Two cointegrated series will not drift too far apart over the long run. Engel and Granger (1987) considered a variety of tests for cointegration. The simplest test for cointegration is the Cointegrating Regression Durbin–Watson test. Findings for this study reveal that cointegration does not exist in the model.

It should be noted that due to annual data, the size of the coefficients could be affected by cyclical factors, the rates of increase in physical capital stocks especially. Fortunately, Taiwan experienced very few cyclical shocks, not even in the early 1980s when US and world interest rates went to 18%, nor in 1997–98 when five East Asian countries — Indonesia, Malaysia, South Korea, the Philippines, and Thailand — experienced sharp currency and banking crises (Barro, 2001; and Park and Lee (2001).³

The results of estimation from eq. (7) are reported in Table 2. The hypothesis of no educational effect was tested; findings showed an education effect, which is 15% and statistically significant at the 5% level. This means that one additional year of average education is estimated to increase real output by approximately 0.15%. The hypothesis of constant returns to scale was also tested. According to results, the hypothesis was not rejected at the 5% level. The estimates of labor share, capital share, and constant term (i.e., technical progress) are 64%, 14%, and 2.83%, respectively. All effects are statistically significant at the 5% level. The coefficient of R-square elucidates a 43% explanatory power of the

Table 2 Estimates of $\ln Y_t - \ln Y_{t-1}$

Explanatory variables	Eq. (7)
Constant $\ln K_t - \ln K_{t-1}$ $\ln L_t - \ln L_{t-1}$ $E_t - E_{t-1}$ R^2	0.02832**(2.05) 0.13872**(3.19) 0.6377**(3.50) 0.15224**(2.29) 0.430
Autocorrelation (LM Test) Heteroskedasticity (LM Test)	(Inconclusive) No No
Test of constant returns to scale	Accept C.R.T.S.

** variable is significant at the 0.05 level, t-value is in parenthesis. C.R.T.S.= Constant Returns to Scale.

³ Both Barro (2001) and Park and Lee (2001) employed annual data from East Asian countries and consider the impacts of short-term fluctuations. Each addresses the relation between short- and longer-term effects and conclude that there is no evidence for a direct impact of a financial crisis on long-run growth independent variables. The Durbin–Watson (DW) statistic is 1.5, which is between the lower bound and the higher bound at the 5% significance level. Hence, the DW test is inconclusive. When such situations occur, one alternative is the Lagrange Multiplier (LM) test. According to the LM test, autocorrelation does not exist. Moreover, to see if there is greater error variability in the early or late portion of the sample, the LM test for heteroskedasticity is used. As a result, no evidence supports a conjecture of heteroskedasticity in the model.

Due to positive and significant effects of education and technical progress on growth, it is possible that capital and education are complements and education and technical progress are complements too. This could be one plausible explanation for finding a significant estimated effect for education. I did a complementarity test (see Note 3) to ascertain whether they are complements. No remarkable relationships were found between capital and education, or between education and technical progress. Hence, complementarity may not explain the significant effect of education in Taiwan.

Since gross enrollment rates were not employed in the study, major parts of the new knowledge and technologies may not be brought to bear on production. The complementarity between education and technology could be more significant if gross investment in human capital or gross enrollment rates and R&D investment were used. In addition, this study might ignore part of education's true contribution to growth, such as externalities from education and non-market returns with long-delayed feedback effects (e.g., the political stability provided a more stable environment for high rates of investment, as well as lower population growth rates due to female education is one of example of a feedback effect that helped growth). Furthermore, it could be a mistake to think of productivity growth as an orderly shift in the production function of the representative plant.

5. Sources of economic growth in Taiwan

The economic growth of a nation can be generally attributed to four factors: growth in physical capital, growth in labor, growth in human capital, and technical progress. Hence, the output can be specified by an aggregate production function:

$$Y = F(K,L,E,t),\tag{8}$$

where Y, K, L and E are real output, physical capital, labor, and human capital, respectively, and t is an index of chronological time. After differentiating eq. (8), the rate of growth of output can be expressed in the following equation of growth accounting:

$$\frac{d\ln Y}{dt} = \frac{\partial \ln F}{\partial t} + \frac{\partial \ln F d\ln K}{\partial \ln K dt} + \frac{\partial \ln F d\ln L}{\partial \ln L dt} + \frac{\partial \ln F dE}{\partial E dt}.$$
 (9)

The four terms on the right-hand-side of eq. (9) can be identified as the contributions of technical progress, physical capital, labor, and human capital, respectively, to the output growth.

Indeed, eq. (9) is the same as the estimated regression of eq. (7). The estimated constant term of eq. (7) is identified as the technical progress. Based on the coefficients from eq. (7), I decompose the economic growth in Taiwan during the period 1965–2000 into its proximate sources, and obtain the average percentage of distribution for technical progress, capital, labor, and education.

The results of the decomposition are reported in Table 3. Findings show that the technical progress accounts for 37% on average as a whole during the period 1965–2000. Human capital, labor, and physical capital account for nearly 25%, 22%, and 16%, respectively. A 37% contribution for technical progress does not appear to be extraordinary high. This result is consistent with Young's (1994) conclusion that the extraordinary rate of output growth is based upon the rapid rates of factor accumulation, with little due to technical progress.

As noted in the previous section, gross investments in human capital or gross enrollment rates were not used in the study. It thus may be a significant problem that major parts of the new knowledge and technologies never brought to bear on production. Gross enrollment rates and gross investment in education include replacement investment, but net increments in average educational attainment and net increments in the real capital stock do not. If the embodiment of technology in human capital and in physical capital is included, then not only the contribution to growth of education, but also of gross investment in physical capital increase essentially. Therefore, the 37% pure technology effect could be expected to be smaller, but the 15% pure physical capital effect may be expected to be higher.

6. Conclusion

In this study, human capital is introduced in the aggregate production function to improve the performance of the growth model and examine the effectiveness of education on economic growth in Taiwan during 1965– 2000. Human capital was measured as the average num-

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Average percent of distribution of economic growth in Taiwan (1965–2000)

Technical pro- gress	Physical tal	capi-	Labor	Human capital
37.27%	15.66%		22.30%	24.77%

ber of years of formal education per person for employed people. The results indicate that average education provides a positive and significant effect on output growth. One additional year of average education is estimated to increase real output by approximately 0.15%.

A time trend is also introduced to capture the effect of technical progress. Results show that technical progress in Taiwan is estimated to be 2.8%. According to the decomposition of sources of output growth, the average contribution of technical progress in Taiwan's economic growth is 37% over the 1965–2000 period. Due to the data employed, some of the knowledge and technology would not be brought to bear on production so that the 37% contribution via the pure technology effect could be expected to be lower.

Finally, the significant effectiveness of education and technical progress on Taiwan's economic growth may render capital and education as complements, and education and technical progress also as complements. More investment in physical capital requires more educated workers to learn new technologies. A higher rate of technical progress mandates a higher level of average education. Results of the complementarity test, however, did not reveal remarkably significant relationships between physical capital and education, or between education and technical progress. Another data set or another empirical specification may find support for that result. This could be an interesting issue for readers to research.

7. Notes

- 1. Labor force is defined as those civilians who, during the reference week, are age 15 or older and who are available to work, including both the employed and the unemployed. The employed population comprises all persons who, during the reference week, work for pay or work 15 hours or more as unpaid family workers. The unemployed population comprises all persons who, during the reference week, are age 15 or older and are under the following conditions: (1) no job, (2) available to work, (3) seeking for a job, or had sought work but waiting for results. Also, the unemployed population also includes persons who are waiting to be recalled or started a new job but not working and paid yet. "Not in labor force" is defined as those people who intend to work but are not seeking it, attend school, are engaged in housekeeping, aged, or disabled, as well as not working and seeking for a job. (See Statistical Yearbook of the Republic of China).
- 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. "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. Education consists of six years of primary school, three years of junior high school, three years of senior high school, and four years of college or university.

 Capital-education complementarity may be modeled by using a generalization of the Cobb–Douglas model, the transcendental logarithmic production function of which is:

$$\ln Y_{t} - \ln Y_{t-1} = C_{0} + a_{K} [\ln K_{t} - \ln K_{t-1}] + a_{L} [\ln L_{t} - \ln L_{t-1}] + a_{E} [E_{t} - E_{t-1}] + b_{KK} [(\ln K_{t})^{2} - (\ln K_{t-1})^{2}]/2 + b_{LL} [(\ln L_{t})^{2}$$
(10)
$$- (\ln L_{t-1})^{2}]/2 + b_{EE} [E_{t}^{2} - E_{t-1}^{2}]/2 + b_{KL} [\ln K_{t} \ln L_{t} - \ln K_{t-1} \ln L_{t-1}] + b_{KE} [\ln K_{t} \cdot E_{t} - \ln K_{t-1} \cdot E_{t-1}] + b_{LE} [\ln L_{t} \cdot E_{t} - \ln L_{t-1} \cdot E_{t-1}] + \varepsilon_{t}.$$

If physical capital and human capital are complements, it should be able to estimate $b_{KE} > 0.A$ simple model for education–technical progress complementarity is constructed as follows:

$$\ln Y_{t} - \ln Y_{t-1} = C_{0} + a_{K} [\ln K_{t} - \ln K_{t-1}] + a_{L} [\ln L_{t} - \ln L_{t-1}] + a_{E} [E_{t} - E_{t-1}] + b_{Et} [E_{t} \cdot t \quad (11) - E_{t-1} \cdot (t-1)] + \varepsilon_{t}.$$

If technical progress and human capital are complements, an estimate of $b_{Et} > 0$ should be feasible.

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References

- Armer, M., & Liu, C. (1993). Education's effect on economic growth in Taiwan. *Comparative Education Review*, 37(3), 304–321.
- Barro, R. (2001). Economic growth in East Asia before and after the financial crisis. NBER Working Paper 8330.
- Engel, R. F., & Granger, C. (1987). Co-integration and error correction: Representation, estimation, and testing. *Economterica*, 55, 251–276.

- Hsieh, C. (1999). Productivity growth and factor prices in East Asia. American Economic Review (Papers and Proceedings), 133-138.
- Kim, J., & Lau, L. (1994). The sources of economic growth of the East Asian newly industrialized countries. *Journal of Japanese and International Economics*, 8(3), 62–78.
- Krugman, P. (1994). The myth of Asia's miracle. Foreign Affairs, 62–78.
- Lau, L., Jamison, D., Liu, S., & Rivkin, S. (1993). Education and economic growth: Some cross-sectional evidence from Brazil. *Journal of Development Economics*, 41, 45–70.
- McMahon, W. (1998). Education and growth in East Asia. Economics of Education Review, 17(2), 159–172.
- Page, J. (1994). The East Asian miracle: Four lessons for development policy. NBER Macroeconomics Annual 1994, Cambridge, MA: MIT Press.
- Park, Y. and Lee, J. (2001). Recovery and sustainability in East Asia. NBER Working Paper 8373.

- Rodrik, D. (1995). Getting interventions right: How South Korea and Taiwan grew rich. *Economic Policy*, 20, 55–107.
- Tallman, E., & Wang, P. (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.
- World Bank (1993). The East Asian miracle: Economic growth and public policy. Oxford University Press for the World Bank, Washington DC.
- Young, A. (1995). A tale of two cities: Factor accumulation and technical change in Hong Kong and Singapore. NBER Macroeconomics Annual 1992, Cambridge, MA: MIT Press.
- Young, A. (1994). The tyranny of numbers: Confronting the statistical realities of the East Asian growth experience. NBER Working Paper 4680.