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Human Capital Returns and Technological Change: Evidence from Taiwan

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Abstract

Using 1978-2000 Taiwan's Manpower Utilization Survey data, this paper estimates the trends of returns to education and on-the-job training, evaluate the Nine-Year Compulsory Education policy in implemented in 1968, and investigate the relationship between investment in human capital and technological improvement. The estimated results shows that return to education is about 6.5% higher than that of 4.5% of on-the-job training, and the return of firm-specific training is around 5% higher than that of 3% of general training. However, over the period return to education has an increasing trend while return to training depicts a declining trend, implying that education of basic knowledge is relatively more important than training of occupational-specific skills under a dynamic and rapid changing industrial environment as in Taiwan. Policy evaluation of the Nine-Year Compulsory Education policy shows that it did increase the returns to education and on-the-job training.

Granger causality test shows that investment in human capital positively unidirectional causes exports of mid technology and negatively unidirectional causes imports of high technology. Moreover, human capital and imports of mid technology have bidirectional causality relation. The results from Taiwan's developmental experience suggest that investment in human capital is helpful in increasing workers productivity and upgrading of domestic technology. Moreover, the imports of more appropriate technology instead the state-of-the-art technology is beneficial to the accumulation of domestic human capital. Hence, Taiwan's case study provides an evidence of growth mechanism of human capital investment and policy implications for the other developing countries to follow.

Keywords: Education, on-the-job training, technological change
JEL classification: J24, O15, O33

Human Capital Returns and Technological Change: Evidence from Taiwan

I. Introduction

Empirical researches have shown that rates of returns on human capital are around 15%-20%, see, for example, Heckman (2003). Aside from formal education, which is the major channel for human capital investment, about one-third to a half of skill acquisition is from after school on-the-job training (Heckman, Lochner, and Taber, 1998). Cross-country studies have also shown that human capital is a critical factor in enhancing productivity hence affecting a country's long run growth. Human capital investment contains the access of new information and knowledge (Thomas et al., 1991) or capability to absorb new information (Schultz, 1975), which in turn enhances productivity. If human capital is so important, why aren't there any significant improvements in human capital investment of less-developed countries? Human capital investment is by no means happened automatically, and it must be cultivated and required certain prerequisite conditions for it to happen. Rosenweig (1995) points out that changes in technology and learning environment for effective learning is the key for human capital investment.

The educational investment in Taiwan for the past forty years has been increased by leaps and bounds. The net enrollment rate of higher education increases from 9.97% in 1976 to 45.68% in 2002. The share of population over age 15 who has

higher educational attainment increased from 3.8% in 1976 to 13.08% in 2002, an increase of 3.4 times. In the late 1950s to early 1960s, economic condition in Taiwan was about the same compared to that of other developing countries. However, from then on Taiwan has continuously accumulated its human capital which contributes to its rapid economic growth. Chuang (1999) find that human capital accounts for 46% of output growth of Taiwan's manufacturing industry.

The purpose of this research is to analyze the relationships among human capital return and technological change. Using data from 1978-2000 of Taiwan's Manpower Utilization Survey, the research will estimate returns to education and experience at different periods and among different cohorts and evaluate the effect of compulsory education policy implemented in 1968. What kind of employment quality change was undergoing during the development process? Did the improvement of workers' quality meet the needs of industrial development? Finally, using Granger causality test we try to identify the relationship between human capital investment and technological improvement. Theoretically, human capital investment upgrades potential workers' quality which is a prerequisite condition for absorbing new technology. Thus, human capital investment leads to technological improvement. However, it is also possible that the improvement in the technological environment increases the return on human capital and thus generates human capital

investment. Foster and Rosenweig's (1996) research of India's green revolution find that during the period of rapid technological progress, the return on primary education significantly increased and in turn stimulated investment in education. Munshi (2003) find globalization affects educational choice in Bombay, though the increase in the year of receiving education is small, the rate of return on English education has increased tremendously, from 16% to 23% for male and 2.5% to 26% for female. Dutlo (2001) also find a significant effect of the use of oil revenue for the mass construction of schools in Indonesia in 1973. Construction of a new school for every one thousand students will increase 0.12-0.19 year of education, raise wage by 1.5-2.7%, and has a rate of return on education of 6.8-10.6%.

This paper is organized as follows. Section 2 estimates the returns to education and on-the-job training and evaluates the Nine-Year Compulsory Education policy implemented in 1968. Section 3 investigates the evolution of employment structure and workers' quality and tests the argument of corresponding demand shift for more educated workers in the 1980s. Section 4 examines the possible causal relationship between human capital investment and technological change. Concluding remarks follow in Section 5.

II. Returns to Human Capital

There are many forms of human capital and it can be accumulated, for example, by education, on-the-job training, health and nutrition, migration, etc. In this paper, we only consider two of the most important human capital accumulation – education and on-the-job training. Standard Mincerian earnings function is used for the estimation of rates of return to human capital:

$$LnW_{it} = \alpha_0 + \alpha_{1t} S_{it} + \alpha_{2t} EX_{it} + \alpha_{3t} EX_{it}^2 + \alpha_4 TN_{it} + \alpha_5 TN_{it}^2 + \varepsilon_{it}, \quad (1)$$

where the dependent variable is hourly wage in logarithmic form, S is year of schooling, EX is work experience, TN is tenure, ε is the disturbance term, and i is an index for worker. The parsimonious specification of equation (1) has the advantage of easy comparability with other studies. The coefficient α_1, a reduced form coefficient of education, measures the gross return to education which includes all the direct and indirect effects of education on wage. The coefficients α_2 and α_4 determine the effects of general training and firm-specific training on wage, respectively, and hence a measure for the returns for on-the-job training.

The data used in this paper is from Taiwan's Manpower Utilization Surveys for the period 1978-2000. The MPUS data are repeated cross sections, stratified random samples of around 19,700 households from about 7510 villages and neighborhoods of

Taiwan. Work experience is calculated as age – years of schooling – 8 for males over 20 (6 for males under 20).[1]

Figure 1 shows the rates of return on human capital investment from regression results of equation (1).[2] Rate of return to education in Taiwan denotes a stable increasing trend from 5.3% in 1978 to 7.3% in 2000. The corresponding average years of schooling were 8.1 years to 11.4 years. Moreover, the return of on-the-job training, denoted by the coefficients of work experience and tenure, is around 4.5% lower than that of formal education. Figure 2 presents the wage premiums by education level. On average, wage premiums are 20%, 50%, and 100% for primary school, high school, and university respectively with respect to no education. However, the wage premiums shrunk after 1990s. Figure 3 presents the retes of return to education by education level. In general, return to education is increasing by educational level with the highest return of 12% for university. However, all the returns to education had a decreasing time trend, especially for senior high and vocational schools.

As educational choice is a self-selection process, selection bias may be encountered for the time series data, we further reconstruct manpower utilization data

[1] In Taiwan, males have to do military service once they reach the age of eighteen and leave school.

[2] As the educational choice is a sequential and self-selection process, Chuang and Chao (2001) estimate return to education using Taiwan Manpower Utilization Survey data of 1996 and taking the relevant selection properties into account and, however, their estimation results are comparable to the findings reported in this paper.

into a pseudo panel data by birth cohort. Figure 4 shows the regression results for the cohort analysis. The estimated rate of return to education from cohort data is about 10%, higher than that from previous time series data. Note that the return to education (11.6%) is highest for the 1960s cohort. This group of people was actually the early recipients of nine-year compulsory education implemented in 1968; they entered the labor market by 1980. Using difference-in-difference method, we evaluate the effect of compulsory education policy. We divide the sample into two group, one for those were born before 1956 and the other for those after 1956. The former group is the people who did not received compulsory education and hence was taken as the reference group, while the latter group is the people who received compulsory education and was considered as the treatment group. The average years of school are 8.3 and 11.2 years for the two groups, respectively. Regression results from Table 1 show that rate of return to education for the reference group is 8.7% and that for the treatment group is 11%, a significant difference of 27%. Therefore, it is clear that nine-year compulsory education not only increase the years of education for the people but also increase their returns to education. Regression results also show that the returns of on-the-job training also significantly increased for the treatment group. These results suggest that the increased in the return to

education will also enhance the returns of on-the-job training, i.e., education and skill formation are complementary.

III. Employment Structure and Quality Change

Before 1990 industry sector employed the largest share of labor force reaching its peak of 45.7% in 1987, in 1990 service sector surpassed industry sector as the leading sector and expended steadily ever since climbing to 54.7% in 2000. From 1978 to 2000, the employment structure of both industry and service sectors has changed toward more education oriented, especially for the service sector. From figures 5 and 6, significant improvement in workers' educational attainment are vocational school, junior college, and university. Even though that the number of workers with higher education has increase over the past two decades, their rates of return to education are actually increased during the period. This may happen unless there is a strong increase in labor demand for more educated worker during the development process, i.e. technological improvement generates the needs of more educated workers.

Under stable labor demand, an increase in labor supply will reduce the wage and increase the employment level, while a decrease in labor supply will increase the wage and decrease the employment level. Thus, wage and employment level are negatively correlated. Under stable labor supply, an increase in labor demand will

increase the wage and increase the employment level, while a decrease in labor demand will decrease the wage and decrease the employment level. Thus, wage and employment level are positively correlated. Therefore, the test of stable labor demand requires that the matrix of the cross-price effect on labor demand is negative semi-definite. On the contrary, if the cross-product effect is positive semi-definit, then an underlying demand shift prevails.[3] Table 2 presents the results of inner products of wage-employment matrix for vocational school, junior college, and university workers by experience level. The results of inner-product analysis showing a positive relation between changes in wage and employment in the 1908s, it thus confirms a strong demand shift toward more educated workers in 1980s across industries. Therefore, it suggests that a stable increase of workers' quality is coincidence with a stable increase in the demand for more educated workers.[4] The increase in both demand and supply of more educated workers help to stabilize the wage gap between skilled to unskilled workers. Moreover, the large employment of more educated workers enhances the productivity of domestic industry and also conducive to the upgrade of domestic technological level.

[3] See, for example, Murphy and Welch (1992) and Katz and Murphy (1992) for a detail discussion of inner product method.

[4] The examination of the cause of supply creates its own demand in labor market is beyond the scope of the paper. However, Acemoglu (1998) and Machin and Manning (1997) provide theoretical reasons that why it may happen.

IV. Human Capital Investment and Technological Change

In this section, we try to disentangle the relationship between human capital investment and technological change. The recent developed econometric technique of unit root, cointegration and Granger causality tests is adopted. Variables for the human capital are the ratios of higher education workers relative to the lower education workers. Higher education includes vocational school, junior college, and university, while lower education includes primary school, junior high, and senior high school. Meanwhile, a human capital index is also constructed using the idea of efficiency unit by weighting each individual worker with his wage relative to the wage of non-educated worker. Technology level is proxy by the content of the goods that imported or exported in the international market. There are classified by high technology intensive and mid technology intense imports and exports goods. All the variables except mid technology intensive imports have a unit root, however, no cointegration can be detected between any pair of human capital and technology variables.

Granger Causality test from Table 3 shows that in all cases human capital positively unidirectional causes mid technology exports and negatively unidirectional causes high technology imports. Moreover, positively bidirectional cause is found between human capital and mid technology imports. These results imply that

investment in higher education, especially in vocational school and junior college, will enhance the productivity of workers, improve the competitiveness of mid technology exports and substitute for the needs of high technology imports. Furthermore, investment in human capital and the imports of mid technology are complements which justifies the arguments of importing appropriate technology is more crucial than importing high technology for a developing country's economic development.

V. Concluding Remarks

Using 1978-2000 Taiwan's Manpower Utilization Survey data, this paper estimates the trends of returns to education and on-the-job training. The return to education is about 6.5% in general higher than that of 4.5% of on-the-job training, and the return of firm-specific training is around 5% higher than that of 3% of general training. However, over the period return to education has an increasing trend while return to training depicts a declining trend, implying that education of basic knowledge is relatively more important than training of occupational-specific skills under a dynamic and rapid changing industrial environment as in Taiwan. Policy evaluation of the Nine-Year Compulsory Education policy shows that it did increase the returns to education and on-the-job training. With the increase of the number of

higher education worker the increasing trend of return to education implies a consistent corresponding increase in the demand for higher education. This shift in demand for more educated workers is confirmed by the analysis of cross-product method for the periods of 1998s and 1990s. Therefore, during the development process demand and supply factors favor more educated workers.

We next try to identify whether investment in human capital causes the improvement on technology or vice versa. This is pure an empirical question as, theoretically both directions are possible. Using recent development econometric technique of unit root, cointegration, and Granger causality tests, we find the investment in human capital positively unidirectional causes exports of mid technology and negatively unidirectional causes imports of high technology. Moreover, human capital and imports of mid technology have bidirectional causality relation. The results from Taiwan's developmental experience suggest that investment in human capital is helpful in increasing workers productivity and upgrading of domestic technology. Moreover, the imports of more appropriate technology instead the state-of-the-art technology is beneficial to the accumulation of domestic human capital. Hence, Taiwan's case study provides an evidence of growth mechanism and policy implications of human capital investment for the other developing countries to follow.

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Figure 1. Returns of Human Capital in Taiwan: 1979-2000

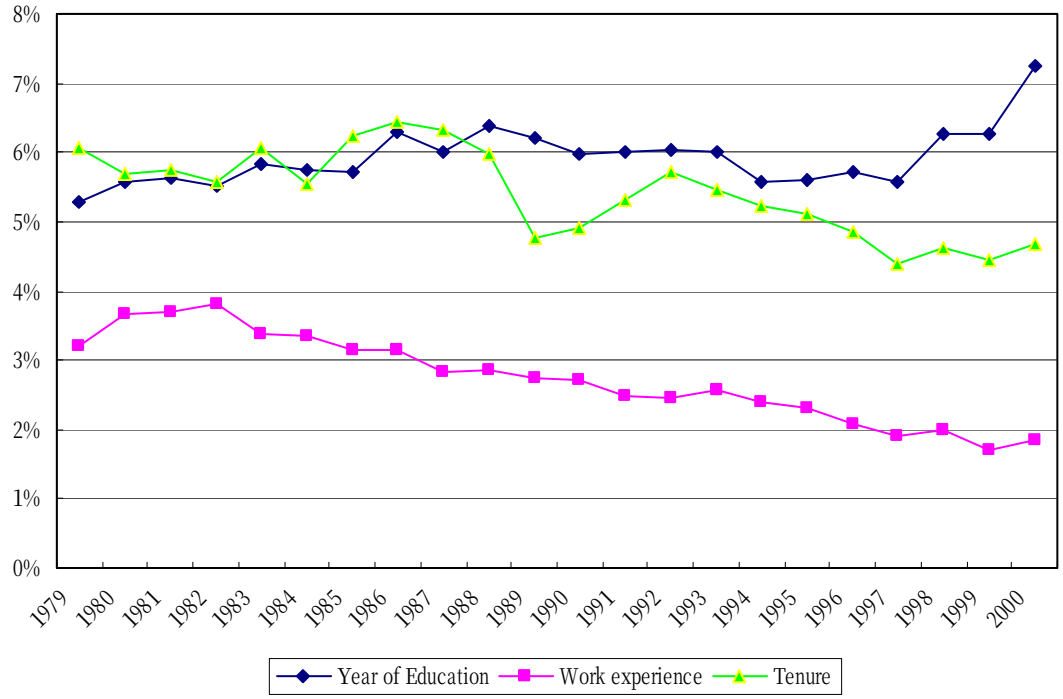

Figure 2. Wage Premium by Education Level

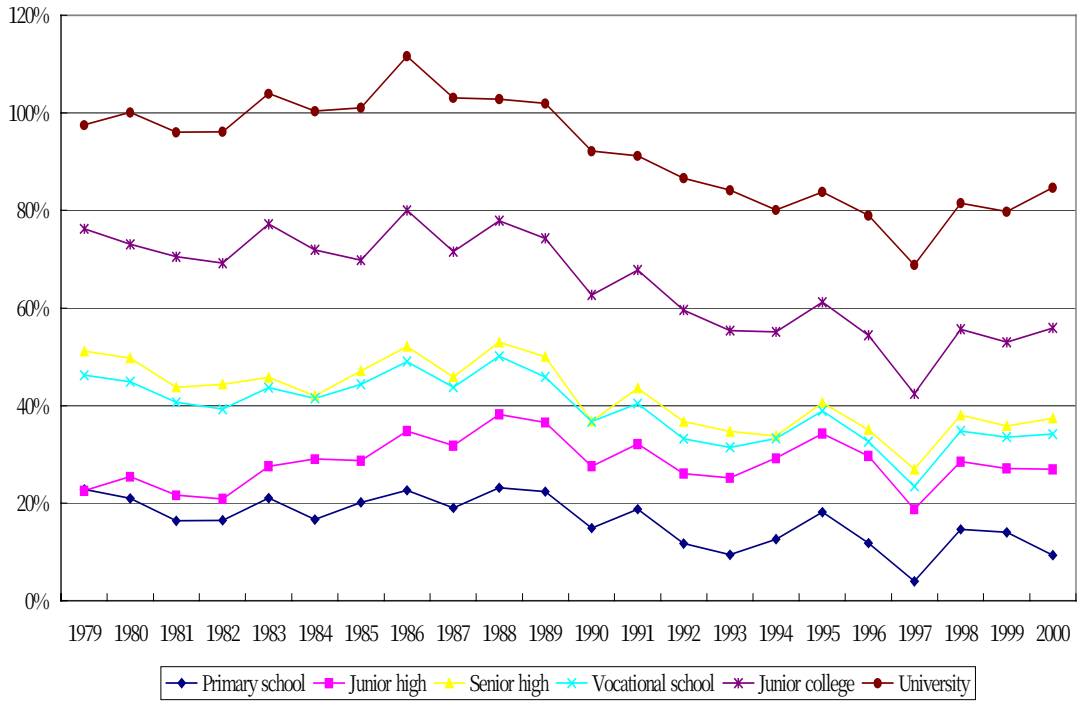

Figure 3. Rates of Return by Education Level

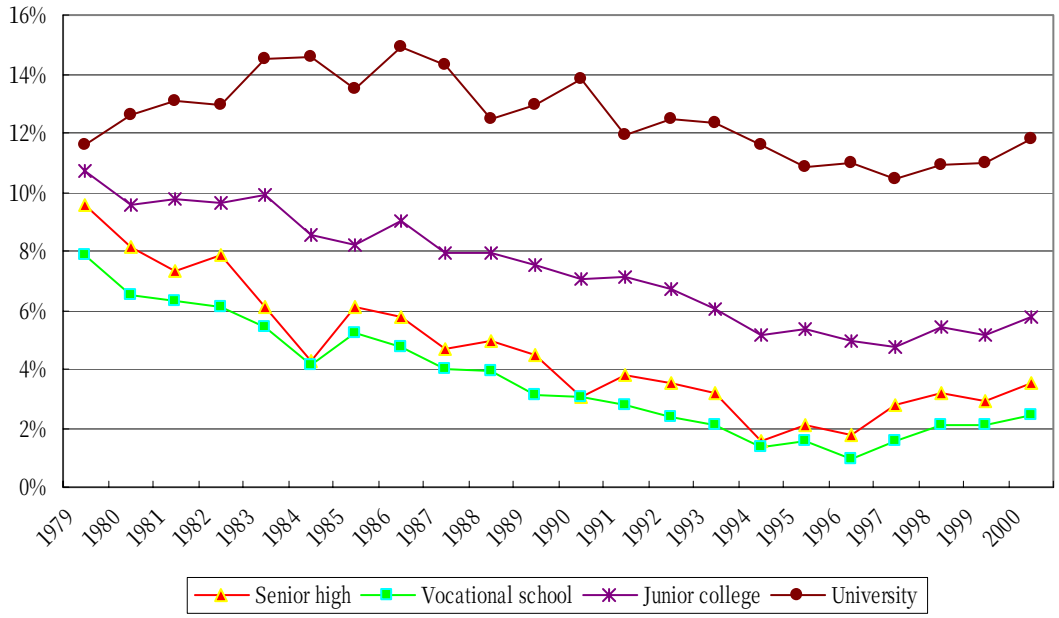

Figure 4. Returns of Human Capital by Cohort

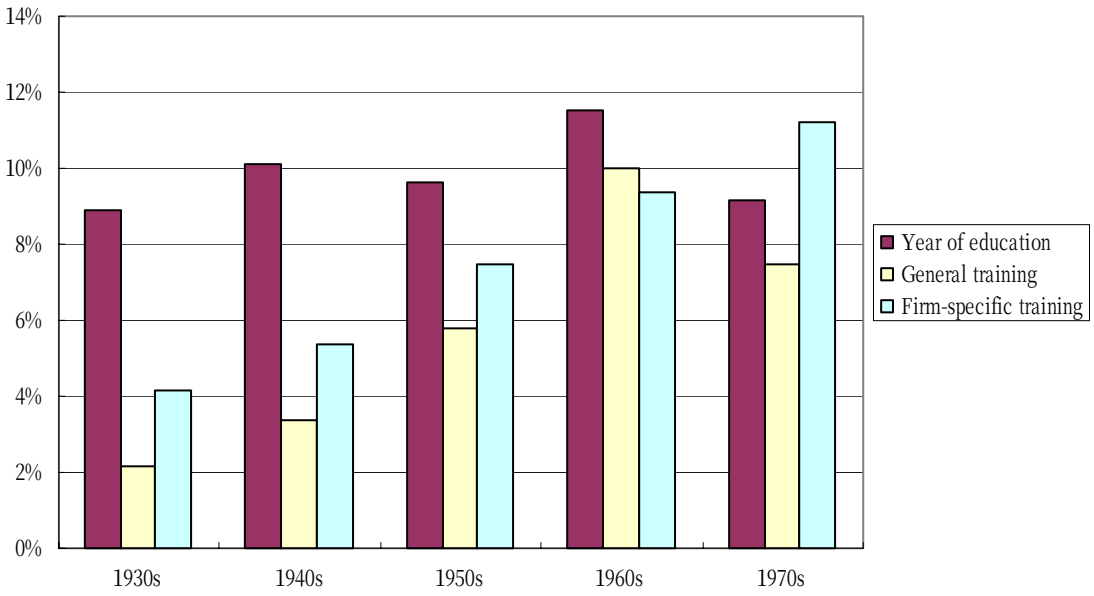

Figure 5. Employment structure of industry sector by educational attainment

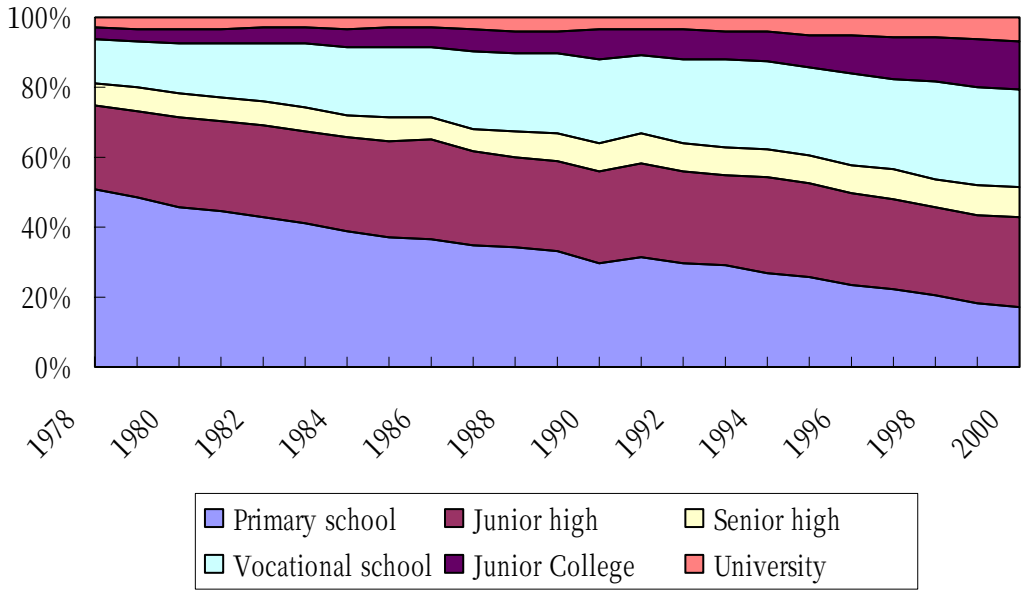

Figure 6. Employment structure of service sector by educational attainment

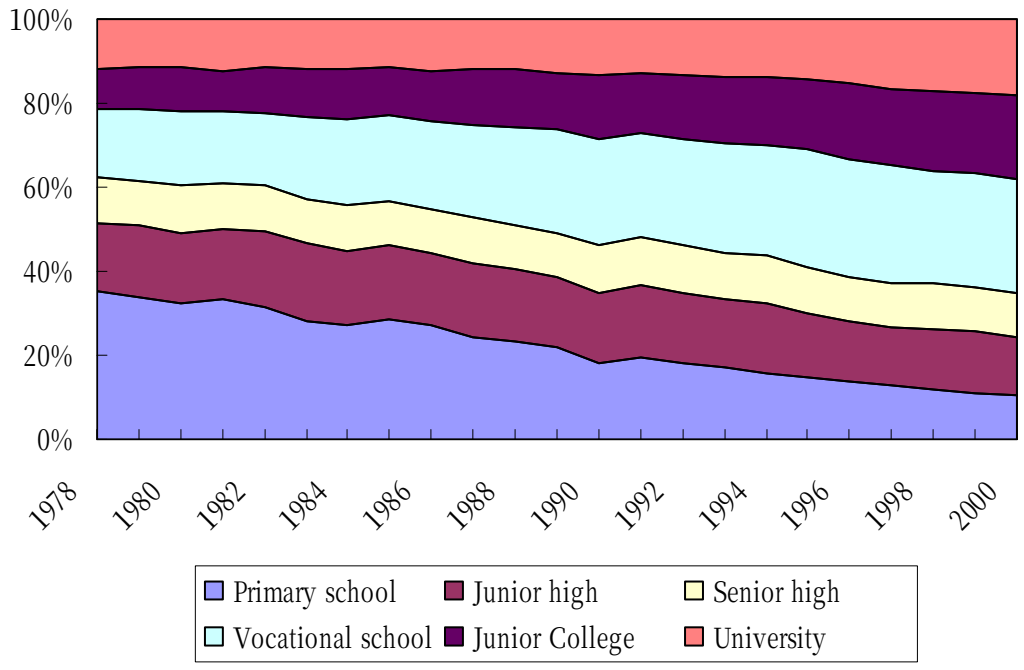

Table 1. The Effect of Nine-Year Complusory Education

	(1)	(2)	(2)-(1)/(1)
	Before 1956	After 1956	
Return to education	0.08719	0.10961	0.25714
Return to general training	0.03205	0.07099	1.21498
Return to firm-specific trainin	0.04222	0.07845	0.85812

Table 2. Inner products of Wage-employment Matrix

Vocational School

1-5 year experience

Year	1980	1985	1990
1985	0.2643		
1990	0.6288	0.0605	
1995	1.1084	0.2275	0.0527

6-10 year experience

Year	1980	1985	1990
1985	-0.1823		
1990	-0.2252	0.0186	
1995	-0.1484	0.0797	0.0174

Junior College

1-5 year experience

Year	1980	1985	1990
1985	1.7122		
1990	3.9343	0.4542	
1995	6.7582	1.6666	0.3731

6-10 year experience

Year	1980	1985	1990
1985	-1.8130		
1990	-1.7388	0.3228	
1995	-1.6127	1.0805	0.2092

University

1-5 year experience

Year	1980	1985	1990
1985	0.057		
1990	-0.3481	-0.4391	
1995	-0.0075	-0.2482	0.0968

6-10 year experience

Year	1980	1985	1990
1985	-0.0953		
1990	0.042	0.018	
1995	0.001	0.0053	0.0029

Table 3. Results of Granger Causality Test

Human Capital	Granger Causality	Technology Level	F-Statistics
Human1	X	EXHI	0.42844
	X	EXMID	1.15613
	→	IMHI	3.29387*
	←	IMMID	4.24211*
Human2	X	EXHI	0.14552
	→	EXMID	4.20356*
	→	IMHI	3.57515*
	↔	IMMID	5.37877**
Human3	←	EXHI	8.25879**
	→	EXMID	3.63171*
	→	IMHI	4.4637*
	↔	IMMID	6.56833**
Human4	←	EXHI	7.68355**
	X	EXMID	2.77204
	→	IMHI	4.81227**
	↔	IMMID	5.83724**

Notes:

Human1: The ratio of higher education (vocational school, junior college, and university) workers in total employment

Human2: The ratio of higher education workers relative to lower education (primary school, junior high and senior high schools) workers

Human3: workers measured in efficiency unit (weighting by corresponding worker's wages relative to wage of worker without education) in the whole economy

Human4: workers measured in efficiency unit in the manufacturing sector

Exmid: exports of mid technology-intense goods

Exhigh: exports of high technology-intensive goods

Exsum: exports of mid and high technology-intensive goods

Immid: imports of mid technology-intense goods

Imhigh: imports of high technology-intensive goods

Imsum: imports of mid and high technology-intensive goods