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Human Capital and Technological Catch-up in the Asian Developing Countries

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Abstract

The importance of technology transfer in economic growth has been emphasized in recent research. Developing countries can increase their productivity and efficiency levels through the acquisition of technological knowledge from the advanced countries. Thus, the ability of a country to take advantage of foreign technologies is important in determining the successful of technology diffusion. Human capital not only acts as an input in the production function, it also contributes to facilitate the adoption of new technology. This paper empirically investigates the impact of the aggregate level effect and composition of human capital in the process of technology diffusion and productivity growth in a panel of 16 Asian developing countries over the period 1970 – 2009. We test the hypothesis by adopting logistic function of technology diffusion model by Benhabib and Spiegel (2005).

1. Introduction

Developing countries increase their productivity and efficiency levels through the acquisition of technological knowledge from the advanced countries by engaging in international economic activities. They were highly dependent on accessible foreign technology acquisition for technology development through trade and foreign direct investment which have been commonly recognised as the conduits of technology transfer. With regard to exploit foreign technology, Asia developing countries have implemented proactive policy in the economy by encouraging FDI and imported technology with an open international trade policy framework. A high degree of economic integration of developing Asian countries in the world economy does not necessary lead to effective transfer of technology as the main challenges facing developing countries are not their access to technology but their absorptive capacity in the technology catch-up process (World Bank, 2008).

Technology diffusion models relate productivity growth to the technology gap between lagging country and the technology frontier and explain the ability of a lagging country to catching-up by the extent of the adoption of technological knowledge. The technology gap refers a notion of the absorptive capacity of a country. Nelson and Phelps (1966) formalized the role of human capital in facilitating the diffusion of technology. Human capital facilitate productivity growth not only by developing innovation activities but also increase its capacity to adopt new technologies developed elsewhere (Barro and Sala-i-Martin, 1995; Barro, 1999 and Benhabib and Spiegel, 1994, 2005). As the technological progress is dual dimensions (innovation and imitation) thus different levels of human capital may have different effects on growth (Vandenbussche et al., 2006 and Ljungberg and Nilson, 2009).

Asian developing countries have made strong progress in improving educational capital to encounter the changing demands and improve the efficiency of resource allocation (Lee, 2001) and efficient adoption of technologies. The rapid education growth in Asia is mainly contributed by the strong improvement in average year of primary and secondary schooling (Lee & Francisco, 2012). Stock of human capital is often cited as one of the crucial factor that contributed to their remarkable economic performance. Does education have a heterogeneous effect on the productivity growth and technological catch-up of Asian developing countries? This paper aims to enhance the Asian empirical literature by investigating the impact of the aggregate level effect and composition of human capital on productivity growth and catch-up empirical specification on the logistic technology diffusion function.

The significance of human capital in influencing productivity by stimulating innovation and technology adoption have been consistently proven by recent studies (e.g. Griffith et al., 2004; Benhabib and Spiegel, 2005; Madsen et al., 2010). However, Vandenbussche et al. (2006) has noted that human capital does not affect innovation and imitation uniformly, in which different types of human capital –skilled workers (represented by primary and secondary education) and unskilled workers (represented by tertiary education) would facilitate innovation and imitation differently depending on the relative distance of the country to the technology frontier. This finding is endorsed by Ang et al. (2011) that higher education contributes to growth for countries that moves colder to the technology frontier.

The next section establishes the empirical framework; section 3 explains the data and estimation methodology; section 4 presents the empirical results and section 5 discuss the conclusions.

2. Empirical framework

This paper uses Benhabib and Spiegel (2005) logistic model of technology diffusion empirical specification to test the total factor productivity (TFP) catch up model of technology diffusion as follows:

$$GTFP_{it} = ghc_{it} + chc_{it}\left(1 - \frac{A_{it}}{A_{Lt}}\right)$$

$$= (g+c)hc_{it} - chc_{it}\left(\frac{A_{it}}{A_{Lt}}\right) \qquad (1)$$

where, $GTFP$ is total factor productivity growth, hc indicates human capital, $hc_{it}\left(\frac{A_{it}}{A_{Lt}}\right)$, represents the interactive term of human capital with the TFP gap. As the technological leader and the major trading partner of the developing countries in the world, the US technology is considered as the world frontier technology, (A_L). Equation (1) shows that international technological diffusion follows a logistic pattern in which the gap between the technology leader and follower may widen over time[1].

Accordingly, the following empirical specification is adapted:

$$GTFP_{it} = b_0 + b_1(g+c)hc_{it} - b_2 hc_{it}\left(\frac{A_{it}}{A_{Lt}}\right) + \varepsilon_{it} \qquad (2)$$

where $b_1 = (g+c)$, $b_2 = c$ and ε_{it} is a stochastic error term.

[1] For detail explanation refer Banhabib and Spiegel (2005).

3. Estimation Method and Data

The empirical estimates are based on the fixed effects and random effects estimators for a panel of 16 Asian developing countries[2] over the period 1970 – 2009.

Penn World Data Table version 7.0 is used to computing the TFP growth rate. TFP is estimated as a residual of the aggregate production function: $Y = AK^{\alpha}(L)^{1-\alpha}$ where y is real GDP per worker, K is physical capital stock, α is the share of income contributed by capital stock and is set to 0.3 while $(1-\ \alpha)$ is the share of income contributed by labour. Dividing by labour input L: $\frac{Y}{L} = A\left(\frac{K}{L}\right)^{\alpha}$, where $\frac{Y}{L}$ is the output-worker ratio, $\frac{K}{L}$ is the capital-worker ratio and A represents the contribution of TFP. Thus, the estimation of TFP is as follows: $A = TFP = \frac{Y}{L}/\left(\frac{K}{L}\right)^{\alpha}$. The TFP growth rate is calculated by taking first differential of the log of TFP: $\Delta \ln A = \ln \mathrm{A_{it}} - \ln \mathrm{A_{it-1}}$. The physical capital stock series is computed by using the perpetual inventory method, $K_t = I_t + (1-\delta)K_{i,t-1}$, where K is the amount of capital, δ is the depreciation rate which was assumed at five percent and I is the amount of investment. To obtain capital stock data series, initial capital stock is estimated by: $K_0 = \frac{I_0}{g_{ss}+\delta}$, where g_{ss} is the average rate of real investment over the period 1970–2009.

Human capital is measured by the average years of schooling of the population aged 15 and over provided by Barro and Lee (2010) schooling dataset in term of: average year of total schooling, average year of primary schooling, secondary schooling and tertiary schooling. Sample observations are in term of the average value or initial value over each five-year period to reduce the pressure of business cycle fluctuations.

The ordinary least square estimation on a cross-section of countries is under the assumption that ε_{it} is the same across countries. However, there is an unobservable individual effect that captures country specific heterogeneity which may cause the parameter estimates inconsistent. The panel data method allows controlling for individual effects and allows the use of more observation and gives more degree of freedom. Thus, this study uses the static panel data method: fixed effects and random effects model. The fixed effects model allows the individual specific effects to correlate with the independent variables, while random effects model does not allow such correlation. Restricted F-test is applied to select the appropriate model between pooled cross-section effect and the fixed effect. Hausman test is carried out to compare fixed effects and random effect model.

4. Estimation Results

This study analyse the impact of human capital and the composition of human capital on the TFP growth and its absorptive capacity on technology diffusion across countries. Table 1 presents the estimation of Equation (2) on the balanced panel of 16 Asian developing countries over the period 1970 – 2009. In comparing pooled OLS with fixed effects model, the F-test shows that the fixed effect model is more appropriate than pooled OLS model. Thus, there are country-specific effects in the data. The Huasman test indicates that random effects estimator is more appropriate than fixed effects model. Accordingly, the effect of human capital and its composition on technology transfer and TFP growth are estimated by random effect model with corrected standard error (Table 1).

[2] The countries involved are: Bangladesh, China, Hong Kong, India, Indonesia, Malaysia, Nepal, Pakistan, Papua New Guinea, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, Thailand and Vietnam.

Table-1. Human Capital and Human Capital Composition, Technology Transfer, Absorptive Capacity and TFP Growth

Variable	**Human Capital Random Effects with Corrected Standard Error**	**Primary Education Random Effects with Corrected Standard Error**	**Secondary Education Random Effects with Corrected Standard Error**	**Tertiary Education Random Effects with Corrected Standard Error**
Constant	-0.007 (0.008)	-0.003 (0.006)	-0.017 (0.003)***	-0.015 (0.005)***
LnHC	-0.017 (0.006)***			
LnHC*GAP	-0.008 (0.005)*			
LnPRI		0.018 (0.006)***		
LnPRI*GAP		-0.005 (0.005)		
LnSEC			0.017 (0.006)***	
LnSEC*GAP			-0.027 (0.009)***	
LnTER				0.005 (0.003)
LnTER*GAP				-0.020 (0.005)***
F-Test	2.07 (0.0165)**			
Hausman Test	5.59 (0.0612)	4.23 (0.1207)	4.80 (0.0909)	3.09 (0.2129)
Observations	128	128	128	128
Multicolinearity (vif)	1.88	1.64	3.56	1.12

1. Figures in the parentheses are t-statistics, except for F-test and Hausman test which are p-value.
2. *, ** and *** indicate the respective 10%, 5% and 1% significance levels.

Empirical results of the random effects model with corrected standard error show a significant positive effect of human capital on TFP growth. The coefficient of human capital and of its interaction with the technology gap has the expected negative sign and is statistically significant at 10 percent level. In the logistic functional form as in Equation (2), the interactive term of negative sign implies that countries with higher educational attainment are closing the TFP gap with the frontier faster than others. The education attainment seems to enhance TFP growth of Asian developing through its impact on the speed of technology catch-up and absorptive capacity.

Primary and secondary educations have a significant positive effect on TFP growth. Even though, tertiary education has an expected positive sign it is insignificant in TFP growth. This may be due to the relatively low average year of tertiary education in Asian developing countries resulting in tertiary education not able to contribute sufficiently to TFP growth.

The coefficient of primary education interaction with the technology gap has expected negative sign but insignificant. This implies that low level of education (primary education) is not sufficient in absorb foreign technology whereby absorption technology need well educated workforce (Kim and Terada-Hagiwara, 2010). On the other hand, secondary and tertiary education are important in closing the TFP gap with the frontier for Asian developing countries in which both interactive terms are statistically significant at one percent confidence level. As a country moves closer to the technology frontier, higher education level (secondary and tertiary education) act as important absorptive capacity in absorbing foreign technology and further closing the gap. The point estimates show that the influence of secondary education school on the absorptive capacity (interactive term) is slightly higher than tertiary education interaction with the technology gap as the Asia' educational attainment has significantly increased particularly in secondary education for the past four decades (Lee & Francisco, 2010).

5. Conclusion remarks

Human capital is an important factor in driven the economic growth. Human capital not only acts as an input in production function. It also affects growth directly through the technological progress by facilitating innovation and indirectly through diffusion and adoption of foreign technologies. Vandenbussche et al. (2006) argues that human capital does not affect innovation and imitation uniformly but depends on the composition of human capital. Thus, different types and levels of human capital are also plausible in affecting economic growth. This study has investigated whether the contribution of human capital to productivity growth in the Asian developing countries by not only considering the overall human capital accumulation but also the composition of human capital over the period from 1970 to 2009.

The empirical results in this study found that the human capital accumulation has positive impact on TFP growth and also enhance the technology absorptive capacity to closing the technology gap with frontier. In term of different types of education, Asian developing countries are highly relying on secondary and tertiary education to closing the TFP gap with frontier.

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