Investigating the Interaction between FDI and Human Capital on Productivity Growth

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Abstract
This study proposed to investigate how FDI affect economic growth and how important are human capital and its interactions with domestic investment. By decomposing productivity growth into technological progress and efficiency improvement, we are able to consider two kinds of spillovers through FDI: technology spillovers and efficiency spillovers. We empirically analyzed the effect of FDI on productivity growth, efficiency improvement and technological progress using data from eight East Asian countries from 1980 to 2009. The results of our estimation indicated that the interaction term of human capital and FDI had significant positive effect on productivity growth and MNEs are an important channel of international productivity spillovers for a country reaching a human capital threshold level. In conclusion, when FDI combines with human capital, it increases productivity growth of East Asian countries mostly by increase technological progress rather than efficiency improvement.

Keywords: FDI, Human Capital, Domestic Investment, Knowledge Spillovers, Technological Progress, Efficiency Improvement

1. Introduction
The relationship between FDI and economic growth has been one of the central key elements in academic discussions for long a time. Based on the classical concepts, FDI inflow will help to accelerate economic growth by adding to an economy tangible and intangible asset. More importantly, the recent literature point out that FDI is a channel for international technology transfer. There is much evidence to prove how FDI causes technological progress through technological diffusion. Doubtless, the role of international enterprises in the process of technological diffusion is crucial. For this purpose, multinational companies primarily choose to locate in the industries with special attention to research and development accompanied by major technical and professional activities. Multinational corporations normally strive to benefit from the most advanced technology available in the industry and their great resources can help them keep their position in the market by investing in research and development. This will make FDI become a channel not only for the transfer of more advanced technologies, but also for generation of technological spillovers from multinational companies to domestic firms.
FDI inflows among ASEAN region are of great significance. The information shows that from 1995 to 2008, the FDI inflows to the ASEAN region had increased from US$ 28,164.3 million in 1995 to 60,596.1 million in 2008. However, the FDI inflows do not solely show a steady growth during this period owing to financial crisis and other economic factors in the region along with the global economic slowdown. For example, in 2007, we can see a very strong year for ASEAN region which benefited from inflows of 69,481.6 million. Among the members of ASEAN, the main contributors to the FDI inflows are Singapore with 46.1%, Thailand with 17.0% and Malaysia with 13.8%. Singapore remained at the top of the FDI destination among the members from 1995 to 2008. For the countries like Thailand and Malaysia, FDI inflows showed a decline in the early 2000s. FDI inflows started to growth in Thailand from 2003 again and reached US$ 11,238.1 million in 2007. One of the countries that greatly suffered from negative FDI inflows in the region was Indonesia. (UNCTAD, World Investment Report, 2009).

The following graph shows share of inflow FDI in gross domestic products in eight East Asian countries under this study from 1970 to 2008. FDI share in GDP has increased from around 1.5 percent in 1970 to more than 5 percent in 2000 and then with a slight fall reaching between 3 and 4 percent.

**Figure 1.1.:** Total Foreign Direct Investment (Inward FDI) in Eight East Asian Countries Percentage of Gross Domestic Product

![Graph showing share of inflow FDI in GDP from 1970 to 2008](image)

**Source:** World Investment Report 2009, UNCTAD

East Asian countries have continued to attract a substantial part of foreign investments in the world. In 2010, FDI inflows to South and East Asian countries had reached $300 billion and then increased to 24% compared to the corresponding preceding year. ASEAN countries also benefited from $79 billion FDI inflow in 2010, which surpassed 2007 record of $76 billion. Among these countries, Malaysia with 537%, Indonesia with 173%, and Singapore with 153% are among the main FDI destinations.

In recent years there has been a great interest in the impact of FDI on economic growth in developing countries. While there is no consensus on the relationship between FDI and growth, the popular view states that FDI is positively interlinked with growth. In the neoclassical growth models, technology progress in exogenous and FDI simply increases the investment rate which will give rise to transitional increase in per capita income growth. But this increase is short time and it doesn’t imply long run growth effect.

The objective of this study is to identify the relationship between FDI, human capital, domestic investment and productivity growth. We developed a model in which FDI affect the growth rate endogenously and generates increasing return in production. Our endogenous growth framework
enables FDI to contribute to long-run growth rate. We construct two main statements when investigating the effect of FDI on economic growth. First we investigate the role of human capital in technology spillover and investment flow. Therefore, we address the question that does FDI alone affect economic growth or interaction of FDI and human capital is required to boost economic growth. Second, we investigate whether there is sufficient evidence that the inflow of foreign capital crowds out domestic investment in the host country. This effect could be positive or negative.

2. FDI, Growth and Human Capital

Many researchers contend that FDI is a major avenue for the transfer of technology from the leader countries to the follower countries, and that this has had positive consequences for future growth in income (Xu, 2000), Benhabib and Speigel (1994), and Borensztein, De Gregorio, and Lee, (1998). Using both cross section and panel data analysis, Johnson (2006) demonstrated that FDI inflows boosted economic growth in developing countries, but not in advanced nations. Numerous other empirical studies have also provided mixed evidence on the link between economic growth and FDI (Wijeweera et. al. 2007; Zhang, 2001; Johnson, 2006). The surveys of the literature conclude that it is increasingly recognised that, within the right setting, foreign direct investment can be a powerful engine for sustainable growth (Nissanke & Thorbecke, 2006; Ozturk, 2007; Meyer & Sinani, 2009). FDI is usually viewed as a channel through which knowledge and technology is able to spread into host countries contributing positively to economic growth (Findlay, 1978; Romer, 1993; Tang et al., 2008; Thangavelu et al., 2009; Waldkirch, 2010).

In the recent study, Javorcik and Spatareanu (2008), using the firm-level data of Romania, further explore the horizontal and vertical spillovers, taking into account the structures of foreign ownerships. They conclude that there is a positive correlation between downstream presence of joint venture affiliates and the productivity growth of Romanian firms in the supplying industries. Some studies have considered learning through export as a driving force of productivity growth (Bernard & Jessen, 2001; Blalock & Gertler, 2004). Although many studies have investigated the relationship between exports and technology spillovers through backward and forward linkages, there are a few studies examining the impact of imports on downstream and upstream spillovers. Blalock and Veloso (2007), using panel data of Indonesian manufacturers, show that downstream imports are associated with productivity achievements and consider imports as one of the key elements to promote economic growth. The presence of FDI in one location may affect the productivity of domestic firms located in another region in a host country.

Human capital can be introduced into models of economic growth as an input into the production function with or without externalities. Human capital can also be modeled as a determinant of technological progress. It has been argued that the main contribution of the recent growth theories is to endogenize the underlying source of per capita income growth, namely the accumulation of knowledge or technological advances. Technological advances can be made via formal education, on-the-job training, scientific research, learning by doing, process innovations and product innovations (Aghion & Hewitt, 1992).

While the relationship between FDI, growth and the role of the moderating variable ‘absorptive capacity’ has been intensely debated, the identification of the minimum thresholds of absorptive capacity for a positive effect from FDI to arise remains largely unexplored (Ford et al., 2008; Meyer & Sinani, 2009). Hence, by using host country’s human capital level and technology spillovers from FDI, this research investigate the relationship between economic growth and FDI.

3. Research Framework

In this section an endogenous growth model is developed using neoclassical growth framework. To develop the model, we follow theoretical framework of models with an expanding variety of products,
adapted from Barro and Sala-i-Martin (1995) and Borensztein et al (1998). Technological progress takes place through a process of “Capital Deepening” in form of the introduction of new varieties of capital goods. The increase in the number of varieties causes to economic growth. Therefore, an increase in the number of capital varieties requires the adaptation of technology available in more advanced countries to permit the introduction of new type of capital goods. Multinational enterprises (MNCs) possesses more advanced knowledge which allows them to introduce new capital goods at lower cost. The model is based on three sectors: (1) Final Good Sector, (2) Intermediate Good sector, and (3) Household Sector. Following assumptions are considered as follow:

1. Final good sector produces a single consumption good under perfect competition.
2. Intermediate good sector manufactures varieties of intermediate goods under monopolistic competition.
3. Households supply human capital to final good sector and intermediate good sector.
4. Final good is traded but intermediate goods are not traded.
5. FDI primary goes through foreign affiliates in the host country. Therefore domestic firms are affected by foreign affiliated through international knowledge spillovers.
6. Both domestic firms and multinational enterprises (MNEs) produce intermediate good and then final good is produced using intermediate goods.
7. Household consumes only final good.
8. Specialized firms produce each variety of capital good and rent to final good sector.

General equilibrium model is presented the following figure.

- no. of countries = 1, 2, ..., i, ..., C
- no. of firms = no. of varieties of capital goods: n1, n2, ..., ni, ..., N

Domestic firms produce “n” varieties and foreign firms produce “n*” capital goods such that N=n + n*

The production and consumption process can be shown by the following figures.

**Figure 1: Research Model**

The production function takes the simple Cob-Douglass Format as follow:

\[ Y_t = A H_t^\alpha K_t^{1-\alpha} \]
In the production function, “A” represents the overall measure of productivity. “H” denotes labor output (human capital) and is a given endowment. “K” stands for physical capital. Physical capital consists of aggregate of varieties of intermediate goods and we assume that capital accumulation takes place through the expansion of the number of varieties where N is the number of varieties of intermediates. This means that at each instant in time, the stock of domestic capital is given by:

\[ K = \left\{ \sum_{0}^{N} x_j t^\alpha dj \right\}^{1/\alpha} \]

The above equation indicated that the total capital K is a composite of a continuum of varieties of intermediate goods. Each intermediate good denoted by \( x_j \).

The optimality condition implies that the price of intermediate good must be equal to marginal product of intermediate good. If we solve this equation for \( x_j \), we get:

\[ x_j = \frac{1}{A(1-a)H^\alpha_j} P_j^{1/\alpha} \]

The profit for a certain time (s) for the firm which produces a new intermediate good “j” and the present value of profit flow from time “t” to infinite for monopolistic firm inventing a new intermediate good “j” are:

\[ \pi_s = P_j x_j - x_j, \]

\[ V(t) = \int_t^\infty \pi_j e^{-r(t-\omega)} d\omega - F \]

Where

\[ r = \frac{1}{s-t} \int_t^s r(\omega) d\omega \]

By maximizing the profit flow subject to demand, substituting price for new intermediate good “j” and taking derivative we got as follow:

\[ V(t) = \int_t^\infty \left( \frac{1}{1-a} - 1 \right) A^{1/\alpha} (1-\alpha) H^\alpha_j x_j e^{-r(t-\omega)} d\omega - F \]

\[ V(t) = \int_t^\infty \left( \frac{a}{1-a} \right) A^{1/\alpha} (1-\alpha) H^\alpha_j x_j e^{-r(t-\omega)} d\omega - F \]

\[ V(t) = \int_t^\infty a(1-a) \frac{2\alpha}{1-a} A^{1/\alpha} H^\alpha_j x_j e^{-r(t-\omega)} d\omega - F \]

Free entry condition implies that any firm can enter to the intermediate good sector pay the setup cost and produce a new variety of product. Therefore free entry assumption leads to zero profit in intermediate good sector. In other word, the rate of return \( r \) will be such that profits are equal to zero. Solving for the zero profits condition we obtain:

\[ \int_t^\infty a(1-a) \frac{2\alpha}{1-a} A^{1/\alpha} H^\alpha_j x_j e^{-r(t-\omega)} d\omega - F = 0 \]

\[ a(1-a) \frac{2\alpha}{1-a} A^{1/\alpha} H^\alpha_j x_j e^{-r(t-\omega)} d\omega = F \]

\[ a(1-a) \frac{2\alpha}{1-a} A^{1/\alpha} H^\alpha_j x_j e^{-r(t-\omega)} d\omega = F \int_t^\infty e^{-r(t-\omega)} d\omega \]

\[ r = A^{1/\alpha} a(1-a) \frac{2\alpha}{1-a} H^\alpha_j F^{-1} \]

where

\[ r = \int_t^\infty e^{-r(t-\omega)} d\omega \]

The households in this economy supply labor services and receive wage and interest income on assets they provide to firms. They use total income for consumption of single final good.
In utility function $L_t = e^{\rho t}$ represents adult family size in the economy and "$\rho$" represent time preferences.

Capital accumulation and resource constraint give us the budget constraint. The consumption maximization problem takes the following form:

Max

$$U_t = \int_0^\infty (\frac{c_t^{1-\sigma}}{1-\sigma}) e^{-\rho t} dt$$

s.t.:

$$\dot{k} = w + rk - c$$

The present value Hamiltonian can be constructed as follow:

$$H = \left(\frac{c_t^{1-\sigma}}{1-\sigma}\right) e^{-\rho t} + \lambda \left[ w + rk - c_t \right]$$

The first order condition gives us the Euler Equation. We take log from the first equation and then time derivative. We know that in equilibrium the growth rate of consumption equals economic growth. We can substitute the expression we got for interest rate into Euler equation.

$$g = \frac{\dot{c}}{c} = \frac{r - \rho}{\sigma} = \frac{1}{\sigma} \left[ A^{\frac{1-\alpha}{\alpha}} \alpha (1-\alpha) \frac{2-\alpha}{\alpha} F^{-1} H - \rho \right]$$

Equation above produces our basic theoretical results. Technical progress seems to be a determinant of growth. It is represented through the variety of capital goods available. Technical progress is itself determined by FDI as foreign firms encourage adoption of new technologies and increase the production of capital goods, hence increasing variety. Thus, FDI leads to growth via technology transfer that increases total factor productivity. Certain host country conditions are necessary to ensure the positive spillover effects. In particular, a critical level of human capital specifically an educated labor force is necessary for new technology and management skills to be absorbed.

To estimate the model, we need to calibrate our model into an empirical model for testing. In this study, the fixed cost is a setup cost of producing a differentiated intermediate good. We assume that the fixed setup cost depends negatively on the ratio of the number of foreign firms operating in the host economy to the total number of firms ($n^*/N$). This indicates that the host country has higher portion of multinational firms it is cheaper to adopt advance technology and produce new variety of products. Therefore, with more multinational firms in a country, it could benefit faster and easier from advanced technology. Thus, FDI makes it easier and cheaper to produce new capital varieties by increasing ($n^*/N$). Foreign direct investment is the main channel of technological progress in this framework.

In addition it is logical to state that if foreign countries have already produced many new products then it is much easier to transfer technology to the host country. This is called “catch-up” effect and reflects the fact that it is cheaper to imitate products already in existence for some time than to create new products at the frontier of innovation. If we denote the total capital goods produced in foreign countries $N^*$ and having total variety of products produced in host country (by domestic firms and multinational firms) $N$, then the setup cost depends positively on the number of capital varieties produced domestically compared to those produced in the more advanced countries. That is, in the countries with lower $N/N^*$ imitation possibilities are larger and thus the costs of adopting new technology is lower. Therefore, we can construct the setup cost as follow:
where $\frac{\partial F}{\partial n^* / N} < 0$, and $\frac{\partial F}{\partial (n^* / N)} > 0$.

To have a specific form for the fixed setup cost, we assume that fixed cost represents the fixed human capital inputs needed to produce intermediate goods. Furthermore, we assume that spillover effects from all foreign countries are the same. Then we can construct the following functional form for fixed cost.

$$F(n) = a \left[ \sum_j \delta_j n_j \right]^\beta, \quad j = 1, 2, ..., C$$

$$\beta < 0, and, 0 \leq \delta_j \leq 1$$

assumption:

$$\begin{cases} 
C = 2 \\
\beta = -1 
\end{cases}$$

$$F(n) = a \left[ \delta n + \delta n^* \right]$$

Where “$a$” represents the fixed amount of human capital needed to produce the intermediate goods which are assumed to be identical in all countries. Also “$\delta j$” denotes the magnitude of spillovers from intermediate goods produced by firms in country $j$ and $\beta$ stands to extend that spillovers contribute to the productivity improvement. Because $\beta$ is negative, fixed cost decreases with the large value of $\delta j$. There are perfect spillover when $\delta j = 1$ and there is no spillovers when $\delta j = 0$. Now we can substitute for fixed setup cost in equation above.

$$g = \frac{\dot{c}}{c} = \frac{r - \rho}{\sigma} = \frac{1}{\sigma} \left[ A^{1/\alpha} \alpha (1 - \alpha)^{2-\alpha} F^{-1} H - \rho \right]$$

$$g = \frac{1}{\sigma} \left[ A^{1/\alpha} \alpha (1 - \alpha)^{2-\alpha} F^{-1} H - \rho \right]$$

$$g = \frac{1}{\sigma} \left[ A^{1/\alpha} \alpha (1 - \alpha)^{2-\alpha} a^{-1} (\delta n + \delta^* n^*) H - \rho \right]$$

$$g = -\frac{\rho}{\sigma} + \frac{A^{1/\alpha} (1 - \alpha)^{2-\alpha} \delta^* n H}{\sigma} + \frac{A^{1/\alpha} (1 - \alpha)^{2-\alpha} \delta^* n^* H}{\sigma}$$

In addition, as $n$ and $n^*$ are number of intermediate goods produced in foreign countries and in the host country, it is assumed that $n$ and $n^*$ are functions of FDI and domestic investment. Then we have:

$$\gamma_1 > 0 \quad n = \gamma_1 DIN$$

$$\gamma_2 > 0 \quad n^* = \gamma_2 FDI$$

This equation implies that the number of varieties produced by domestic firms is proportional to domestic investment and number of varieties produced by foreign firms is proportional to Foreign Direct Investment (FDI).

By substituting the above expression into growth equation we get:

$$g = -\frac{\rho}{\sigma} + \frac{A^{1/\alpha} (1 - \alpha)^{2-\alpha} \delta^* n H}{\sigma} + \frac{A^{1/\alpha} (1 - \alpha)^{2-\alpha} \delta^* n^* H}{\sigma}$$

For simplicity denote:
\[ \beta_0 = -\frac{\rho}{\sigma} \]
\[ \beta_1 = \frac{A^{1-\alpha}}{\sigma} \left( 1 - \alpha \right) \delta_1 \gamma_1 \]
\[ \beta_2 = \frac{A^{1-\alpha}}{\sigma} \left( 1 - \alpha \right) \delta_2 \gamma_2 \]

Many studies report that FDI growth spillover and productivity growth; also depend on many other explanatory variables. We add as set of explanatory variables, initial level of GDP per capita, openness, government share of real GDP, and inflation rate as other determinants productivity growth.

\[ g = \beta_0 + \beta_1 . D I N . H + \beta_2 F D I . H + \beta_3 G D P_0 + \beta_4 I n f + \beta_5 G S G + \beta_6 O p e n s \]

The equation above is our key empirical equation. It implies that growth rate of economy is affected by interaction of domestic investment and human capital and also with FDI and human capital.

An important issue concerning the relationship between growth and FDI is that the first-generation endogenous growth models of Romer (1990) and Aghion and Howitt (1992) is generally no longer accepted as an empirical regularity in the growth literature. Instead, the second-generation models such as Schumpeterian and semi-endogenous growth theory have gradually become the dominant paradigm (Ha & Howitt, 2007; Madson, 2008). To incorporate this, we measured FDI in terms of GDP (FDI/GDP) and both in nominal term. In addition, investment was also measured as investment income ration instead of level of investment. Finally, to incorporate semi endogenous growth theory, we measured all growth rates in log differences.

To account for unexpected errors, we added four control variables to our model namely initial level of GDP, inflation rate, and government share, and openness as the control variables. Therefore, in our empirical model we get:

\[ M P E G_{it} = c_{i0}^M + c_{i1}^M \left( \frac{D I N}{G D P} \right) . H + c_{i2}^M \left( \frac{F D I}{G D P} \right) . H + c_{i3}^M G D P_0 + c_{i4}^M I n f + c_{i5}^M G S G + c_{i6}^M O p e n s \]

Since MPI was decomposed into EI and TI, and growth rates are calculated, we estimates the following two equations in order to analyze the effect of efficiency spillovers and technology spillovers through FDI.

\[ E F F G_{it} = c_{i0}^E + c_{i1}^E \left( \frac{D I N}{G D P} \right) . H + c_{i2}^E \left( \frac{F D I}{G D P} \right) . H + c_{i3}^E G D P_0 + c_{i4}^E I n f + c_{i5}^E G S G + c_{i6}^E O p e n s \]

\[ T E C G_{it} = c_{i0}^T + c_{i1}^T \left( \frac{D I N}{G D P} \right) . H + c_{i2}^T \left( \frac{F D I}{G D P} \right) . H + c_{i3}^T G D P_0 + c_{i4}^T I n f + c_{i5}^T G S G + c_{i6}^T O p e n s \]

Where EFFG and TECG represent efficiency improvement and technology progress

4. Research Method

The analysis in this study consisted of two parts. The first part of the analysis was productivity analysis and decomposition and the second part was regression analysis. Hence, two sets of data were used in this study. We used a data set to calculate productivity indexes and decomposition. Second data set was used to estimate our growth model.

For productivity measurement and decomposition, we use output-oriented measures. To get output-oriented measure, we use a single-output and two-input model. Real gross domestic product (GDP) measured in million US Dollars at constant prices (2005) and constant exchange rates (2005) was used as the output measure whereas; labor force measured number of people aged 15 and over and capital formation measured as gross capital accumulation referring to the total stock of capital that has
been formed were used as the two aggregate input proxies. The data on capital and labor used for DEA analysis came from World Bank.

Following Borensztein (1998), we used the educational attainment of the total population of aged 15 and over of tertiary level as human capital constructed by Barro and Lee (2001). UNCTAD database was used to obtain the data on nominal Inflow FDI. It is measured as million inward and FDI investment flow at US dollars at current prices and current exchange rates in millions. Data on real domestic investment came from Penn World Table and is measured as investment share of PPP converted GDP per capita at 2005 constant prices. Data on real GDP and inflation rate came from World Bank database. Data on openness (ratio of export plus import to GDP with constant 2005 US$) and government share in real GDP came from Penn World Tables.

The model is specified in terms of second generation endogenous growth theories. According to Schumpeterian growth theory, FDI should be measured in term of GDP. Following Ha and Howitt (2007) and Madson (2008), we divided FDI by GDP and measure it both in nominal term. Similarity, I divided domestic investment by GDP and measure it in real term. Investment consists in non-residential investment term. All variables are measured in logs. Initial level of GDP per capita came from UNCTAD database, Inflation came from World Bank database, Openness and Government share in Real GDP came from Penn World Table.

5. Results
5.1. Data Envelopment Analysis

For productivity analysis, we used the DEAP computer program. Our data includes observations of eight countries over 30 years from 1980 to 2009. We perform the analysis in two parts. In the first part, we calculate productivity indexes using the whole data from 1980 to 2009. In the next part, data was divided into two periods of 1980-1994 and 1995-2009. The reason for this was to investigate the change in productivity indexes during the two periods.


By decomposition of productivity change index into efficiency improvement and technological progress, we are able to make a comparison based on specific countries. The results show all eight countries have overall improvement in MPI change overall the period 1980-2009. However, efficiency improvement and technological progress in some countries declines. Only, China, Hong Kong, Korea and Singapore have MPI, efficiency and technological change greater than unit.

In the next step, in order to better comprise productivity indexes, we divided data into two periods of 1980-1994 and 1995-2009 and calculated the indexes for eight economies again. The results are reported in the Table 1. Our findings suggest that the average performance of the China, Hong Kong and Korea are even better than other countries. The best average performance belongs to China during 1995-2009. In addition, average productivity change in all eight countries improve over two periods since the Malmquist index for these economies are greater than one in both period and increases in second period. Regarding the sources of productivity growth, the results in Table 1 suggests that during 1980-1994, some Asian economies experienced either technical regress or efficiency loss, and thus deterioration in productivity. The only exceptions are China, Hong Kong, Korea, Singapore and Thailand which perform rather well in catching up.
Table 1: Geometric Means of Productivity Indexes

<table>
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</thead>
<tbody>
<tr>
<td>China</td>
<td>1.000</td>
<td>1.001</td>
<td>1.087</td>
<td>1.088</td>
<td>1.087</td>
<td>1.088</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>1.000</td>
<td>1.000</td>
<td>1.057</td>
<td>1.030</td>
<td>1.057</td>
<td>1.030</td>
</tr>
<tr>
<td>Indonesia</td>
<td>0.969</td>
<td>0.962</td>
<td>1.080</td>
<td>1.079</td>
<td>1.047</td>
<td>1.037</td>
</tr>
<tr>
<td>Korea</td>
<td>1.000</td>
<td>1.000</td>
<td>1.074</td>
<td>1.053</td>
<td>1.074</td>
<td>1.053</td>
</tr>
<tr>
<td>Malaysia</td>
<td>0.971</td>
<td>0.999</td>
<td>1.069</td>
<td>1.039</td>
<td>1.038</td>
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</tr>
<tr>
<td>Philippine</td>
<td>0.953</td>
<td>0.997</td>
<td>1.080</td>
<td>1.073</td>
<td>1.029</td>
<td>1.070</td>
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<tr>
<td>Singapore</td>
<td>0.995</td>
<td>0.999</td>
<td>1.050</td>
<td>1.023</td>
<td>1.044</td>
<td>1.022</td>
</tr>
<tr>
<td>Thailand</td>
<td>0.978</td>
<td>1.001</td>
<td>1.080</td>
<td>1.071</td>
<td>1.056</td>
<td>1.072</td>
</tr>
</tbody>
</table>

The overall finding of productivity analysis imply that in average most of East Asian countries showed a good performance in productivity indexes during the periods of study. The some fluctuations in productivity in the second period were because of financial crisis in the region and its influence on economic performance of East Asian countries. Moreover, only China has progress in all three indexes and in both periods.

5.2. Panel Data Analysis

In this section, we estimate three models using panel analysis techniques. We performed panel unit root test to ensure our variables are stationary. In order to check whether our main series are stationary or not, we perform unit root test of productivity growth, efficiency improvement and technological progress.

The results of panel unit root test of productivity growth show that the Levin, Lin & Chu (LLC), Im, Pesaran and Shin W-stat (IPS), and both Fisher tests (ADF - Fisher Chi-square and PP - Fisher Chi-square) are significant and therefore we can reject the null of existing unit root (P<0.05) in productivity growth. Similarly, the Hadri test statistic (Hadri Z-stat), which tests the null of no unit root is not significant and hence it fails to reject the null (P>0.05).

The results of unit root test for efficiency improvement show that efficiency improvement doesn’t have unit root and is a stationary variable I(0). In contrast, the Levin, Lin & Chu (LLC), Im, Pesaran and Shin W-stat (IPS), and both Fisher tests (ADF - Fisher Chi-square and PP - Fisher Chi-square) are significant and they reject the null of a unit root (P<0.05). The Hadri test statistic (Hadri Z-stat) to test the null of no unit root is not significant and then we can not reject the null hypothesis (P>0.05).

The last dependent variable in our models was technological progress. The results of unit root test for technological progress indicate that technological progress is a stationary variable and has no unit root I(0). The Levin, Lin & Chu (LLC), Im, Pesaran and Shin W-stat (IPS), and both Fisher tests (ADF - Fisher Chi-square and PP - Fisher Chi-square) statistics are significant and reject the null of unit root (P<0.05). The Hadri test (Hadri Z-stat) is not significant and indicates the same results (P>0.05). Therefore, we can not reject the hypothesis that technological progress is a stationary variable.

In the next step, we apply panel unit root test for main exogenous variables in the model. There independent variables existed in the models including interaction of human capital and Foreign direct investment (Human Capital x FDI), and interaction of domestic investment and human capital (Domestic Investment x Human Capital). Table 2 presents the results.

Table 2: Panel Unit Root Test

<table>
<thead>
<tr>
<th>Variable</th>
<th>FDI x Human Capital</th>
<th>Domestic Investment x Human Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>I(0)</td>
<td>I(1)</td>
</tr>
<tr>
<td>Levin, Lin &amp; Chu</td>
<td>-0.71260</td>
<td>-4.5074</td>
</tr>
</tbody>
</table>
Table 2: Panel Unit Root Test - continued

<table>
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<tr>
<th></th>
<th>Im, Pesaran and Shin W-stat</th>
<th>ADF - Fisher Chi-square</th>
<th>PP - Fisher Chi-square</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.0000*</td>
<td>12.9132</td>
<td>23.2751</td>
<td>0.0000*</td>
</tr>
<tr>
<td></td>
<td>0.0000*</td>
<td>5.5785</td>
<td>227.026</td>
<td>0.0000*</td>
</tr>
<tr>
<td></td>
<td>1.0000</td>
<td>1.67738</td>
<td>1.71384</td>
<td>1.0000</td>
</tr>
<tr>
<td></td>
<td>76.3546</td>
<td>80.4894</td>
<td>79.6593</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

For the all variables of order zero, the Levin, Lin & Chu (LLC), Im, Pesaran and Shin W-stat (IPS) and Fisher tests (ADF - Fisher Chi-square and PP - Fisher Chi-square) were not significant (P=1). It implies that the null hypothesis of common unit root can not be rejected. Therefore, interaction of FDI and human capital, and interaction of domestic investment and human capital, are not stationary variable. Then, we performed the test of integration order one I(1). The most of tests and especially Fisher tests with null hypothesis of unit root were significant. Therefore we can conclude that the first order of these variables is stationary. The overall results of unit root test imply that the regressands and regressors are of a different order of integration.

Next, we apply cointegration test. The purpose of the cointegration test is to determine whether a group of non-stationary series is cointegrated or not. The results of cointegration test are presented in Table 3. The test was significant at 0.05 confidence level. It indicated that all non stationary variables are cointegrated at 5% significant level.

Table 3: Cointegration Test

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Trace Eigenvalue</th>
<th>Statistic</th>
<th>Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.145583</td>
<td>42.39393</td>
<td>12.32090</td>
<td>0.0000</td>
</tr>
<tr>
<td>At most 1 *</td>
<td>0.003851</td>
<td>1.014730</td>
<td>4.129906</td>
<td>0.3642</td>
</tr>
</tbody>
</table>

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

5.3. Panel Data Estimation

The following Table reveals several interesting results for the effects of FDI on economic growth. We conducted 4 regressions with various control variables to investigate how FDI, human capital and their interaction impact productivity growth.

Table 4: Productivity Growth and FDI

<table>
<thead>
<tr>
<th>Reg.</th>
<th>Regression 1</th>
<th>Regression 2</th>
<th>Regression 3</th>
<th>Regression 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MPI EFFG TECG</td>
<td>MPI EFFG TECG</td>
<td>MPI EFFG TECG</td>
<td>MPI EFFG TECG</td>
</tr>
<tr>
<td>GDP &lt;i&gt;/&lt;/i&gt;</td>
<td>0.024 (0.005)</td>
<td>0.063 (0.335)</td>
<td>0.041 (0.023)</td>
<td>0.036 (0.004)</td>
</tr>
<tr>
<td>H</td>
<td>0.091 (0.074)</td>
<td>0.178 (0.716)</td>
<td>0.635 (0.071)</td>
<td>0.095 (0.236)</td>
</tr>
<tr>
<td>GSG</td>
<td>0.325 (0.962)</td>
<td>-0.091 (0.037)</td>
<td>-0.658 (0.008)</td>
<td>0.026 (0.039)</td>
</tr>
<tr>
<td>FDI</td>
<td>0.214 (0.172)</td>
<td>0.145 (0.082)</td>
<td>0.172 (0.266)</td>
<td>0.027 (0.005)</td>
</tr>
<tr>
<td>(FDI/GDP)&lt;i&gt;/&lt;/i&gt;H</td>
<td>0.124 (0.003)</td>
<td>0.174 (0.002)</td>
<td>0.094 (0.013)</td>
<td>0.167 (0.003)</td>
</tr>
</tbody>
</table>
Table 4: Productivity Growth and FDI - continued

<table>
<thead>
<tr>
<th>(DIN/GDP)H</th>
<th>0.025 (0.032)</th>
<th>0.049 (0.004)</th>
<th>0.021 (0.024)</th>
<th>0.017 (0.015)</th>
<th>0.024 (0.032)</th>
<th>0.076 (0.000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inf</td>
<td>0.189 (0.045)</td>
<td>-0.001 (0.03)</td>
<td>0.043 (0.014)</td>
<td>-0.187 (0.042)</td>
<td>0.001 (0.015)</td>
<td>-0.125 (0.031)</td>
</tr>
<tr>
<td>Opens</td>
<td>-0.362 (0.002)</td>
<td>-0.041 (0.047)</td>
<td>0.187 (0.005)</td>
<td>-0.041 (0.007)</td>
<td>0.008 (0.000)</td>
<td>0.087 (0.000)</td>
</tr>
<tr>
<td>Adjusted R-Square</td>
<td>0.28</td>
<td>0.29</td>
<td>0.31</td>
<td>0.39</td>
<td>0.38</td>
<td>0.35</td>
</tr>
</tbody>
</table>

*Only Coefficient and its probability is reported

Regression 1 shows that human capital has a positive impact on economic growth, after controlling for initial GDP per capita and government share in real GDP but it isn’t statistically significant. In the next regression we added single FDI. This regression controls for inflation and openness as a measure of trade. Hence, it results that FDI is positive but it is not statistically significant and also it shows that inflation and openness are statistically significant.

Next, in regression 3 and 4, we dropped human capital and FDI, which were in the regression as two single variables, but we added interaction of human capital with FDI. Including the interaction between FDI and human capital and interaction between human capital and domestic investment improve the overall performance of the regression. The specification replaces the FDI variable by the product between FDI and human capital, and yields a coefficient that is positive and highly statistically significant. Thus, it is better to include FDI and human capital together instead of having them as separate variables. In that way, we can test jointly whether these variables affect productivity growth through the interaction term.

Our main results come from regression 4. It indicates that FDI has a positive overall effect on productivity growth, although the magnitude of this effect depends on its interaction with human capital in the host economy. Regressions 1 to 4 also test inclusion of additional control variables affecting productivity growth. In all cases, the interaction term between FDI and human capital is statistically significant, implying that the estimated effect does not result from the omission of other policy variables. Overall, the results from the regressions displayed in above table show strong complementary effects between FDI and human capital on the productivity growth rate. This result is consistent with the idea that the flow of advanced technology brought along by FDI can increase the growth rate of the host economy only by interacting with that country’s absorptive capability.

The results is consistent with Borensztein et al. (1998), which shows the interaction term of human capital and FDI has a positive effect on economic growth, and Xu (2000), which concludes MNEs are an important channel of international productivity spillovers for a country reaching a human capital threshold level.

The interaction term of human capital and domestic investment also has significant positive effect on productivity growth. This result shows that since East Asian countries have relatively large human capital, domestic investment is also an important factor to increase productivity growth. However, the effect of interaction term of human capital and domestic investment on productivity growth is smaller than those of human capital and foreign direct investment.

Among the other independent variables, the effect of Initial level of GDP per capita on productivity growth is greater than other growth determinants (0.324). For example this effect for inflation rate was negative (-0.018), for government share of real GDP was 0.021 and finally for openness is 0.014. These findings are consistent with Xu (2000) which shows that catch up effects are positive for developing countries. This positive effect seems to indicate that productivity tends to be accelerated in those countries that already have higher productivity levels.

Regarding the effect of FDI on efficiency improvement and technological progress, the results presented on the Table show that H*FDI has significant positive effect on technological progress. The interaction term of human capital and domestic investment (DInv*H) has positive effect of technological progress. In addition, the effect of interaction term of DInv*H and H*FDI on...
technological progress is larger than efficiency improvement. However the effect of interaction term of Dlnv*H on productivity growth is smaller than those of H*FDI. This implies that productivity growth through FDI is mainly due to technological progress rather than efficiency improvement.

In the panel regression if stationary variables are cointegrated, the OLS estimator is also super-consistent, but bias. Kao (1999) argue that there is no reason to presume that the bias will become negligible in panel regression due to the introduction of the cross section dimension. In our model, a regressand is a stationary variable, but regressors are cointegrated non-stationary variables. This means that there exists a linear relationship between regressors which makes the error term stationary, so there maybe the bias which is from the endogenously of the regressors. Thus we need to test if the bias is significant or not. To deal with the bias in cointegrated panel data, the dynamic OLS estimation is proposed (Baltagi, 2001; Kao & Chiang, 2000).

The results from conventional OLS and dynamic OLS are presented the Table 5. The effect of H*FDI on productivity growth is larger in the conventional OLS estimation, but smaller in Dynamic OLS. However, the effect of Domestic investment and FDI on productivity growth is larger in dynamic OLS and smaller in conventional OLS. From the Table it is clear that the effect of FDI from dynamic OLS are not largely different than those from conventional OLS estimation. This indicates that the bias from cointegration nonstationary regressors is not large in our estimation.

Table 5: Dynamic Panel Estimation

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Productivity Growth</th>
<th>Efficiency Improvement</th>
<th>Technological Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DOLS</td>
<td>OLS</td>
<td>DOLS</td>
</tr>
<tr>
<td>GDP0</td>
<td>0.053 (0.021)</td>
<td>0.324 (0.042)</td>
<td>0.011 (0.123)</td>
</tr>
<tr>
<td>GSG</td>
<td>-0.014 (0.021)</td>
<td>0.021 (0.014)</td>
<td>-0.023 (0.023)</td>
</tr>
<tr>
<td>(FDI/GDP)H</td>
<td>0.024 (0.034)</td>
<td>0.094 (0.013)</td>
<td>0.042 (0.016)</td>
</tr>
<tr>
<td>(DIN/GDP)H</td>
<td>0.134 (0.045)</td>
<td>0.017 (0.015)</td>
<td>0.013 (0.014)</td>
</tr>
<tr>
<td>Inf</td>
<td>-1.035 (0.045)</td>
<td>-0.018 (0.031)</td>
<td>-1.362 (0.512)</td>
</tr>
<tr>
<td>Opens</td>
<td>0.425 (0.023)</td>
<td>0.014 (0.008)</td>
<td>0.140 (0.052)</td>
</tr>
<tr>
<td>Adjusted R-Square</td>
<td>0.19</td>
<td>0.28</td>
<td>0.34</td>
</tr>
</tbody>
</table>

*Only Coefficient and its probability is reported

5.4. Endogeneity Problem

In analyzing the effect of FDI on productivity growth or economic growth, we should notice that there may be an endogeneity problem. This means that the correlation between FDI and growth rate could arise from an endogenous determination of FDI; that is FDI itself may be influenced by innovations governing growth rates. To avoid endogeneity problems, we have formally introduced instrumental (IV) techniques. We use lagged FDI values and other exogenous variables as instrumental variables for FDI, following Xu (2000).

First, we use lagged FDI values and six exogenous variables:

\[
\frac{F_{DI}}{GDP}(lag), H + \beta_0 + \beta_1 \frac{F_{DI}}{GDP}, H(lag) + \beta_1 Inf + \beta_1 Opens + \beta_1 GSG + \beta_1 \frac{D_{IN}}{GDP}, H + \beta_1 GDP + \epsilon
\]

where H*FDI(lag) represents one year lagged value, Inf stands for inflation rate, Open stands for openness, Govn stands for government share in real GDP.

First, we run a regression using all the variables, we saw that some of the independent variables are not determinants of FDI. In the second regression, there variables were removed from the model.
and we repeated the regression. The results of our estimation, suggested that we should construct an instrumental variable with two variables of $H^*FDI$ (lag) and $RGDP$.

\[
(H_{FDI/GDP})_t \beta_0 + \beta_1 (H_{FDI/GDP})_{t-1} + \beta_2 Inf + \beta_3 Opens + \beta_4 GSG + \beta_5 (DIN/GDP)_t + \beta_6 GDP_o + \epsilon_t
\]

The results of these estimations are presented in the following Table.

**Table 6:** Determinates of Inward FDI

<table>
<thead>
<tr>
<th>Variable</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(FDI/GDP)H (lag)</td>
<td>1.279</td>
<td>1.025</td>
</tr>
<tr>
<td>Inf</td>
<td>0.124</td>
<td>0.079</td>
</tr>
<tr>
<td>Opens</td>
<td>0.005</td>
<td>0.027</td>
</tr>
<tr>
<td>GSG</td>
<td>-0.004</td>
<td></td>
</tr>
<tr>
<td>(DIN/GDP)H</td>
<td>-0.034</td>
<td></td>
</tr>
<tr>
<td>GDP_o</td>
<td>-0.094</td>
<td>-0.027</td>
</tr>
<tr>
<td>Adjusted R-Square</td>
<td>0.58</td>
<td>0.61</td>
</tr>
</tbody>
</table>

Now, we can do regression using instrumental variables. The following Table shows the results of instrumental variable. The effect of $H^*FDI$ are similar to those from the basic results. $H^*FDI$ still has significant positive effect on productivity growth, efficiency improvement and technology growth. $H^*DInv$ has positive effect on technology growth but no effect on productivity growth. The effect of $H^*DInv$ on technology growth are still smaller than those of $H^*FDI$. It still has no effect on efficiency growth, and $H^*DInv$ has negative effects.

**Table 7:** Regression Results with Instrumental Variables

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Productivity Growth</th>
<th>Efficiency Improvement</th>
<th>Technological Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>(FDI/GDP)H (IV)</td>
<td>0.127</td>
<td>0.105</td>
<td>0.183</td>
</tr>
<tr>
<td>(DIN/GDP)H (IV)</td>
<td>0.045</td>
<td>-0.017</td>
<td>0.152</td>
</tr>
<tr>
<td>GDP_o</td>
<td>0.019</td>
<td>0.024</td>
<td>0.087</td>
</tr>
<tr>
<td>Adjusted R-Square</td>
<td>0.39</td>
<td>0.41</td>
<td>0.28</td>
</tr>
</tbody>
</table>

Notes: (1) IV denotes instrumental variables
(2) This estimation is based on Coefficient and Prob

To better investigate the contribution of FDI to economic growth, we analyze the relationship between FDI and domestic investment. Our objective is to see whether domestic investment behaves as a complement of foreign direct investment or FDI crowds out domestic investment in the host country. We stated that FDI could add economic growth simply by augmenting capital accumulation in the host economy. This requires that FDI dose not crowd out equal amounts of investment from domestic sources by competing in product markets or financial markets. Furthermore, FDI could increase economic growth if it is more productive or efficient than domestic investment. The Table 8 shows the results. It indicates that FDI stimulate or crowds in domestic investment.

\[
DIN = \delta_0 + \delta_1 (DIN_{GDP})_t + \delta_2 Inf + \delta_3 Opens + \delta_4 GSG + \delta_5 FDI + \delta_6 GDP_o + \epsilon_u
\]
Table 8: Effect of FDI on Domestic Investment

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Regression</th>
</tr>
</thead>
<tbody>
<tr>
<td>(FDI/GDP)H</td>
<td>0.184</td>
</tr>
<tr>
<td>Inf</td>
<td>0.0745</td>
</tr>
<tr>
<td>Opens</td>
<td>0.0374</td>
</tr>
<tr>
<td>GSG</td>
<td>-0.328</td>
</tr>
<tr>
<td>FDI</td>
<td>1.627</td>
</tr>
<tr>
<td>GDP0</td>
<td>-0.2876</td>
</tr>
<tr>
<td>Adjusted R-Square</td>
<td>0.51</td>
</tr>
</tbody>
</table>

The interaction between FDI and human capital however turns to be statistically insignificant for the determination of total domestic investment. It suggests that the positive relationship between foreign and domestic investment is not sensitive to the productivity of FDI. This relationship between domestic and foreign investment however is not very robust to different specifications in the models. While only for some variables the estimated coefficients are statistically insignificant. It might be multicollinearity and the overall poorer fit of domestic investment that are responsible for the lack of strong crowding in effect.

Now, we can investigate the possibility that higher efficiency of FDI than domestic investment. It means we investigate whether FDI has stronger effect on productivity growth than domestic investment. This investigation is inline with the previous section where we looked for how FDI and domestic investment affect each other. We performed a regression analysis that control for domestic investment in addition to other variables that determine the growth productivity. The Table 9 shows the results. Our results indicate that our findings are not different from what we found without adding domestic investment as a new independent variable. Hence, FDI has stronger effect on productivity growth rather than human capital.

Table 9: Productivity Growth, FDI and Domestic Investment

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Productivity Growth</th>
<th>Efficiency Improvement</th>
<th>Technological Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIN 0.025 (0.018)</td>
<td>0.074 (0.021)</td>
<td>0.214 (0.004)</td>
<td></td>
</tr>
<tr>
<td>FDI 0.014 (0.002)</td>
<td>0.062 (0.028)</td>
<td>0.148 (0.026)</td>
<td></td>
</tr>
<tr>
<td>(DIN/GDP)H 0.095 (0.009)</td>
<td>0.174 (0.032)</td>
<td>0.081 (0.006)</td>
<td></td>
</tr>
<tr>
<td>(FDI/GDP)H 0.184 (0.003)</td>
<td>0.047 (0.002)</td>
<td>0.108 (0.008)</td>
<td></td>
</tr>
<tr>
<td>GDP0 0.243 (0.041)</td>
<td>0.176 (0.013)</td>
<td>0.104 (0.039)</td>
<td></td>
</tr>
<tr>
<td>Inf -0.127 (0.034)</td>
<td>-0.027 (0.004)</td>
<td>-0.002 (0.028)</td>
<td></td>
</tr>
<tr>
<td>Opens 0.328 (0.009)</td>
<td>0.142 (0.039)</td>
<td>0.284 (0.034)</td>
<td></td>
</tr>
<tr>
<td>GSG -0.089 (0.007)</td>
<td>-0.076 (0.047)</td>
<td>-0.098 (0.042)</td>
<td></td>
</tr>
<tr>
<td>Adjusted R-Square</td>
<td>0.52</td>
<td>0.48</td>
<td>0.63</td>
</tr>
</tbody>
</table>
6. Discussion and Conclusion
This paper deals with international knowledge spillovers from advanced nations to the developing countries through foreign direct investment. We investigate what factors influence the effect of FDI on productivity growth in a host country.

We developed an endogenous growth model with technological change in the form of expanding variety of products. The model assumes that technological progress is brought about by an increase in the number of types of intermediate goods, or capital goods (capital deepening). Technological progress takes place through a process of “Capital Deepening” in form of the introduction of new varieties of capital goods. The increase in the number of varieties leads to economic growth. The firms with technological progress operate in a monopolistic competition market with free entry condition.

An increase in the number of capital varieties requires the adaptation of technology available in more advanced countries to permit the introduction of new type of capital goods. The model explains that the effect of FDI on growth comes from interaction of human capital and FDI and interaction of domestic investment and human capital which show the importance of human capital in productivity growth. Then, in order to analyze the effect of knowledge spillover through FDI on productivity, we decomposed productivity growth into efficiency improvement and technological progress and calculated the growth rates of productivities using Malmquist Productivity Index (MPI).

The model was calibrated and empirically tested with panel data of eight East Asian countries. We found that the interaction term of human capital and domestic investment had significant positive effect on productivity growth. This result indicates that abundant of human capital and domestic investments are two important factors to in knowledge spillover and growth. However, we found that interaction term of human capital and domestic investment has smaller effect on growth than interaction term of human capital and foreign direct investment. Further, we found positive effect of real GDP on productivity growth showing that catch up effects are positive for developing countries. Our findings indicate that productivity tends to be accelerated in those countries that already have higher GDP. Therefore, combination of FDI with human capital could increases productivity growth mostly by an increase in technological progress rather than efficiency improvement. This results, emphasizes that FDI is in general more technological intensive than domestic investment.

References


