Journal of Global Business and Social Entrepreneurship (GBSE)
Vol. 3: no. 5 (2016) page 75–85| gbse.com.my | eISSN 24621714|

INTERNATIONAL R&D SPILLOVERS AND PRODUCTIVITY GROWTH IN THE ASEAN COUNTRIES

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Abstract

The aim of this study is to examine the role of international R&D spillovers for the ASEAN countries. The dynamic ordinary least square panel estimator (DOLS) is employed using data from 1996 to 2012. The important conclusions that can be drawn from the reported results are import is the main channel for international R&D spillovers in ASEAN countries. Therefore, policymakers and governments should play an important role in promoting trade activity and other policies that related with trade especially import activities as both are expected to boost host country productivity.

Keywords: International R&D, ASEAN, Panel Dynamic Ordinary Least Square.

2016 GBSE Journal

Introduction

New growth model predict that innovation activity is a major source of productivity improvements. According to UNCTAD (2007), innovation is defined as a new or improved product, process or marketing change that introduced to market and the structure of innovation may be in technological or non-technological nature. Innovation is the main driver for economic growth and research and development (R&D) activity is one of the key strategies to secure technological potential. R&D leads to the growth of new knowledge that can increase the efficiency with which inputs to production such as capital and labor are translated into outputs.

However, only a handful of rich countries involve actively in R&D activity. In fact, the main source of global R&D investment is developed countries, where they contribute more that 70 percent of global R&D investment. This is one of reasons why less developed countries should pay more attention to R&D activity as it has been widely accepted that R&D is one of the central drivers for productivity improvement. This suggests that less developed countries that hardly invest in R&D and lags behind the technology frontier may boost their productivity by interacting with R&D leaders. In this way, other countries may benefit from R&D activity done by R&D leaders via R&D spillovers. As reported by UNESCO data, total R&D expenditure in the world is concentrated by triad countries (United States, the European and Japan) and China. Among developed countries, seven major economies namely Canada, Japan, France, Germany, Italy, United Kingdom and United States appear to be the top spender in R&D investments where they contribute around 50% to 60% of total global R&D expenditure. Furthermore, among the developed countries, the major source of global R&D investment is the Organization of the Economic Co-operation and Development (OECD) countries. Specifically, this group contributes approximately 94% of total gross domestic expenditure in R&D investments by the developed countries during 1996-2012 periods.

It has been widely recognized that productivity difference is the main determinants of output variations across countries, and technology improvement appears to be the key factor in explaining productivity (Grossman and Helpman, 1991; Howitt, 2000; Rivera-Batiz and Romer, 1991). Moreover, several studies reveal that technology spillovers from foreign countries are important because it determines the pace at which the world's technology frontier may be expanded in the future. In fact, recent evidence show that many countries benefit significantly from international spillovers (Klenow and Rodriguez-Clare, 2005) and their major source of productivity growth is actually from abroad (Keller, 2004). Several channels has been identified to be important in transmitting technology across borders and inward foreign direct investment (FDI) by multinational corporations (MNCs) is one of them (Gorg and Greenaway, 2004; Javorcik, 2004; Hale and Long, 2006; Blalock and Gertler, 2007; Yao and Wei, 2007; Liu, 2008 and Bhavan et al., 2011). Besides the FDI channel, import also is regarded as the other important channel of R&D spillovers. Studied by Ang and Madsen (2013), they examined the R&D spillovers of six Asian miracle economies from OECD countries and import channel is the key driver of foreign R&D spillover in Asian miracle economies. The other channels of R&D spillovers that discussed in the empirical literatures are (i) export channel (Falvey et al., 2004); (ii) outward FDI (van pottelsberghe and Lichtenberg, 2001); (iii) knowledge channel (Ang and Madsen, 2013); (iv) geographical proximity (Keller, 2004) and (v) Flow of patents (Eaton and Kortum, 1996).

This paper examines the impact of international R&D spillover on productivity growth for of five selected ASEAN countries including Malaysia, Indonesia, Singapore, Thailand and Philippines over the periods 1996 to 2012. There are only two channels of R&D spillovers that were examine in this study that is FDI channel and import channel. This study contributes to the literature in several important aspects. It has been generally recognized that only a few developed countries involve actively in R&D activity. Since the benefits of R&D cannot be completely internalized, third countries can benefit from their efforts in R&D through economic interactions. The literature suggests two important channels through which R&D spillovers may happen namely, imports and FDI. However, most of the studies have focused on spillovers within developed countries (especially OECD countries). Little is known about how R&D activities in developed countries affect the productivity of less developed countries. This chapter fills this gap in the literature by assessing R&D spillovers from developed countries to ASEAN countries. This paper is organized as follows: Section 2 lays out the empirical model, the panel dynamic ordinary least square estimation (D-OLS) and the data; Section 3 contains a discussion of the empirical findings; and Section 4 provides a summary and conclusions.

Methodology

In order to analyze the international R&D spillovers, this study uses a model developed by Coe and Helpman (1995) and van Pottelsberghe and Lichtenberg (2001). This model can be used to test R&D spillovers via import and inward FDI channels. Equation (1) provides the basic econometric model which states that total factor productivity is a function of international R&D capital stocks channel. The model can be expressed as follows:

$$TFP_{it} = \alpha + \beta_1 S^{im}{}_{it} + \beta_2 S^{ifdi}{}_{it} + \varepsilon_{it} \qquad (1)$$

where TFP is total factor productivity, S^{im} is stock of international R&D based on import-weighted channel and S^{ifdi} is inward FDI-weighted. The first measure is an import weighted R&D capital stock (S_{it}^{im}) following Lichtenberg and van Pottelsberghe (1998). The stock can be computed as follows:

$$S_{it}^{im} = \sum_{j=1}^{20} (M_{ijt}/Y_{jt}) DS_{jt}\ , i \neq j \qquad (2)$$

where M_{ijt} is a country i's imports from the exporting country j at time t: Y_{jt} is exporter *j*'s GDP at time t; and DS_{jt} is exporter *j*'s real GDP at time t, that is R&D expenditure of 20 OECD countries. Following van Pottelsberghe and Lichtenberg (2001), the inward FDI weighted foreign R&D capital stock S^{ifdi} is constructed as follows:

$$S_{it}^{ifdi} = \sum_{j=1}^{20} (F_{ijt}/K_{jt}) DS_{jt}\ , i \neq j \qquad (3)$$

where the F_{ijt} is the flow of FDI from country j towards country i, and K_{jt} is gross fixed capital formation of country j, both expressed in constant value and DS_{jt} is exporter *j*'s real GDP at time t, that is R&D expenditure of 20 OECD countries.

Our empirical analysis involves three important steps. First, we evaluate the stationary properties of all variables. Second, we test whether these variables are cointegrated. In the final stage, we obtain reliable estimates of slope parameter using panel dynamic OLS (P-DOLS) estimator. To examine unit root test, this study use two panel unit root tests namely, Im-Pesaran-Shin (henceforth IPS) test and Levin-Lin-Chu (henceforth LLC) test. This study employs a panel cointegration methodology proposed by Pedroni (1999) employed to examine the cointegrating properties of the variables involved. Pedroni (1999) proposes seven test statistics to test the null hypothesis of no cointegration against the alternative hypothesis of cointegration. The test statistics are grouped into two groups. The first group is based on pooling the residuals along the within dimension of the panel. The second group is based on pooling the residuals along the between dimension of the panel. It allows for a heterogeneous autocorrelation parameter across members.

In order to obtain reliable estimates of long run coefficients for each of the variables, this study uses a dynamic ordinary least squares estimators (DOLS) proposed by Kao and Chiang (2000). This estimator corrects the standard pooled OLS for serial correlation and endogeneity of regressors that normally present in long run relationship. This approach is an extension of Stock and Watson (1993) procedure. In order to obtain an unbiased estimator, the dynamic OLS estimator uses a parametric adjustment to the errors by augmenting the static regression with the leads, lags, and contemporaneous values of the regressors in first differences. The DOLS estimator can be applied to equation (4) as follows:

$$TFP_{it} = \alpha + \beta_1 S_{it}^{im} + \beta_2 S_{it}^{ifdi} + \sum_{j=-q}^{q} c_{ij} \Delta S_{i,t+j}^{im} + \sum_{j=-q}^{q} c_{ij} \Delta S_{i,t+j}^{ifdi} + \varepsilon_{it} \quad (4)$$

The number of lead and lags of the model estimation (4) were selected according to Akaike information criterion (AIC). The key variable in this analysis is TFP, which is measured based on Klenow and Rodrigues (1997). They suggest estimation of TFP by incorporating human capital augmented labour that considers the quality of labour instead of only labour. To highlight the computation of total factor productivity (A), let assume the following production function:

$$Y = K^{\alpha} H^{\beta} A^{1-\alpha-\beta} L^{1-\alpha-\beta} \quad (5)$$

$$A = \frac{Y/L}{(K/Y)^{\alpha/1-\alpha-\beta} (H/Y)^{\beta/1-\alpha-\beta}} \quad (6)$$

where *Y* is output, *K* is stock of physical capital, *L* is labour, *H* is stock of human capital, A is productivity, Gollin (1996) set the value of α and β as 0.30 and 0.28, respectively. Klenow and Rodrigues (1997) uses using Mincer regression to estimate human capital stock. Following Mincer (1974), the estimated of human capital as follow:

$$H = hL = (\phi s)L \quad (7)$$

where h is human capital per worker, s is a year of schooling attainment and value of ϕ is 0.085 as described by Psacharopoulos and Patrinos (2002). This study focuses on five selected ASEAN countries namely, Malaysia, Indonesia, Thailand, Singapore and the Philippines using data spanning over the 1996–2012 periods and the examination of R&D spillovers is from 20 OECD countries (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States).

Results and discussions

This study focuses on five selected ASEAN countries namely, Malaysia, Indonesia, Thailand, Singapore and the Philippines using data spanning over the 1996–2012 periods. The key variable in this analysis is TFP, which is measured based on Klenow and Rodrigues (1997). They suggest estimation of TFP by incorporating human capital augmented labour that considers the quality of labour instead of only labour. Tables 1 and 2 present the descriptive statistics and correlation matrix of the variables employed in the analysis, respectively. As demonstrated in the tables there are positive correlations between TFP with interest variables. The highest correlation is recorded between TFP and outward FDI weighted foreign R&D stock (r=0.5367). Meanwhile, import channel indicate a positive correlation with TFP but correlates with a lower value of 0.1192 compared to other types of foreign R&D stocks.

Table 1. Descriptive statistics

Variable	Mean	Std. Dev	Maximum	Minimum
TFP	0.9885	0.0532	1.0815	0.9281
S^{ifdi}	2.2905	0.4822	3.5598	1.3129
S^{im}	0.3774	0.1746	0.7374	0.1256

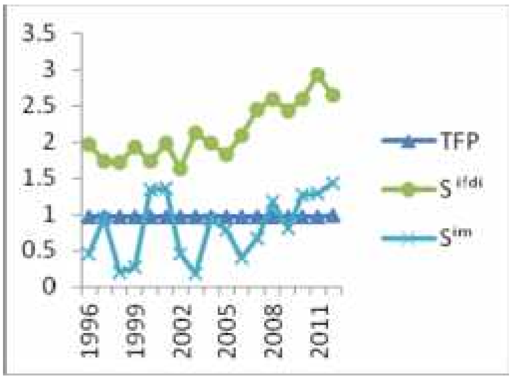
Note: TFP= total factor productivity; S^{ifdi} = inward FDI weighted foreign R&D stock; S^{im} = import weighted foreign R&D stock

Table 2. Correlation matrix

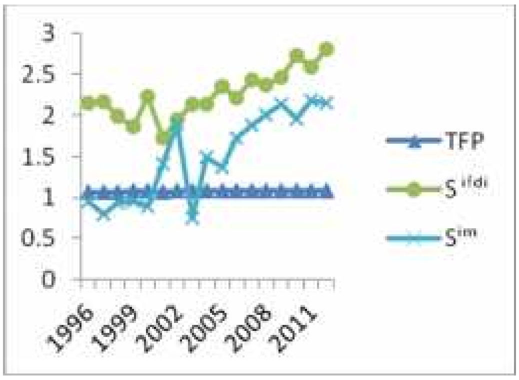
	TFP	S^{ifdi}	S^{im}
TFP	1.0000		
S^{ifdi}	0.3708	1.0000	
S^{im}	0.1192	0.4873	1.0000

Note: TFP= total factor productivity; S^{ifdi} = inward FDI weighted foreign R&D stock; S^{im} = import weighted foreign R&D stock

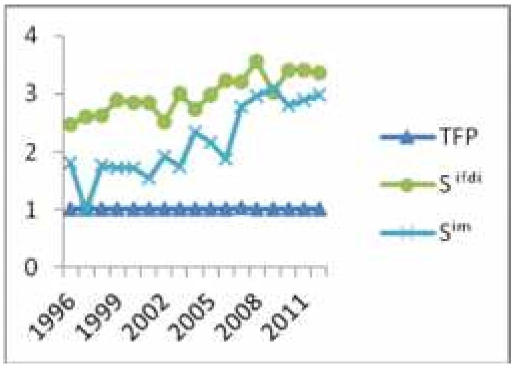
Figure 1 displays the trends of all variables for five ASEAN countries over the sample period from 1996 to 2012. Overall all variables for all countries show upward movements over the time span but the trend were no uniform across countries.



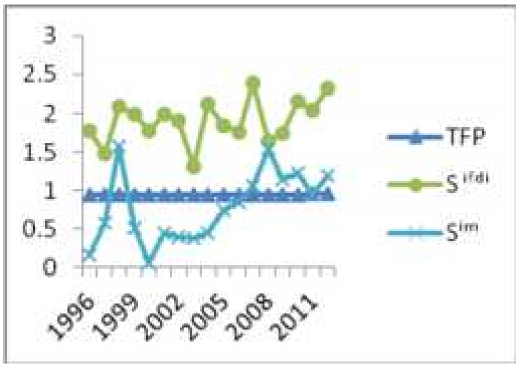
a) Indonesia



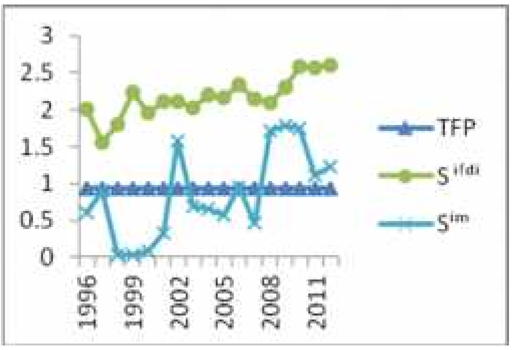
b) Malaysia



c) Singapore



d) Philippines



e) Thailand

Figure 1: Trends of the Main Variables

As a necessary test for cointegration test, two panel unit root tests were carried out to evaluate the unit root properties of all variables. The tests employed in this study are LLC and IPS test. The panel unit root tests are based on the null hypothesis that a unit root exists in the autoregressive representation of the data variable. The results of LLC and IPS tests are presented in table 3. The panel unit roots are tested using model with intercept and intercept plus trend. The results suggest the null hypothesis cannot be rejected at level suggesting that

Test Statistics	Intercept	Intercept + Trend

all variables contain unit root. However, the results for testing unit root at first difference generally suggest that all variables are stationary as the nulls can be rejected at the usual level. By and large, the variables are integrated of order 1 or they are *I(1).*

Table 3: Panel unit root tests

Levin, Lin and Chu (LLC) test.				
	Level		**First Difference**	
Variable	Intercept	Intercept +trend	Intercept	Intercept + trend
TFP	-0.9236	-1.1235	-7.7461***	-6.8475***
S^{tfdi}	0.6540	-3.9317	-14.5516***	-13.1129***
S^{im}	0.6844	-1.7231	-11.0055***	-12.1535***
Im, Pesaran and Shin (IPS) test.				
TFP	-0.1913	-0.1807	-6.1648***	-4.8564***
S^{tfdi}	1.1353	-2.5753	-12.6004***	-11.1178***
S^{im}	1.6545	-0.2239	-11.0055***	-10.2449***

Note: TFP= total factor productivity; S^{tfdi} = inward FDI weighted foreign R&D stock; S^{im} = import weighted foreign R&D stock

Panel Cointegration Test

Having established that each of the variable is integrated of order one *I*(1), the cointegration test suggested by Pedroni (1995, 1999, 2004) are employed for panel cointegration test. Based on seven test statistics of cointegration proposed by Pedroni, four tests examine the cointegration within the dimension and three tests examine group mean panel cointegration between the dimensions. The results of Pedroni panel cointegration test are reported in table 4. Five models with different combination of independent variables are estimated. The test results indicate that, the null hyphothesis of no cointegration can be rejected by panel PP statistics, panel ADF statistics, group PP statistics and group ADF statistics. According to Pedroni (1999), panel ADF test and group-ADF test have better sample property and more reliable. Therefore, it can be safely concluded that there are cointegration among the variables used in this analysis.

Z_v	-3.0762***	-2.5010***
Z_ρ	-3.1075***	-8.0947***
Z_t	-1.8492**	-2.1405**
Z_t^*	3.1103***	-3.4671***
$\tilde{Z}_\rho$	-3.0496***	-1.7611**
$\tilde{Z}_t$	-2.3511***	-6.2780***
$\tilde{Z}_t^*$	-3.4632***	-4.0312***

Table 4. Results of Cointegration test based on Pedroni (1999, 2004)

Note: Optimal lag lengths were selected based on AIC. Z_v= panel v-statistic, Z_ρ= panel ρ-statistic, Z_t= panel t-statistic, Z_t^*= group t-statistics (non-parametric), $\tilde{Z}_\rho$= group ρ-statistic, $\tilde{Z}_t^*$= group t-statistics (parametric), TFP= total factor productivity; S^{ifdi}= inward FDI weighted foreign R&D stock; S^{im}= import weighted foreign R&D stock. ***, ** indicates significant at 1% and 5% significant level.

Long-run elasticities

As the variables are integrated of order one I(1) and cointegrated, the next step is to examine the long run relationship between variables using dynamic OLS estimator. The results of estimating the baseline model which include all variables are reported in table 5. The result shows that the TFP elasticities for five Asian countries with respect foreign R&D's only with the import weighted channel is positive and significant. This is consistent with Coe and Helpman (1995), Acharya and Keller (2009) and Coe et al. (2009). Ang and Madsen (2013) who also find import as an important channel for R&D spillovers. As reported in table 5, the elasticities of import channel is 0.03% and inward FDI indicate the negative value of elasticities at -0.003%. Thus, these results suggest that import channel of international R&D activity is important for a country's productivity.

Table 5. Result of dynamic OLS estimation.

Note: TFP= total factor productivity; S^{ifdi}= inward FDI weighted foreign R&D stock; S^{im}=

Variable	Coefficient	p-value
S^{ifdi}	-0.0034	0.4165
S^{im}	0.0389	0.0093

import weighted foreign R&D stock

Robustness Checks

In order to gauge the robustness of the finding, sensitivity analyses are performed. By evaluating the sensitivity of the estimation results by incorporating other channels of international R&D as proposed by van Pottelsberghe and Lichtenberg (2001) and Ang and Madsen (2013) like outward FDI and knowledge channel. Table 6 reports the results and the estimation results show that the results are similar to the one presented earlier that import channel is the most important channel in transmitting knowledge spillovers across the borders. Inward FDI channel remain negative and insignificant and the other additional channels indicate positive but insignificant at any level. Therefore the previous interpretation on the important role of import channel as a main channel of international R&D spillovers is unchanged. The result is robust and not driven by the other variables.

Table 6. Sensitivity Result with Additional International R&D channels

Variable	Outward FDI Channel	Outward FDI + Knowledge Channel
S^{ifdi}	-0.0025	-0.0021
S^{im}	0.0331**	0.0323**
S^{ofdi}	0.0239	0.0248
S^{kn}		0.0004

Note: TFP= total factor productivity; S^{ifdi} = inward FDI weighted foreign R&D stock; S^{im} = import weighted foreign R&D stock; S^{ofdi} = outward FDI weighted foreign R&D stock and S^{kn} = other knowledge weighted foreign R&D stock. ** indicates significant at 5% significant level.

Conclusion

The objective of this study is to examine the most important channel of international R&D spillovers on productivity growth. Five ASEAN countries (Indonesia, Malaysia, Philippines, Singapore and Thailand) are examined using dynamic ordinary least squares (DOLS) panel estimator using data over the period 1996 to 2012. There are two channels of foreign R&D that examined here namely, inward FDI and import. Import channel appears to be the main channel via which foreign knowledge is transmitted to ASEAN countries. Import is one of the most important channels of technology spillovers as explained by past studies. For instant introduction of trade liberalization last two decades by developing countries encourage more inflows in developing countries especially inflows of new technology from abroad. Therefore developing countries experience the technology spillovers from these trade activities and contribute to the country productivity growth. Due to the important role of trade spillovers, trade policies must put in places. For instant, implementation of Strategic Plan of Custom

Development by ASEAN countries encourage the free flows of goods and services, thus policy maker and government should seek other ways in order to promoting more bilateral trade and multilateral trade like elimination of tariff and non-tariff barriers that will provide more inflows from biggest economy like U.S, Japan and China. The availability of data for selected ASEAN countries gives an opportunity to examine best channel of R&D spillovers. However, other than focus on the five ASEAN countries, this study may extend to (i) Asian Miracle economies (China, India, Japan, Korea, Singapore, Taiwan); (ii) Asian tigers (Singapore, Hong Kong, South Korea and Taiwan); or (iii) refer to the region of Asia (East Asia, South Asia and Western Asia), where the finding may valuable because of same countries classification. Besides that, there could be explore in future study by estimating other foreign R&D channels; (i) export channel; (ii) patent channel; (iii) international students' flows channel and (iv) geographical proximity channel.

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Acknowledgements

Kolej Universiti Islam Antarabangsa Selangor,
Geran Penyelidikan dan Inovasi KUIS (Fasa - II) 2016