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FDI Inflows and R&D Activity in Developing Countries

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ABSTRACT

This study investigates the impact of FDI inflows on R&D activity in 48 developing countries for the 1996-2013 periods. The results based on the system Generalized Method of Moment (GMM) estimator show that FDI inflows discourage R&D activity in developing countries. This finding is consistent with the view that foreign R&D investment is a substitute for domestic R&D efforts. This suggests that firms in developing countries are more inclined toward imitation of the existing products rather than innovation of a new technology. However, domestic R&D activity appears to benefit from imports of machinery and equipment, stronger legal protections, better human capital and higher economic growth.

JEL Classification: F21, O30,

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INTRODUCTION

Foreign direct investment (FDI) by multinational corporations (MNCs) is viewed as an important channel for host countries (especially the developing ones) to access new technologies that are available at the world's frontier.[1] MNCs have always been linked to superior technologies, patents, trade secrets, brand names, management techniques and marketing strategies (Dunning, 1993). MNCs are known for their huge investment in research and development (R&D) activities and they also hire a large number of professional and technical employees (Markusen, 1995). In addition, they invest substantially to improve the quality of their workforce through extensive trainings (Fosfuri et al., 2001). Since knowledge cannot be completely internalized, some of the benefits linked to FDI may be transmitted to local firms once MNCs have established their subsidiary in host countries. This is expected to enhance the productivity of local firms, leading to the expansion of local business activities. Given that MNCs has many benefits to offer, policymakers believe that FDI should be an integral part of development strategies for counties that wish to improve their economic performance.

Since the 1980s, many countries have liberalized their policies on FDI by relaxing the restriction on foreign firms and adopting FDI-enhancing policies. According to UNCTAD (2013) an annual average of 102 changes in FDI regulation were made during the 1991-2012 period. Of these changes, 84% changes were made on liberalization, promotion and facilitation to create a more favourable environment for investment prospect. As a result of policy changes that encourage more investments by MNCs, FDI inflows into both developed and developing countries have increased significantly over the past few decades, especially in developing countries. Specifically, FDI flows into developing and transition economies have increased from around US$3.8 billion in 1970 to around US$690 billion in 2010. For the first time in history, FDI inflow to developing and transition countries accounted for more than half of the global FDI inflow in 2010. Over the periods, the average growth of global FDI is 13% per year with the highest growth rate of 55% was recorded in 1999. In fact, the performance of FDI is much better than the growth of world's output which was recorded only 2.67% per year.

Given that FDI flows have increased significantly in the past few decades, several studies have examined the impact of FDI on host country economic performance. However, most studies have mainly focussed on the impact of FDI on domestic output growth (see for example *Borensztein* et al., 1998; Alfaro et al., 2004; Azman-Saini et al 2010, among others). The FDI-growth link has been tested using different procedures, data sets and time periods, and the findings show mixed results. While there is a plethora of research on the influence of FDI on output growth, the potential impacts of FDI on other local activities such as research and development (R&D) activity has been largely ignored. However, ignoring the impact of FDI on R&D activity may lead to a significant underestimation of the overall impact of FDI on the economy.

There are several reasons to expect that domestic innovation activity such as R&D may benefit from FDI inflows, thus allowing domestic firms to improve their technological base. First, competition introduced by MNCs may encourage local firms to make a more efficient use of existing resources and technology or even to adopt new technologies (Markusen & Venables, 1999; Wang & Blomstrom, 1992). MNCs presence may also promote backward linkages between MNCs and their local suppliers by means of technological know-how transfer, staff training, and so on. These vertical spillovers can then enhance the innovation capability of local suppliers (Rodrıguez-Clare,1996). It should also be noted that FDI inflows may also have a negative impact on local R&D activity as MNCs presence will allows domestic firms to adopt and internalise foreign technology at lower cost. Second, MNCs presence may has demonstration effects on local R&D activity. MNCs may inspire local firms to develop new products and processes because every successful innovation by MNCs will allow local firms to study the attributes of the newly invented product and improve upon it. This allows local firms to begin their R&D activity from a higher level of technology. Finally, technology spillovers may take place through labour mobility (Fosfuri et al., 2001; Glass &Saggi, 2002). Local firms may hire workers who were trained by MNCs with latest technology and this is expected to improve local firm's innovation capability. MNCs are known to be among the most technologically advanced firms, as they are responsible for a large part of the world's R&D expenditures (Borensztein et al., 1998). They also hire a large number of technical and professional workers and provide extensive trainings for their workforce (Markusen, 1995). However, this spillover channel may have negative impact as MNCs always attract the best workers from local firms by offering higher wages (Sinani & Meyer, 2004).

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[1] Apart from new technology, MNCs presence is also viewed as a source of new capital injection and additional investment in both human and physical capital. It also contributes to foreign exchange earnings for local economies and employment creation (de Mello,1999).

This paper examines the impact of FDI on R&D activity in developing countries by employing a system generalised method of moment (GMM) estimator proposed by Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998). The choice of this estimator over other alternatives is because of its ability to control for country-specific effects, dynamic effects, as well as endogeneity problem. The findings show that FDI has a negative impact on R&D activity. Meanwhile, import, protection of property right, human capital and income growth appear to have positive impacts on domestic R&D activity.

The rest of the paper is organised as follows. Next section summarizes the findings on past literature. The following section highlights the empirical model. Then, the descriptions of methodology and data are provided. After that, empirical results are presented. The final section concludes.

LITERATURE REVIEW

FDI is widely accepted as an important ingredient for development strategy in many countries (especially the developing ones). The adoption of FDI-stimulating policies and provision of incentives (i.e., tax incentives and/or subsidies) by many countries are based on the expectation that MNCs presence will bring significant benefits to the local economy. MNCs have been linked to superior technologies, patents, trade secrets, brand names, management techniques, and marketing strategies (Dunning, 1993). Besides that, MNCs are known for huge spending in R&D activity and they are technologically far superior compared to local firms (Borensztein et al., 1998). Additionally, they employ a large number of technical and professional workers (Markusen, 1995). Through FDIs, the recipient countries are granted instant access to advanced technology available at the world's frontiers that may benefit local firms.

A large body of the existing literature on FDI spillovers has focussed on the growth-effect of FDI with inconclusive findings. In a review of firm-level studies on FDI spillovers Gorg and Greenway (2004) find that only six out of 25 studies find some positive evidence of FDI spillovers. Meanwhile, Herzer et al (2008) re-examines the FDI-led growth hypothesis for 28 developing countries using cointegration techniques on a country-by-country basis. They find that there is no effect of FDI on growth (both long-term and short-term) in most countries. In fact, there is not a single country where a positive unidirectional long-term effect from FDI to GDP is found. However, several recent studies suggest that the growth-effect of FDI is dependent on local conditions. Several factors have been put forward in the literature such as human capital (Borensztein et al., 1998), financial market (Hermes and Lensink, 2003; Alfaro et al., 2004; Durham 2004) and quality of institution (Azman-Saini et al., 2010; Algualcil et al., 2011), among many others

Several studies examine the impact of technology transfer embodied in FDI on domestic productivity. For instance, van Pottelsberghe and Lichtenberg (2001) extend Coe and Helpman's (1995) work by incorporating inward and outward FDI as channels for technology transfer.[2] They analyse 13 countries find that foreign R&D spills over across borders via imports and outward FDI channels but not through inward FDI. However, several recent studies reveal that inward FDI is an important channel for enhancing domestic productivity (see for example, Bitzer and Kerekes, 2008; Zhu and Jeon, 2007; Savvides and Zachariadis, 2005; Ang and Madsen, 2013).

Apart from the impact on domestic output and productivity, FDI may also affect domestic innovation performance. However, empirical studies of FDI spillover effects on local innovation performance are rare and mainly focus on micro level. FDI inflows may increase competition in the domestic market by offering similar products that have been locally produced, but with better quality and at cheaper prices. This puts pressure on local firms to produce better products and encourage them to engage in R&D activity. However, some may argue that FDI discourages R&D activities when local firms merely imitate newly introduced imported products which eventually diminish the creativity and innovation in the long run. Generally, the findings reveal mixed evidence. For instance, one of the earliest studies by Co (2000) compare the effect of greenfield FDI and non-greenfield FDI on domestic R&D activities in the United States. Using industry-level data, the author find a significant positive impact only when there is a continuous flow of non-greenfield FDI. This finding is consistent with Cheung and Lin (2004) who also find positive effects of FDI on the number of domestic patent

[2] Coe and Helpman (1995) is the pioneering work on R&D spillovers. The authors assess R&D spillovers across 21 OECD countries plus Israel and provide empirical evidence of a positive relationship between R&D expenditures and total factor productivity They find that not only domestic R&D contributes significantly to productivity growth but also (trade-embodied) foreign R&D.

applications in China. This finding was further supported by Fan and Hu (2007) who find that FDI has a positive impact on the R&D effort by Chinese firms only in sectors with more foreign presence. However, the overall impact of MNCs presence on R&D activity for all firms (firms in all sectors with or without foreign presence) is negative. Several studies find that the impact of FDI on innovation is dependent on other conditions. For instance Kathuria (2008) examines Indian firms in the high-tech industries during the post-reform period. The author found that the effect on R&D is negative during the earlier phase of liberalisation. In the later phase, the effect is found to be not significant. More recently, Crescenzi et al. (2015) examine the U.K firms and find that domestic firms in sectors with greater investments by MNCs show a stronger innovative performance. Furthermore, they find that the internationalization of both their market engagement and ownership structure is the main driver of this effect.

Although evidence using micro-level data are voluminous, studies at macro-level are relatively limited. Alvi et al. (2007) examines if patent protection and technology transfer facilitate R&D in a sample of 21 countries (developed and emerging countries). The results suggest that there is threshold effect such that FDI has a positive effect only if the country depends heavily on FDI inflows. Specifically, they find that the threshold level of FDI to be three per cent (of GDP). Moreover, they find that patent protection has a positive effect on R&D which weakens at high levels of protection. In a similar study, Wang (2010) examines the determinants of R&D investment in 26 OECD countries using Extreme Bound Analysis approach and find that the transfer of foreign technology via trade and FDI had a robust negative impact on R&D. Moreover, human capital (i.e. tertiary education and the proportion of scientific researchers) appear to be robust in explaining R&D investment. Meanwhile, in a study of 44 countries (OECD plus developing) Ang (2011) find that the implementation of financial reform policies is negatively associated with accumulation of new ideas. However, the impact of financial development is found to be positive.

Several studies examine the impact of import on R&D activity and many of them focus on the micro level analysis. Lee (1996) investigate the Korean manufacturing firms and find that the firms utilizing imported technology are more willing to engage in R&D only when there is a formal R&D institution. Funk (2003) find that the U.S manufacturing firms which are not involved in foreign sales are affected by the increased competition induced by imports, hence reducing their investment in R&D.[3] However, the author cautions that this result may be biased as it does not consider the embedded research or knowledge in imported goods. In the case of Chinese firms, Li et al. (2011) find that public R&D subsidies and disembodied technology imports positively impact on firms' private R&D, while non-high-tech product exports and embodied technology imports do not have positive effects. Moreover, they find that high-tech product exports have no significant impact on R&D investment. Meanwhile, Katrak (1989) find evidence of a positive relationship between technology importing firms and their decision to engage in R&D using data from India. However, R&D investment allocation depends on the cost of importing the technology. Recently, Parameswaran (2010) reveal that export, in general, encourages investment in innovation by Indian firms. Moreover, the impact of import competition depends on domestic market structure. It promotes investment in R&D only when domestic market is highly concentrated, otherwise the effect is negative.

A patent law or other intellectual property right (IPR) protections can provide an incentive for the firms to allow temporary technological rents of knowledge (Edquist and Johnson, 1997). Thus, protections laws may encourage firms to engage in R&D. Varsakelis (2001) examine the impact by using a cross country analysis for selected 50 countries. The empirical results show that countries with a strong patent protection framework are willing to invest more in R&D. These findings were further supported by Falk (2006) and Wang (2010). However, Alvi et al. (2007) find that strict protection laws tend to demotivate R&D activities and can encourage imitation of imported products.

MODEL SPECIFICATION

This study utilizes a model which is similar to Wang (2010). The model can be expressed as follows:

[3] Import-induced competition arises as more imported products penetrate the local market and compete with local products. Funk (2003) argue that import-induced competition tends to reduce the R&D efforts by domestic firms by increasing the first mover advantages. Domestic firms are less to engage in research activities due to lack of information on embedded knowledge in imported products.

$$RD_{i,t}=\beta_1 RD_{i,t-1}+ \beta_2 FDI_{i,t} + \beta_3 Z_{i,t} + \eta_i+ \varepsilon_{it} \quad (1)$$

where i *is country index, t is time index,* RD is R&D intensity (gross R&D expenditure over GDP), FDI is foreign direct investment, Z is a vector of conditional variables which are believed to affect R&D activity, η_i is country-specific effect and ε_{it} is the usual error term. *The group of conditional variables* includes human capital, import of high technology products, investment in physical capital, intellectual property right and income growth.

METHODOLOGY

This study employs the generalized method-of-moments (GMM) panel estimator which was first proposed by Holtz-Eakin et al. (1990). This method was then extended by Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998). This estimator has several advantages. It can control country-specific effects, dynamic effects and simultaneity bias caused by the endogenous explanatory variables. This methodological procedure has been used in the of finance-growth link (Levine et al., 2000; Beck et al., 2000), FDI-growth link (Alguacil et al 2011), R&D spillovers (Chee-Lip et al., 2015), among many others. Arellano and Bond (1991) suggested that the country-specific effect to be eliminated by transforming Equation 1 into first differences, as follows:

$$(RD_{i,t}-RD_{i,t-1}) = \beta_1(RD_{i,t-1}-RD_{i,t-2}) + \beta_2(FDI_{i,t}-FDI_{i,t-1}) + \beta_3(Z_{i,t}-Z_{i,t-1}) + (\varepsilon_{i,t}-\varepsilon_{i,t-1}) \quad (2)$$

Furthermore, Arellano and Bond (1991) proposed the use of lagged levels for the regressors to identify the possible simultaneity bias of explanatory variables and the correlation between $(RD_{i,t-1}-RD_{i,t-2})$ and $(\varepsilon_{i,t}-\varepsilon i_{t-1})$. However, this is only valid under the condition that the error terms are not serially correlated. According to Arellano and Bond (1991), the following moment conditions are applied:

$$E\left[RD_{i,t-s}\cdot\left(\varepsilon_{i,t}-\varepsilon_{i,t-1}\right)\right] = 0 \text{ for } s \geq 2; t = 3; \ldots; T \quad (3)$$
$$E\left[FDI_{i,t-s}\cdot\left(\varepsilon_{i,t}-\varepsilon_{i,t-1}\right)\right] = 0 \text{ for } s \geq 2; t = 3; \ldots; T \quad (4)$$
$$E\left[Z_{i,t-s}\cdot\left(\varepsilon_{i,t}-\varepsilon_{i,t-1}\right)\right] = 0 \text{ for } s \geq 2; t = 3; \ldots; T \quad (5)$$

Alonso-Borrego and Arellano (1999) and Blundell and Bond (1998) argued that the lagged levels of the variables can be inefficient when the explanatory variables are persistent. This may lead to biased parameter estimates in small samples and a larger asymptotic variance. Blundell and Bond (1998) developed a procedure that transforms these instruments to become exogenous to the fixed effects. Under this procedure, it is assumed that changes in any instrumenting variable are uncorrelated with the fixed effects in Equation 1. Therefore, according to Arellano and Bover (1995), additional moment conditions for the second part of the system (the regression in levels) are to be set as follows:

$$E\left[(RD_{i,t-s}-RD_{i,t-s-1})\cdot\left(\eta_{i,t}+\varepsilon_{i,t}\right)\right] = 0 \text{ for } s = 1 \quad (6)$$
$$E\left[(FDI_{i,t-s}-FDI_{i,t-s-1})\cdot\left(\eta_{i,t}+\varepsilon_{i,t}\right)\right] = 0 \text{ for } s = 1 \quad (7)$$
$$E\left[(Z_{i,t-s}-Z_{i,t-s-1})\cdot\left(\eta_{i,t}+\varepsilon_{i,t}\right)\right] = 0 \text{ for } s = 1 \quad (8)$$

There are two specification tests to determine the consistency issue of the GMM estimators. First, the Hansen Test (1982) overidentifies the joint validity of the instruments. The null hypothesis is that the instruments are not correlated with the residuals. Under the null hypothesis of joint validity in all instruments, the empirical moments have zero expectations and the J-statistic is distributed as a χ^2 with degrees of freedom equal to the degree of overidentification. Secondly, in order to identify autocorrelation besides the fixed effects, the Arellano-Bond test is applied to the residuals of the first difference. The Arellano-Bond test for autocorrelation examines the hypothesis of no second-order serial correlation in the error terms of the first difference. Failure to reject the null hypotheses in both tests provides support to the estimated model.

There are two variants of GMM estimators, namely one- and two-step estimators (Arellano and Bond, 1991). The one-step GMM estimator utilises weighting matrices that are independent of estimated parameters, while the two-step estimator employs optimal weighting matrices[4]. This adjustment makes the two-step estimator asymptotically more efficient than the one-step estimator. Consequently, this paper uses the moment conditions presented in Equation 3 to Equation 8 and employs the two-step estimator.

DATA DESCRIPTION

The aim of this study is to examine the impact of FDI inflows on local R&D in developing countries. In 2013, there were 76 developing countries listed by the World Bank. After omitting countries with missing data, small island economies and outliers, our final data set consists of 48 countries. This *balanced panel* data set covers the period from 1996 to 2013, where the average data are taken for every three years. To measure the R&D intensity, this study uses the annual ratio of gross expenditure on R&D (GERD). This indicator is widely used in the literature (see for example, Alvi et al., 2007; Wang, 2010; Ghazalian, 2012). The data were retrieved from the UNESCO Institute of Statistics (UIS) database. We employ a ratio of FDI inflows to GDP as a proxy for FDI and the data were collected from the World Development Indicators database. Additionally, we include import of machinery and equipment expressed as a ratio to GDP and the data were retrieved from the World Trade Organization (WTO) database.

Based on the endogenous growth theory and production function theory, human capital stock and scientific researcher are important for R&D activity. This study employs the human development index (HDI) as a proxy for human capital. The index is calculated by taking the average of two indicators, the schooling years and the return on education. The data were obtained from the Penn World Table (PWT) database. The data on scientific researcher proportion is measured by taking the total researchers to the total employment ratio, available from the UIS database. Furthermore, we include the protection property right index compiled and published by the Fraser Institute (Gwartney et al., 2013). The data are collected based on a survey on 150 partner institutes of recognized departments of economics in national universities, independent research institutes, or business organizations. This inclusion of this variable is based on the fact that protection measures related to intellectual property rights is expected to reduce the uncertainty that surrounds the possibility of misappropriation of new invention. They also serve as an incentive for firms to engage in R&D because it allows firms to enjoy temporary technological rents. In addition, we include income growth based on the prediction of R&D-driven growth model which predict that incentives to invest in R&D is strongly tied to the size of the economy. Larger market implies stronger incentive to invest in R&D, which in turn result in faster growth. The data were taken from the WDI. Finally, we also include gross fixed capital formation to GDP as a proxy for investment in physical capital and the data were taken from the World Development Indicator database. Physical capital formation is widely known for their contribution for national output. Investment in physical capital could either complements R&D investment (from the viewpoint of aggregate production) or substitutes R&D because they compete for limited national resources (Bebczuk, 2002). Table 1 provides a summary of variables used in this study.

Table 1 List of Variables

Variable	Proxy	Source
Research and development	*Gross expenditure on R&D (GERD) to GDP*	*UIS database*
FDI	*FDI inflows to GDP*	*WDI*
Import	Total import of machinery and equipment to GDP	WTO
Human capital	Human Development Index	Penn World Table
Scientific Researcher	Total researchers to total employment	UIS
Property Right	Protection of Property right index	Fraser Institute
Income growth	GDP per capita growth rate	WDI
Investment	Gross fixed capital formation to GDP	WDI

Figure 1 displays R&D spending and FDI inflows for the sampled countries using data averaged over the entire period (1996–2013). The fitted line shows a weak positive relationship between the FDI and growth (R2=0.074). This observation shows that countries with higher FDI inflows tended to have higher level of R&D activity. However, this simple correlation analysis does not imply any causal effect between R&D and FDI which is precisely the type of relation that we are interested in this study.

[4] Specifically, the moment conditions are weighted by a consistent estimate of their covariance matrix.

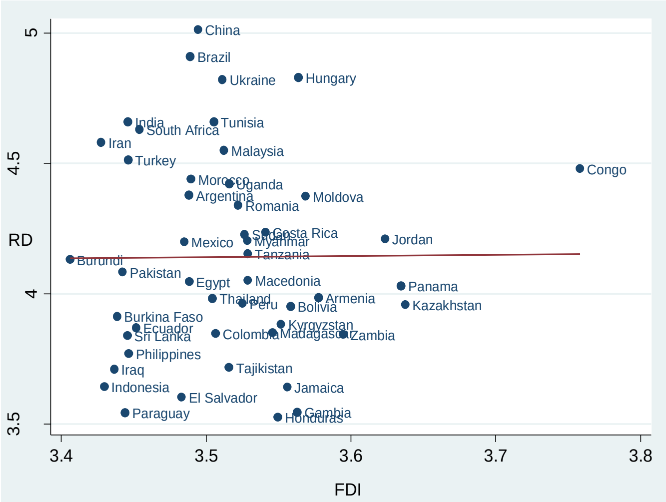

Figure 1 Scatterplot of FDI versus R&D

EMPIRICAL FINDINGS

This section presents the empirical findings of this study. Table 2 shows the mean, median, standard deviation, minimum and maximum values of all variables. For the dependent variable (RD), the mean value is 0.40 per cent and the standard deviation is 0.363, while the maximum value of intensity is 2.66 per cent and the lowest is 0.01 per cent. Our main variable, FDI, has a mean value of 3.74 per cent with a standard deviation of 3.13. The minimum value of FDI intensity is 0.003 per cent, while the maximum value is 25.118 per cent. Similar to R&D and FDI, the rest of the variables show considerable variation in data across countries.

Table 2 Descriptive statistics

Variable	Mean	Median	Std. Dev.	Min	Max
R&D intensity	0.40	0.29	0.36	0.01	2.66
FDI	3.74	2.99	3.13	0.003	25.11
Import	0.30	0.29	0.11	0.02	0.66
Human Capital	23.96	24.89	5.17	5.48	33.06
Scientific Researcher	2.24	1.05	3.10	0.04	25.25
Property Right Index	44.44	45	15.40	3.00	99.66
Investment	21.00	20.53	6.21	2.91	46.47
Income Growth	4.59	4.67	3.49	-4.99	35.45

Table 3 present the results of estimating the impact of FDI and other variables on domestic R&D activity. Results in Column 2 are based on the one-step estimator, while results in Column 3 are obtained from the two-step estimator which is our preferred estimator. The result of one-step estimator does not pass the speficication test and therefore unreliable. Interestingly, our preferred equation pass the Hansen and *AR*(2) specification tests which suggest that the models are adequately specified and the instruments used are valid. The results reveal that all variables are significant in both one-step and two-step estimations, except for the investment, which is only found to be significant in the one-step estimation.

Looking at the core variable, FDI intensity shows a negative effect on R&D activities in host countries with the elasticity range between 0.7185 and 0.7685. This finding complements Fan and Hu (2007) and Kathuria (2008) who find the negative impact of FDI on R&D. In addition, Wang (2010), also find that foreign technology inflows (which include import and FDI) exert a negative impact on R&D activity in OECD countries. This finding is consistent with the view that FDI inflows and domestic R&D activity are substitutes as MNCs presence will allows domestic firms to access foreign technology at lower cost. Given that firms in developing countries have limited resources for R&D activity, they may improve their technological base by interacting with R&D leaders through licensing, cooperation, and so on. Another possible reason for this finding is that local firm in developing countries poses poor technological absorption and innovative capability. Consequently, domestic firms are discouraged from engaging in R&D activities as they are more inclined towards imitation of newly introduced products.

Meanwhile, our finding on imports of machinery and equipment shows a positive and significant effect on local R&D activity. Interestingly, this finding appears to be contradicting to the finding on FDI which has a negative impact on R&D. However, our finding is consistent with the view that trade liberalisation leads to greater competitive pressure on domestic firms. Specifically, openness to imports will force domestic firms to improve the quality of the products, to reduce management inefficiencies, and most importantly, to increase the technological base by investing more on R&D activity in order to stay competitive.

Protection of property right appears to have the biggest impact on R&D activity in developing countries with the elasticity of about one. This finding is consistent with the view that protection of property right, especially protection of intellectual property, serves as an effective tools for promoting inventions by providing inventors with a limited monopoly over a technological solution. The finding is consistent with Hu and Mathews (2005), Wu et al. (2007) and Alvi et al. (2007). The results on human capital and scientific researcher reveal that both variables are found to be positive and statistically significant in both models. This finding is consistent Wang (2010) who find that both education and scientific researchers are robust determinants of R&D intensity with positive impact in OECD countries. Investment in physical capital is found to be significant only in model using one-step estimator with elasticity of 0.3379. This finding is in line with the view that investment in physical capital complement R&D activity in developing countries. In the case of income growth, the result indicate that the variable is an important determinant of R&D activity as the estimated coefficients turn out to be positive and significant in both models. Specifically, the elasticity ranges from 0.1267 to 0.1455. This is in line with the view that larger market implies stronger incentive for investors to generate new knowledge. This finding is consistent with Braconier (2000) and Hartman (2003).

Table 3 Results of GMM estimation

	System GMM	
Variables	One-Step	Two-step
Lag R&D	0.9031[a]	0.8424[a]
	(0.0573)	(0.0280)
FDI	-0.7185[a]	-0.7685[a]
	(0.1850)	(0.1096)
Import	0.2485[b]	0.2094[a]
	(0.0997)	(0.0361)
Property Right	1.0369[c]	1.0017[a]
	(0.1922)	(0.1742)
Investment	0.3379[c]	0.1082
	(0.1923)	(0.0925)
Human Capital	0.1717[c]	0.0748[c]
	(0.0882)	(0.0361)
Scientific Researcher	0.8191[a]	0.6365[a]
	(0.3100)	(0.2347)
Income Growth	0.1455[a]	0.1267[a]
	(0.0527)	(0.0222)
T3	-0.04741	-0.0474
	(0.0294)	(0.0292)
T4	-0.1057[a]	-0.1057[a]
	(0.0334)	(0.0402)
T5	-0.0508	-0.0508
	(0.0319)	(0.0405)
T6	-0.0282	-0.0282
	(0.0303)	(0.0455)
Hansen test (p-value)	0.0000	0.7426
AR (1) test (p-value)		0.0695
AR (2) test (p-value)		0.6930
Observations	235	235

Notes: a, b, c indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Figures in parentheses are standard errors. All variables are in logarithmic form. T3, T4, T5 and T6 are time dummies for 2002-2004, 2005-2007, 2008-2010 and 2011-2013 periods, respectively.

As a robustness check, we identify potential outliers in our sample and to ensure that the negative link established between FDI and R&D is robust and not driven by outlier observations. In order to test for outlier presence, this study employs the DFITS statistics as suggested by Belsley et al. (1980).[5] The test shows that

[5] The DFITS test identifies observations with high combination of leverage and residual. The test is computed as $DFITS_j = r_j\sqrt{h_j/(1-h_j)}$, where r_j is studentized residual given by $r_j = e_j/(s_{(j)}\sqrt{1-h_j})$ with $s_{(j)}$ refer to the root mean squared error (s) of the regression equation

Jordan and Ukraine are true outliers as the absolute DFITS scores for these countries are 1.9933 and 1.2220, respectively, which is greater than the threshold value of 0.8433. This means that Jordan and Ukraine have high combinations of residuals and leverage points and they fall relatively far from the rest of the observations. This result suggests that the negative link between FDI and R&D documented earlier may be influenced by outliers. Figure 2 illustrate the distributions of leverage point and residual for all countries in our sample. Clearly, the figure shows that Jordan and Ukraine have high combinations of residual and leverage.

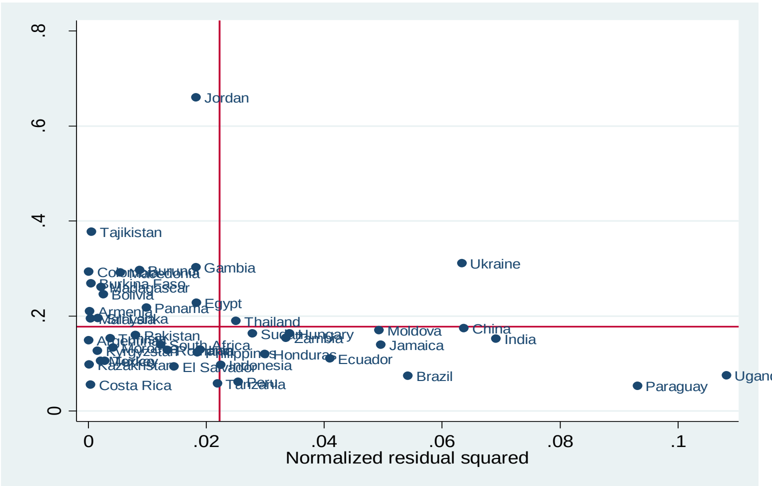

Figure 2 Scatter plot of leverage versus residual squared

We re-estimate a new sample with the exclusion of Jordan and Ukraine. The results are presented in Table 4. Interestingly, the results show that the impact of FDI on R&D remains intact as the *p*-value for the estimated coefficient on FDI is less than one per cent for both one-step and two-step estimators. Therefore, our interpretation on the negative impact of FDI inflows on local R&D activity is unchanged. In addition, almost all explanatory variables are found to be significant at the 10 percent level. However, the coefficient on investment is found to be significant only in model utilizing one-step estimator. More importantly, the specification tests indicate that the preferred model (i.e. two-step estimator) is adequately specified and the result is not affected by simultaneity bias. However, the one-step estimation does not pass the Hansen test as its p-value is less than 0.05. Generally, this supports our previous interpretation regarding the impact of FDI inflows in discouraging R&D investment in the host countries. The result also shows that the link is robust and not driven by outlier observations.

Table 4 Results of GMM estimation with exclusion of outliers

Variables	One-step	Two-step
Lag R&D	0.9268[a]	0.8496[a]
	(0.0577)	(0.0344)
FDI	-0.6312[a]	-0.7205[a]
	(0.2001)	(0.1111)
Import	0.1990[c]	0.2066[a]
	(0.1045)	(0.0347)
Property Right	1.0259[b]	0.7207[a]
	(0.4013)	(0.2655)
Investment	0.3375[c]	0.0569
	(0.2006)	(0.1014)
Human Capital	0.1889[c]	0.1198[b]
	(0.0965)	(0.2655)
Scientific Researcher	1.1771[a]	0.7613[a]
	(0.4233)	(0.2152)
Income Growth	0.1467[b]	0.1426[a]
	(0.0603)	(0.0271)
T3	-0.0546c	-0.0416[a]
	(0.0324)	(0.0152)
T4	-0.1277[c]	-0.7663[a]
	(-0.0389)	(0.0206)

with *j*th observation removed, and *h* is leverage statistic. Following Belsley *et al.* (1980), an observation is considered as outlier if the absolute DFITS statistic is greater than $2\sqrt{k/n}$, where *k* denotes the number of explanatory variables and *n*the number of countries.

Table 4 Cont.

T5	-0.0634^{c}	-0.0234
	(-0.0359)	(0.0229)
T6	-0.0495	0.0006
	(0.0358)	(0.0276)
Hansen test (p-value)	0.0001	0.9498
AR (1) test (p-value)		0.0751
AR (2) test (p-value)		0.7968
Observations	225	225

Notes: a, b, c indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Figures in parentheses are standard errors. All variables are in logarithmic form. T3, T4, T5 and T6 are time dummies for 2002-2004, 2005-2007, 2008-2010 and 2011-2013 periods, respectively.

CONCLUSIONS

Developing countries view FDI as an important channel for them to tap advance technology developed by R&D leaders. Therefore, many countries adopt FDI-stimulating policies by offering various incentives to MNCs. This paper examines the impact of FDI inflows on R&D activity using a data set comprising 48 developing countries for the 1996-2013 periods. The results reveal that FDI inflows tend to discourage domestic R&D activity which suggests that foreign R&D investment is a substitute for domestic R&D efforts. Therefore, developing countries with limited resources for R&D activity should focus on R&D activity on areas with a comparative advantage and imports other technologies from foreign countries at lower costs. Moreover, this study reveals that import, protection of property rights, human capital (both education and number of scientific researchers), and income growth are important for local R&D performance. Therefore, developing countries should embrace trade liberalization by reducing tariff and non-tariff barriers, and strengthen the legal protection policies (such as protection of intellectual property and patent law).They should also improve the quality of education system and accumulate more human capital to engage in R&D activity. Finally, they should also adopt growth-enhancing policies as higher growth is expected to promote R&D activity.

REFERENCES

Aizenman, J., Jinjarak, Y. and Park, D. (2013) Capital flows and economic growth in the era of financial integration and crisis, 1990–2010. *Open Economies Review*. 24 (3), pp. 371–396

Alfaro, L., Chanda, A., Kalemli-Ozcan, S. and Sayek, S. (2004) FDI and economic growth: the role of local financial markets. *Journal of International Economics*. 64, pp. 89–112.

Alguacil, M, Cuadros, A. and Orts, V. (2011) Inward FDI and growth: the role of macroeconomic and institutional environment. *Journal of Policy Modeling*. 33 (3), pp. 481-496.

Alonso-Borrego, C. and Arellano, M., (1999) Symmetrically normalised instrumental-variable estimation using panel data. *Journal of Business and Economic Statistics*. 17, pp. 36–49

Alvi, E., Mukherjee, D. and Eid, A. (2007) Do patent protection and technology transfer facilitate R&D in developed and emerging countries?. A semiparametric study. *Atlantic Economic Journal*. 35 (2), pp. 217-231.

Ang, J (2011) Financial development, liberalization and technological deepening. *European Economic Review*. 55, pp. 688–701.

Ang, J.B. and Madsen, J.B. (2013) International R&D spillovers and productivity trends in the Asian miracle economies. *Economic Inquiry*. 51, pp. 1523–1541.

Arellano, M. and Bond, S. (1991) Some tests of specification for panel data: Monte carlo evidence with an application for employment equations. *Review of Economic Studies*. 58, pp. 277–297.

Arellano, M. and Bover, O. (1995) Another look at the instrumental-variable estimation of error-components models. *Journal of Econometrics*. 68, pp. 29–52.

Bebczuk, R.N. (2002). R&D expenditures and the role of government around the world. *Estudios de Economia*. 29 (1), pp. 109–121.

Beck, T., Levine, R. and Loayza, N. (2000) Finance and the sources of growth. *Journal of Financial Economics*. 58, pp. 261-300.

Belsley, D., Kuh, E. and Welsh, R. (1980) Regression diagnostics. Wiley, New York.

Bitzer, J. and M. Kerekes. (2008) Does Foreign Direct Investment Transfer Technology Across Borders? New Evidence. *Economics Letters*. 100, pp. 355-358.

Blundell, R. and Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*. 87, pp. 115–143.

Borensztein, E., De Gregorio, J. and Lee, J.-W. (1998) How does foreign investment affect economic growth?. *Journal of International Economics*. 45, pp. 115–135.

Braconier, H. (2000) Do higher per capita incomes lead to more R&D expenditure? *Review of Development Economics*. 4 (3), pp. 244–257.

Chee-Lip, T., Azman-Saini, W.N.W., Ibrahim, S. and Ismail, N.W. (2015) R & D Spillovers and The Role of Economic Freedom. *International Journal of Economics and Management*. 9 (S), pp. 41-60.

Cheung, K.Y. and Lin, P. (2004) Spillovr effect of FDI on innovation in China: Evidence from the provincial data. *China Economic Review*. 15 (1), pp. 25-44.

Co, C.Y. (2000) R&D, foreign direct investment and technology sourcing?*Review of Industrial Organization*. 16 (4), pp. 385-397.

Coe, D.T. and Helpman, E. (1995) International R&D spillovers. *European Economic Review*. 39, pp. 859–887.

Crescenzi, R., Gagliardi, L. and Iammarino, S. (2015) Foreign multinationals and domestic innovation: Intra-industry effects and firm heterogeneity. *Research Policy*. 44, pp. 596–609.

De Mello, L. (1999) Foreign Direct Investment Led Growth: Evidence from Time Series and Panel Data. *Oxford Economic Papers*. 51, pp. 133–51.

Dunning, J. (1993) Multinational Enterprises and the Global Economy.Addison-Wesley, Wokingham.

Edquist, C. and Johnson, B. (1997) *Institutions and organisations in systems of innovation. Systems of Innovation: Technologies, Institutions, and Organisations*, Pinter, London.

Falk, M. (2006) What drives business Research and Development (R&D) intensity across Organisation for Economic Co-operation and Development (OECD) countries? *Applied Economics*. 38, pp. 533–547.

Fan, C.S. and Hu, Y., (2007) Foreign direct investment and indigenous technological efforts: Evidence from China. *Economics Letters*. 96 (2), pp. 253-258.

Fosfuri, A., Motta, M. and Ronde, T., (2001) Foreign direct investment and spillovers through workers' mobility. *Journal of International Economics*. 53, pp. 205–222.

Funk, M. (2003) The effects of trade on research and development. *Open Economy Review*. 14, pp. 29–43.

Ghazalian, P.L. (2012) Assessing the effects of international trade on private R&D expenditures in the food processing sector. *Industry and Innovation*. 19 (4), pp. 349-369.

Glass, A.J. and Saggi, K. (2002) Multinational firms and technology transfer. *Scandinavian Journal of Economics*. 104 (4), pp. 495-513.

Gorg, H. and D. Greenaway (2004) Much ado about nothing? Do domestic firms really benefit from foreign direct investment?. *World Bank Research Observer*. 19, pp. 171-197.

Gwartney, J., Hall, J. and Lawson, R. (2013) Economic Freedom of the World: 2013 Annual Report. The Fraser Institute, Vancouver. Internet, data retrieved from http://www.freetheworld.com.

Hansen, L. (1982). Large sample properties of generalized method of moments estimators. *Econometrica*. 50, pp. 1029–1054.

Hartman, G.C. (2003) Linking R&D spending to revenue growth. *Research Technology Management*. 46 (1), pp. 39–46.

Hermes, N. and R. Lensink (2003) Foreign direct investment, financial development and economic growth. *Journal of Development Studies*. 40, pp. 142-163.

Herzer, D., Klasen, S. and Nowak-Lehmann, F. (2008) In Search of FDI-led Growth in Developing Countries: The Way Forward. *Economic Modelling*. 25 (5), pp. 793-810.

Holtz-Eakin, D., Newey, W. and Rosen, H. (1990) Estimating vector autoregressions with panel data. *Econometrica*. 56 (6), pp. 1371–1395.

Hu, M.C., Mathews, J.A. (2005) National innovative capacity in East Asia. *Research Policy*. 34, pp. 1322–1349.

Kathuria, V. (2008) The impact of FDI inflows on R&D investment by medium- and high-tech firms in India in the post-reform period. *Transnational Corporations*. 17 (2), pp. 41-66.

Katrak, H. (1989) Imported technologies and R&D in a newly industrialising country: The experience of Indian enterprises. *Journal of Development Economics*. 31 (1), pp. 123-139.

Lee, J. (1996) Technology imports and R & D efforts of Korean manufacturing firms. *Journal of Development Economics*. 50, pp. 197-210.

Levine, R., Loayza, N. and Beck, T. (2000) Financial intermediation and growth: causality and causes. *Journal of Monetary Economics*. 46, pp. 31- 77.

Li, Z.-W., Millman, C. and Chi, R.-Y. (2011) Government support, international trade and firm's R&D investment: Evidence from Chinese high-tech industries. *Journal of Science and Technology Policy in China*. 2 (2) pp. 146-158.

Markusen, J. (1995) The boundaries of multinational enterprises and the theory of international trade. *Journal of Economic Perspectives*. 9, pp. 169–189.

Markusen, J.R. and Venables, A.J. (1999) Foreign direct investment as a catalyst for industrial development. *European Economic Review*. 43 (2), pp. 335-356.

Okabe, M. (2003) Relationship between domestic research and development activity and technology importation: an empirical investigation of Japanese manufacturing industries. *Asian Economic Journal*. 17, pp. 265–280.

Parameswaran, M. (2010) International trade and R&D investment: Evidence from manufacturing firms in India. *International Journal of Technology and Globalisation*. 5 (1-2), pp. 43-60.

Rodriguez-Clare, A. (1996) Multinationals, linkages, and economic development. *American Economic Review*. 86, pp. 852–873.

Savvides, A. and Zachariadis, M. (2005) International technology diffusion and the growth of TFP in the manufacturing sector of developing economies. *Review of Development Economics*. 9 (4), pp. 482-501.

Sinani, E. and Meyer, K. (2004). Spillovers of Technology Transfer From FDI: The Case of Estonia. *Journal of Comparative Economics*. 32 (3), pp. 445-466.

UNCTAD (2013). World Investment Report: Global value chains. Retrieved from http://unctad.org/en/publicationslibrary/wir2013_en.pdf.

Van Pottelsberghe, B. and Lichtenberg, F., (2001) Does foreign direct investment transfer technology across border? *Revision of Economics and Statistics*. 83, pp. 490–497.

Varsakelis, N.C. (2001) The impact of patent protection, economy openness and national culture on R&D investment: A cross-country investigation. *Research Policy*. 30, pp. 1059-1068.

Wang, E.C. (2010) Determinants of R&D investment: The extreme-bounds-analysis approach applied to 26 OECD countries. *Research Policy*. 39, pp. 103–116.

Wang, J.-Y. and Blomstrom, M. (1992) Foreign investment and technology transfer: A simple model. *European Economic Review*. 36 (1), pp. 137–155.

Wu, Y., Popp, D. and Bretschneider, S. (2007) The effects of innovation policies on business R&D: a cross-national empirical study. *Economics of Innovation and New Technology*. 16 (3–4), pp. 237–253.

Zhang, X. and Zhang, K.H. (2003) How does globalization affect regional inequality within a developing country? Evidence from China. *Journal of Development Studies*. 39, pp. 47–67.

Zhu, L. and Jeon, B.N. (2007) International R&D Spillovers: Trade, FDI, and Information Technology as Spillover Channels. *Review of International Economics*. 15, pp. 955–976.

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