

What Drive Innovation Activity In Developing Countries?

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ABSTRACT

This paper seeks to provide an empirical assessment of the determinants of innovative activity across developing countries by focusing on the roles of trade and capital account openness. The Extreme-Bound-Analysis (EBA) approach is applied to data from 58 countries over the 1996-2011 period. The results reveal that human capital is a robust determinant of innovation activity. Meanwhile, the impact of foreign technology inflow is found to be different depending on the indicators used. The results indicate that import of machinery and equipment is a robust determinant of innovation but the impacts of total import, import of manufactured goods, and FDI inflows appear to be fragile.

Keywords: Innovation, Foreign Direct Investment, Import, Extreme Bound Analysis

ABSTRAK

Kertas kerja ini menguji penentu aktiviti inovasi bagi negara sedang membangun. Kaedah Extreme Bounds Analysis (EBA) digunakan pada data 58 negara bagi tempoh 1996-2011. Hasil penyelidikan ini mendedahkan bahawa modal insan adalah penentu teguh bagi aktiviti inovasi. Pada masa yang sama, kesan memasukkan teknologi asing didapati berbeza bergantung kepada pembolehubah yang digunakan. Keputusan menunjukkan bahawa import jentera dan peralatan adalah penentu yang teguh bagi aktiviti inovasi tetapi jumlah import, import barangan pembuatan, dan aliran masuk FDI adalah merupakan penentu yang rapuh.

Katakunci: Inovasi, Pelaburan Langsung Asing, Import, Extreme Bound Analysis (EBA)

INTRODUCTION

Economic theory predicts that innovative activity such as R&D activity is one of the most important sources of productivity growth (Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1992). Essentially, investment in innovation activity will result in knowledge accumulation, productivity improvement, and the expansion of the economy. It is viewed as an essential element in development strategy for many countries and failure to allocate sufficient resource to innovation activities may limit growth potential.

Even though investment in R&D has been highlighted as a major source of productivity growth, only a few countries appear to engage in R&D activity actively. In fact, only a handful of developed countries are responsible for the most of the world's total R&D investment. According to a report, the developing countries share a global R&D is only 23% in 2007 (UNESCO Science Report

2010). This suggests that developed countries remains as major player in R&D activity and they are responsible for most of the global innovation investments. Given that investment in R&D is not uniformly distributed across countries, it is therefore natural to ask how developing countries with limited innovation effort can improve their technological base. One argument is that domestic productivity does not only rely on domestic knowledge base but also foreign knowledge stock via several spillover channels like import and foreign direct investment (FDI) (see for example, Coe and Helpman, 1995; Coe, Helpman and Hoffmaister, 1997; van Pottelsberghe and Lichtenberg, 2001; Park, 2004; and Le, 2010).

Since the benefits of R&D cannot be completely internalized, other countries can benefit from their effort in R&D through economic interactions. The theory suggests two important channels through which knowledge may spillover across countries namely, trade (i.e. imports) and FDI. A large body of the literature empirically confirms that cumulative foreign R& is an important determinant of productivity growth in the home country. However, most of the studies have focused on spillovers within developed countries (especially OECD countries). Little is known about how OECD R&D activities affect the productivity of less developed countries. Moreover, most of the studies in the cross-border transfer of technology have mainly focussed on its relationship with productivity and output-growth but less attention is given on its impact on other sector of the economy like innovation activity. Since domestic firms can have access to foreign technology, will domestic sector substitute domestic innovation activity with foreign knowledge? Or will they use foreign knowledge to improve own knowledge base and make future innovation become easier? Obviously, there is no certain answer to these questions and therefore it is logical to empirically test the relationship.

The objective of this paper is to investigate the relationship and significance of potential determinants of innovation activity in developing countries with special emphasis on technology transfer through trade and FDI. The Extreme-Bound-Analysis (EBA) approach proposed by Leamer (1983, 1985) and modified by Sala-i-Martin (1997) is used to perform robustness and sensitivity tests using data from 58 countries during the period 1996 to 2011. The findings reveal that among all spillover channels (i.e. total import, import of manufactured goods, import of machinery and equipment, and FDI), only import of machinery and equipment is found to significant with positive effect on domestic innovation activities.

The remainder of this paper are organised as follows. Section 2 reviews past literature related to this issue. Section 3 reviews the methodology used to test the hypothesis and describes the data. Section 4 presents the empirical results of using EBA methodology. The last section concludes.

LITERATURE REVIEW

The importance of technology inflow for developing countries has been debated extensively in the literature. In a study on developed countries, Coe and Helpman (1995) provide important evidence that foreign technology may promote domestic productivity via trade. Complementing this, Coe, Helpman, and Hoffmaister (1997) expand the analysis to developing countries and confirm the significance of import as an important channel for knowledge spillovers to developing countries. They find that import of capital goods and high-tech products, such as machinery and equipment have greater impact on productivity than import of other types of goods. Meanwhile, van Pottelsberghe and Lichtenberg (2001) argue that foreign technology does not only spill over to domestic economy through trade but also FDI.

Openness to trade may enhance domestic productivity through four channels: access to larger variety of products and equipment, communication channel that stimulate cross border learning, adaptation of foreign technology to local condition, and imitate foreign technology or even develop new technology (Coe, Helpman, and Hoffmaister, 1997). Meanwhile, FDI could affect productivity of host country through four channels: imitation by domestic firms, skill acquisition by human capital and labour turnover, competition pressure force domestic firm to improve efficiency, and learn to engage in international trade through collaboration or imitation (Gorg and Greenaway, 2004).

Although there is a large body of literatures which asserts the importance of technology inflows on domestic productivity, the impact on domestic innovation is however ambiguous. Arguably, technology inflow could exert both positive and negative impacts on domestic innovation activity. The theory predicts that both trade and financial liberalisation will promote competition in domestic market. As a result of increased competition, domestic market is expected to innovate in order to improve the quality of their products (Wang, 2010). However, it is also possible that domestic firm may cut their spending for R&D activity due to decline in profitability from greater competition as it involves risky sunk cost (Veugelers and Houte, 1990).

Veugelers and Houte (1990) argue that complementary and substitution effects from technology inflow would bring different impacts. On one hand, it generates opportunity for domestic firms to access foreign knowledge base which could be greater than domestic. By doing so, domestic economy is able to get involved in R&D activity that otherwise is impossible to due to the lack of necessary equipment and facilities. It would then encourage for more innovation investment. On the other hand, foreign technology could directly substitutes the need to perform own R&D. Domestic firm might decides to employ foreign technology instead of developing its own technology because investment in innovation does not guarantee a return. In such case, existence of technology inflow is expected to discourage domestic innovation activity.

METHODOLOGY AND DATA

This study use EBA approach which was first developed by Leamer (1983). The advantage of using this methodology is that it able to provide robustness and sensitivity test to the explanatory variables compared to other alternative estimator (Wang, 2010). This approach involves varying the subset of control variables included in regression to find the widest range of coefficient estimates on the variables of interest. By varying the subset of control variables and repeating the estimations, it would generate a more robust result of the parameter estimates of the hypothesis to be tested.

Following Wang (2010), the general specification of estimated model is as follows:

$$Y = C_i I + C_m M + C_z Z + \mu$$

where Y is dependent variable, which is domestic R&D intensity used to represent host country's innovation effort, I is variable that is always included in the regression, M is the variables of primary interest, and Z is a set of variables that are considered to be potentially important explanatory variables.

The EBA estimation involves several important steps. First, it starts with the estimation of "base regression" which includes only variables I and M . Then, we estimate regression equations for all possible linear combinations up to three Z variables. The next step is to identify the highest value and lowest value for the variable of interest (β_m) which cannot be rejected at the 5% significance level (Levine and Renelt, 1992) or 10% significance level (Wang, 2010). After that, extreme bound is defined by a group of Z variables; maximum and minimum values of C_m plus two standard errors. This extreme bound is used to infer the confidence of partial relationship between dependent variable (i.e. R&D intensity) and independent variables. The relationship is considered as "robust" if C_m remains significant and has the same sign within the extreme bound. If it is not the case, where C_m does not remain significant or the sign is different, the relationship is indicated as "fragile" since alternation in conditioning information set changes the statistical inference that is drawn regarding dependent variable and variables of primary interest.

Nevertheless, this criterion has been criticized by Sala-i-Martin (1997) as too stringent. The author argues that if the distributions of parameters have some positive and some negative support, then one would found at least one regression with changed sign if enough regressions are run (Dreher, Sturm and Haan, 2010). Thus, this study use the alternative criterion proposed in Sala-i-Martin (1997) which is based on the entire distribution of the parameters, or cumulative distribution function (CDF) across regressions. Instead of only "robust" vs. "non-robust" classifications, this approach would assign some levels of confidence to the variables. Compare a parameter with 95% of the density function lies right to the zero, and a parameter with 50% of the density function lies right to the zero, the former would consider more likely to correlate with dependent variable than another. Following this approach, a variable considers as robust when 90% confidence interval around the parameters is entirely on one side of zero, i.e. CDF (0)¹ above 0.95 (Ahrend, 2012).

This study uses cross-country data from 58 developing countries covering the period of 1996-2011. The dependent variable is R&D intensity which is defined as ratio of R&D expenditure to GDP. This data collected from the *United Nations Educational, Scientific and Cultural Organization (UNESCO) Institute of Statistic database*. The endogenous growth theory suggests human capital as a major determinant of innovation capacity and therefore it is considered as I variable. It is represented by the ratio of population above age 25 having tertiary education and the data were collects from Barro and Lee (2012).

¹Following Sala-i-Martin (1997), the area under density divided into two by zero, and the larger area will be called CDF(0), regardless above or below zero.

The *M* variables are the main focus of this paper which is two channels of technology spillovers namely, import and FDI. There are three measures of imports: i) total import (ratio of total import to GDP); ii) ratio of manufactured goods import to GDP; iii) ratio of machinery and equipment import to GDP. All data were obtained from *United Nations Conference on Trade and Development database*. Meanwhile, FDI is represented by the ratio of net FDI inflow over GDP (FDI/GDP) the data were collected from the *World Development Indicators database*.

The *Z* variables consist of several other variables which are hypothesised to influence R&D activity. Income is included because higher income implies greater profitability and will increase incentives of firm to engage in R&D to further improve profitability. Meanwhile, larger market indicates greater ability to get involved in R&D investment and consumers tend to prefer differentiated products when they grow richer. Income however could be less important for economy that exogenous set the R&D target by government, such as European Council (Wang, 2010). Though Wang (2010) found that income is not a robust determinant for R&D investment among developed countries, this paper would include it in analysis as it is not a common practice among developing countries to set the R&D target by government. Population density is also included in *Z* variables. It is suggested that larger country will spend more on R&D, all else being equal (Wang, 2010). Additionally, this paper considers the role of aggregate physical formation in the analysis. Physical formation could act as complement for R&D investment from the view of aggregate production, or substitute to compete for national resources (Bebczuk, 2002; Wang, 2010). Both growth rate of fixed capital formation and ratio of fixed capital formation to GDP are considered. Macroeconomic variables such as inflation and unemployment rate are important indicators for the business cycle and often examined in literatures. Therefore, they are also included in regressions. The data were extracted from the *World Development Indicators database*. Lastly, we consider the importance of public sector. Government usually provides R&D funding to universities or other research institutes (Wang, 2010). Thus, government's expenditures and imbalance are included in his analysis. At the same time, the share of government R&D is also included in *Z* variables as government expenditures in R&D could have crowding-in or crowding-out effect on private expenditures. The data were obtained from both the *World Development Indicators database* and Institute of Statistic database by UNESCO.

EMPIRICAL RESULTS

This study employs both Leamer and Sala-i-Martin's variants of EBA. A variable is considered to be robust under the Leamer's criterion when the estimated parameter remains statistically significant and with same sign at upper and lower bounds in all regressions estimated with all possible combinations of up to three explanatory variables. Nevertheless, Sala-i-Martin (1997) has criticized this criterion as too stringent. Alternatively, the author suggests the use of entire cumulative distribution function (CDF) across regressions.

The results of EBA with different combinations of independent variables are presented in Tables 4-7. In each table, column (1) and (2) respectively present averages of estimated coefficients and standard errors over all regressions. Column (3) shows the percentage of regressions in which the respective variable is significant at least at the 5% level. Then, column (4) reports the p-value of coefficients. CDF(0)s are reported in column (5). Based on Sala-i-Martin (1997) suggestion, a variable is considered robust if the 90% confidence interval condition is fulfilled² (i.e. CDF(0) is above 0.95) as the variable turn out significant in a very large fraction of the regressions. Finally, column (6) and (7) provides Learner's lower and upper bounds. In each table, there are four models estimated. In the first model, whole set of control variables is included. Nonetheless, some of the variables are measuring similar perspective of an economy, such as government expenditure and government imbalance; or fixed capital formation and fixed capital formation growth. Thus, these variables may be inappropriately included the in regression together. Therefore, model 2 restricts government expenditure and government imbalance not to appear together in the control variables while model 3 restricts the simultaneous present of fixed capital formation and its growth. Finally, model 4 shows the result when both restrictions are implemented.

First of all, human capital is found to be positive and statistically significant in all regressions where the p-values for human capital are lower than 0.01 in all regressions. This relationship is found to be robust under Leamer's criterion as shown in Table 1 and 4: positively significant within the range of high value and low value of the coefficient in all regressions. At the same time, Table 2 and 3 also suggest the robustness of this relationship under Sala-i-Martin's criterion: CDF for human capital is

²The test proposed by Sala-i-Martin (1997) is basically a one-sided test.

greater than 0.95 in all regressions. These findings are in line with literature which suggests that human capital is major determinant of domestic innovation effort. This also justifies the inclusion of human capital as *I*-variable in the EBA model.

Table 1 shows the results of using total import as spillovers channel. In all four regressions with different restrictions being imposed, no significant relationship is found. At the same time, both Leamer's and Sala-Martin's criterion also do not indicate any robust relationship between total import with R&D intensity. In other words, the results do not suggest any significant influence of total import on domestic innovation efforts. A possible explanation for this finding is that among total import, some types of product such as raw material may not embody advanced technology in the product. This restricts spillovers potential, and thus fails to show any significant impact on domestic innovation.

Table 2 presents the results of using other indicator for import. Specifically, import of manufactured goods is used as a spillover channel. The coefficients in all four regressions show that the impact on R&D intensity is only significant with positive signs at the 10% level. The Leamer's criteria did not support for existence of a robust relationship but according to the Sala-i-Martin's criteria, import of manufactured goods is found to be robust in three out of four regressions. Overall, there is weak evidence to support a robust relationship between import of manufactured goods and R&D intensity.

Table 3 presents the result of using import of machinery and equipment as a channel for technology spillovers. This type of product is known for its high technological contents. The results show that the coefficients are significant at 5% level with positive sign in all four regressions. The Leamer's criterion indicates that there is no robust relationship as lower bounds and upper bounds for this coefficient in all four regressions have different signs. However, the Sala-Martin's criterion suggests that the relationship could be considered as robust because the CDFs in all four regressions are above 95 which suggest that the variable maintains its positive sign at least 95% in all combination estimation, regardless of with or without restriction imposed in the model. Thus, it provides sufficient evidence to support the robustness of a positive and significant relationship between import of machinery and equipment with domestic innovation effort in developing countries.

Finally, this paper looks at alternative technology spillover channel namely FDI. Table 4 presents the result which does not support any significant impact of FDI on domestic R&D intensity. Both Leamer's and Sala-Martin's criteria do not indicate presence of any robust relationship between FDI and R&D intensity. The findings are consistent in all four regressions. Thus, this indicates that domestic innovation of developing countries is not affected by FDI inflows. A possible explanation for this finding is that domestic economy does not have the necessary quality which enables them to benefit from FDI inflows. This is consistent with the growing view that knowledge spillover is not an automatic consequence of MSCs presence. It requires host country to have absorptive capacity in order to benefit from it.

CONCLUSION

This study investigates the impact of technology inflow via import and FDI on domestic R&D activity in 58 developing countries. Arguments exist in literature that technology inflow could act as complements for domestic innovation as it is able to improve domestic knowledge base. Arguably, it is also possible that technology inflow substitutes innovation activity due to the possibility that domestic firms find it easier to utilize foreign technology directly instead of investing in R&D.

The EBA approach is implemented to investigate the impact of import and FDI on domestic innovation activity and the results can be summarised as follows. First, human capital is found to be a robust determinant in positively R&D activity. Second, no robust effects are found from total import and import of manufactured goods, as well as FDI. This suggests that no significant impact on domestic innovation effort from these channels. Third, import of machinery and equipment which contain high technological content shows positive and robust impact on domestic innovation. This channel not only brings technology to local firms and enhances domestic productivity as suggested in the literature; it also provides incentives for domestic firms to engage in innovation activity. The findings of this paper are different from the one reported in Wang (2010) for developed countries. Wang (2010) found that technology inflow affects domestic innovation negatively but this paper finds a positive impact in developing countries. One possible explanation is due to different levels of technology base of the host countries. Developing countries with greater technology gaps have greater space to learn from foreign and thus willing to invest in innovation activity, while countries with smaller gaps would prefer to use foreign technology and this may reduce investment in R&D activity.

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TABLE 1: Impact Of Total Import On Domestic Innovation Effort

Variables	(1) Avg. Beta	(2) Avg. SE	(3) % Sign.	(4) P-value	(5) CDF(0)	(6) Lower	(7) Upper
<i>Regression one</i>							
HC	0.015	0.004	100	0.0004	99	0.001	0.029
Import	-0.004	0.003	38	0.1888	92	-0.026	0.011
<i>Regression two</i>							
HC	0.015	0.004	100	0.0004	99	0.001	0.029
Import	-0.004	0.003	39	0.1888	93	-0.026	0.011
<i>Regression three</i>							
HC	0.015	0.004	100	0.0004	99	0.001	0.029
Import	-0.004	0.003	38	0.1888	93	-0.026	0.011
<i>Regression four</i>							
HC	0.015	0.004	100	0.0004	99	0.001	0.029
Import	-0.004	0.003	39	0.1888	93	-0.026	0.011

Notes: Regression one has no restriction in select control variables; regression two restricts that either government expenditure or government imbalance will be included; regression three restricts that either fixed capital formation or fixed capital formation growth will be included in control variables; regression four implements both restrictions.

TABLE 2: Impact Of Manufactured Goods Import On Domestic Innovation Effort

Variables	(1) Avg. Beta	(2) Avg. SE	(3) % Sign.	(4) P-value	(5) CDF(0)	(6) Lower	(7) Upper
<i>Regression one</i>							
HC	0.016	0.004	99	0.0002	99	-0.001	0.029
Manu	0.007	0.004	46	0.0855	94	-0.043	0.036
<i>Regression two</i>							
HC	0.016	0.004	99	0.0002	99	-0.001	0.029
Manu	0.008	0.004	46	0.0503	95	-0.043	0.036
<i>Regression three</i>							
HC	0.016	0.004	99	0.0002	99	-0.001	0.029
Manu	0.008	0.004	47	0.0503	95	-0.043	0.036
<i>Regression four</i>							
HC	0.016	0.004	99	0.0002	99	-0.001	0.029
Manu	0.008	0.004	47	0.0503	95	-0.043	0.036

Notes: Regression one has no restriction in select control variables; regression two restricts that either government expenditure or government imbalance will be included; regression three restricts that either fixed capital formation or fixed capital formation growth will be included in control variables; regression four implements both restrictions.

TALBE 3: Impact Of Machinery And Equipment Import On Domestic Innovation Effort

Variables	(1) Avg. Beta	(2) Avg. SE	(3) % Sign.	(4) P-value	(5) CDF(0)	(6) Lower	(7) Upper
<i>Regression one</i>							
HC	0.015	0.004	99	0.0004	99	-0.001	0.028
Mac	0.015	0.006	72	0.0153	98	-0.020	0.062
<i>Regression two</i>							
HC	0.015	0.004	99	0.0004	99	-0.001	0.028
Mac	0.015	0.006	71	0.0153	98	-0.020	0.062
<i>Regression three</i>							
HC	0.015	0.004	99	0.0004	99	-0.001	0.028
Mac	0.015	0.006	73	0.0153	99	-0.020	0.062
<i>Regression four</i>							
HC	0.015	0.004	99	0.0004	99	-0.001	0.028
Mac	0.015	0.006	72	0.0153	99	-0.020	0.062

Notes: Regression one has no restriction in select control variables; regression two restricts that either government expenditure or government imbalance will be included; regression three restricts that either fixed capital formation or fixed capital formation growth will be included in control variables; regression four implements both restrictions.

TABLE 4: Impact Of FDI On Domestic Innovation Effort

Variables	(1) Avg. Beta	(2) Avg. SE	(3) % Sign.	(4) P-value	(5) CDF(0)	(6) Lower	(7) Upper
<i>Regression one</i>							
HC	0.015	0.004	100	0.0004	99	0.001	0.028
FDI	-0.009	0.019	2	0.6376	68	-0.081	0.062
<i>Regression two</i>							
HC	0.015	0.004	100	0.0004	99	0.001	0.028
FDI	-0.009	0.019	1	0.6376	68	-0.081	0.062
<i>Regression three</i>							
HC	0.015	0.004	100	0.0004	99	0.001	0.028
FDI	-0.009	0.019	2	0.6376	68	-0.081	0.062
<i>Regression four</i>							
HC	0.015	0.004	100	0.0004	99	0.001	0.028
FDI	-0.009	0.019	2	0.6376	68	-0.081	0.062

Notes: Regression one has no restriction in select control variables; regression two restricts that either government expenditure or government imbalance will be included; regression three restricts that either fixed capital formation or fixed capital formation growth will be included in control variables; regression four implements both restrictions.