Knowledge Spillovers across Developing Economies

Manjinder Kaur and Lakhwinder Singh

Globalization has dramatically transformed the world economy during the last quarter of 20th century and more vigorously in the first decade and a half in the 21st century. The most important characteristic of this phase of globalization is the rise of cross border flows of trade, investment, finance and technological knowledge. The rising investment in technological knowledge drives increasingly the long term growth process of the developing economies. It is increasingly realized that the level of trade and FDI across borders effects the knowledge generation and dissemination across countries. In this study an attempt is made to examine the relationship between economic growth measured through total factor productivity and knowledge economy variables such as domestic and foreign R&D covering the period of 2001-2012 across 19 developing countries. The regression analysis used in this study is based on panel data analysis using fixed effects models. The results of the study reveals that domestic knowledge stock, openness and the interaction terms of foreign R&D spillovers with openness, human capital and FDI have shown positive impact on total factor productivity of selected 19 developing economies. Further, the impact of foreign knowledge spillovers channeled through the imports of total goods and services are found to be positive and significant while it has been found negative in case of

Manjinder Kaur, Research Fellow, Department of Economics, Punjabi University, Patiala, India 147002. (E-mail): manukaur30@yahoo.in, (Tel): +91-7696734939, (Fax): 91+175-2283073; Lakhwinder Singh, Professor and Coordinator, Centre for Development Economics and Innovation Studies (CDEIS), Department of Economics, Punjabi University, Patiala, India 147002. (E-mail): lakhwindergill@pbi.ac.in, (Tel): +91-9888755642, (Fax): 91+175-2283073.

The comments and suggestions of two anonymous referees of the journal helped in reshaping the article. The authors are grateful to the referees and Professor Keun Lee for their encouragement with positive criticism and suggestions that resulted into substantive improvements in the earlier draft of the paper. However, the errors and omissions if any that remain is the sole responsibility of the authors.

[**Seoul Journal of Economics** 2017, Vol. 30, No. 3]

capital goods. An important policy implication that results from this analysis is that the higher level of human capital and international trade results into higher level of productivity growth via knowledge spillovers.

Keywords: Domestic R&D Spillovers, Foreign Spillovers, Trade, Technological Capabilities

JEL Classification: O3, O4, O32, F14

I. Introduction

The evolution of the global economy shows that the application of knowledge has played a key role in shaping the trends and patterns of development. The recent phase of globalization and transformation of the global economy has increasingly integrated developing economies with the industrially advanced economies through facilitating the greater flow of trade, knowledge, foreign investment and finance. Among the indirect effects, the knowledge spillovers seem to be the most significant and important source of economic growth (Coe, and Helpman 1995). The endogenous growth theory developed by Romer (1990) and Lucas (1988) underlined the importance of externalities in terms of realizing increasing returns to scale. Both the authors had in fact emphasized more on the basic investment in R&D for generation of new knowledge (Romer 1986) and investment in human capital for raising the level of productivity (Lucas 1988). However, the underlined factor for realizing increasing returns to scale is externalities (spillovers) from R&D and skill formation.

The emergence of endogenous growth theories triggered huge empirical literature to examine the existence of knowledge spillovers across countries and the channels that transmits it (Coe, and Helpman 1995; Coe *et al.* 1997; Keller 2004; Evenson, and Singh 1997; Singh 2004). The early studies on international R&D/knowledge spillovers have shown high degree of presence of spillovers for achieving sustained economic growth in the advanced countries of the world. Coe *at al.* (1997) while extending the scope of their study to developing countries have argued that even greater role of advanced countries R&D investment that generates spillover effects in the development process of the developing countries. These kinds of new developments were critically examined by the scholars on two grounds: one the trade was chosen as the only channel of transmission of international R&D spillovers (Keller 1998), and two, the capability to receive knowledge spillovers among the developing countries was completely ignored (Evenson, and Singh 1997; Singh 2004).

As the presence of foreign direct investment was increasingly being felt in the developing countries, several studies argued (Amann, and Virmani 2014) that the rise of long-run total factor productivity of the developing countries is mainly influenced by the channels of R&D spillovers, that is, the outward foreign direct investment and inward foreign investment. Another study, while assessing the role of R&D intensity and five knowledge diffusion channels in augmenting the productivity of manufacturing firms in Turkey over the period 2003-07 reveals that 1 per cent increase in in-house R&D leads to 0.3 per cent increase in labor productivity across the firms. In addition to that regarding the five knowledge diffusion channels, it has been found out that R&D spillovers tend to have negative impact on productivity of firms having low technological capabilities as compared to firms having high technological capabilities. Thus, highlighting the prominence of country's own technological capability and absorptive capacity in the form of human capital, it is emphasized that domestic capabilities help in getting the advantage of foreign knowledge spillovers. On the other hand, impact of foreign ownership shares and technology licensing tends to have positive contribution in augmenting firms' productivity but impact of international trade has remained non-significant (Ulku, and Pamukcu 2015).

The technological catch-up literature has also examined and provided substantial evidence of the presence of international knowledge spillovers through patent citations and its impact on developing short cycle technological capabilities that determine the long run growth and sustainability of the developing countries (Lee 2013). From the foregoing literature, it is safely concluded that there are several channels through which knowledge spillovers effects economic growth process of the developing countries. As seen through the literature each study emphasized on a particular channel of transmission of knowledge spillovers. Therefore, it is difficult to know which channel of transmission is more effective among the developing countries. To fill this gap, this study tries to test alternative channels and national capabilities to catch up the knowledge spillovers by the developing countries. An attempt is made in this study to empirically verify the degree of knowledge spillovers transmitted from the technologically advanced countries to the selected 19 developing countries who have sufficiently developed technological capabilities. It is pertinent to point out here that this study also covers the period of fast phase of globalization which is most important for policy makers and academics alike to know about the extent of knowledge spillovers and most effective channels that transmits it. Thus, the claim of this study is that it is successfully able to provide both.

The rest of the paper is organized in four sections. The second section provides theoretical and empirical review of literature. The third section describes the data base and also develops econometric model. The empirical evidence and analysis is presented in section four. Summary and conclusions are presented in the last section.

II. Theoretical and Empirical Review of Literature

From Neoclassical to endogenous growth models, there has been a drastic shift in the literature on the sources of economic growth. As in case of former, economic growth has been assumed to be spurred by capital accumulation while considering the technological progress as an exogenous process, whereas in the case of latter *i.e.*, endogenous growth models, the underlying force behind the technological progress and economic growth is assumed to be commercially oriented innovative efforts responding to the various economic incentives (Romer 1990; Grossman, and Helpman 1991). But, it has been widely noticed that a considerable share of these innovative activities are concentrated in only a handful of rich countries while the developing countries are lagging far behind in this arena. Thus, the pattern of worldwide technical change is largely getting determined by international technology diffusion (Keller 2004) which results in the growing integration and interdependence among developed and developing economies.

To study the impact of this phenomenon on economic growth and productivity, a number of the studies have been conducted so far by taking the different channels for the transmission of these spillovers especially arising from innovative and technological activities undertaken in developed or advanced economies. Thus, in this section we have very briefly included the glimpses of literature relating to these knowledge or technological spillovers and their consequent impact on productivity and growth across various economies. As, there exist a number of different channels for the diffusion of these knowledge or technological spillovers, we have classified the different studies on the basis of the channels they have included in their studies.

A. Foreign R&D Capital Stock

A pioneering empirical study in this context was conducted by Coe, and Helpman (1995) to assess the impact of domestic as well as foreign R&D capital stock on country's productivity level by using the dataset of 21 OECD economies plus Israel from 1971-90 and found out the positive and significant impact of domestic as well as foreign R&D spillovers on total factor productivity. This study initiated a debate and was extended by other researchers by including the other significant channels of spillovers rather than relying only upon foreign trade as a source of diffusion of technology. Another study conducted by Basant, and Fikkert (1996) by using the dataset of Indian firms have found out the high and statistically significant private returns to technology purchase as compared to private returns from firms' own R&D expenditure. Similarly, another study examining the channels through which less developed countries (LDCs) can realize positive spillovers from interacting with industrialized countries found out that the foreign R&D and FDI stock results into positive spillovers in Latin America, while machinery and equipment imports create spillovers in Southeast Asia (Dimmerman 2003).

B. Trade

Trade has been regarded as an engine of economic growth (Joseph 2013). Bringing into prominence the significance of international growth linkages while determining the factors behind long-run economic growth Singh (2001) have enlarged the scope of Coe, and Helpman (1995) study by including the imports from the leader country and also its interaction with foreign R&D capital stock as another significant channels for the diffusion of international R&D spillovers on productivity level by taking the case of 11 Asian economies over the period of 1970-93. The findings from this study have supported the positive role of international R&D spillovers for productivity growth across this sample. However, import alone has not represented any significant spillovers effect but its interaction with foreign R&D stock have casted the positive role in augmenting the level of TFP. In the similar vein, Engelbrecht (1997) have also provided the empirical support for the existence of large R&D spillovers and the significance of trade as a conduit for their propagation. Further, Coe *et al.* (1997) in his subsequent study, while establishing the positive role of domestic and international R&D stocks in enhancing productivity has also recognized the trade as a major transformation mechanism. Realizing the beneficial impact of trade in boosting the productivity of an economy, the study also confirmed this notion by adding the empirical evidence of developing economies other than newly industrialized economies (NIEs) in which amplifying the imports of manufactures by 5% points of GDP resulted into enhancement of output by 6.5 percent in the long run. Following this study, Kao *et al.* (1999) have also cited that impact of foreign spillover on TFP is determined by the extent of trade of economies with other economies. Thus, openness of the economies is also a major determinant for augmenting foreign R&D spillovers. Frantzen (2000) while estimating the relationship between business sector TFP and domestic R&D efforts across the OECD countries during the time period of 1961-1991 has found out the strong positive influence of international technological diffusion on TFP than that of domestic R&D. Singh (2004) in his another study while assessing the impact of foreign R&D spillovers, by taking the data of 28 industries of South Korea over the time period of 1970-2000 has also brought into prominence potential role of trade in augmenting the impact of foreign spillovers as compared to the technology matrix. Thus, innovation and trade are two important carriers of technological spillovers for developing economies to catch-up with developed ones (Madden *et al.* 2001). A recent study conducted in this context by Ang, and Madsen (2013) while assessing the impact of the stocks of knowledge and international knowledge spillover across six Asian miracle economies on their TFP by taking the imports, exports, inward FDI, flow of patents between countries, geographical prosperity and the general channel as the transmission mechanisms have found the import channel and general channel as the most significant channel of knowledge spillovers for Asian miracle economies.

C. Foreign Direct Investment (FDI)

Although, trade has been considered as the most significant channel for the diffusion of technology spillovers across countries, but after 1991 reforms, there has been a large rise in the inflow of FDI in developing economies (Gill, and Singh 2012), thus it has become an another potential channel for technology transfer. Therefore, a number of studies have been conducted to ascertain the role of FDI as a channel of technology spillovers across economies. Comparing the two different trade regimes *i.e.*, inward and outward oriented in case of Uruguay, where under the former approach, the foreign firms were required to bring with them new technology and also have to focus on the development of local market but in the case of latter, these foreign firms have started exploiting the human capital and skills of the host country, they are no longer engaged in such operations based on new production technologies that can be easily imitated or adopted by local forms. Thus, there exists no evidence of productivity spillovers from the operations of these more outward-oriented MNCs to locally owned (Kokko *et al.* 2001). A study conducted by taking the firm level data of Japanese manufacturing industries has found out the positive impact of R&D stock of foreign owned firms in enhancing the productivity of domestic firms while the effect of capital stocks of foreign firms are found to be absent (Todo 2006). Similarly, while examining the efficiency of three channels of R&D spillovers in case of 21 OECD economies plus Israel from 1981-1991, bilateral trade and information technology have remained as the most significant channels for international R&D spillovers, but the impact of FDI has been found to be very mild (Zhu, and Jeon 2007). Reviewing the possible sources of FDI induced spillovers and then evaluating its empirical evidence on productivity, wages and exports spillovers in developing, developed and transitional economies have revealed that there exists no clear evidence that domestic firms always and unambiguously gain from the presence of MNEs (Gorg, and Greenaway 2004).

D. Geographic Effects on International Technology Diffusion

Assessing the impact of geographic and spatial factors of international technology diffusion, Branstetter (2001) while estimating the relative impact of international knowledge spillovers on innovation and productivity by using data at the firm level from US and Japan for the period 1985-1989 and 1983-89 have found out the strong evidence of intra-national knowledge spillovers as compared to international spillovers. The underlying reason behind it is that weak knowledge flows and strong rivalry results into negative foreign R&D spillovers. Similarly, Bottazzi, and Peri (2003) in their paper have made an attempt to identify and estimate of research externalities in spurring the innovations across space by using data of 86 European regions over the time period of 1977-95. The results of their study revealed that although R&D expenditure incurred by a region tend to generate the externalities for other regions but it is bounded by the distance of 300 kms, afterwards which the impact of these externalities begins to decline. The underlying cause behind this short range of spillovers for other regions is that such spillovers are the outcome of diffusion of non-codified knowledge between people having frequent interactions, thus, they mostly interact within border as compared to across countries leading to weak externalities.

Likewise, a wide range of differences in the institutions, policies and regulations can be traced across the international borders; contrary to it regions within borders are more integrated and engaged in more trade and risk sharing factors. Thus, a study conducted by Naveed, and Ahmad (2014) has explored the border effects of knowledge spillovers by taking the case of various regions of EU and dividing them into internal and external border regions reveals that although regional productivity is determined to a large extent by external regional knowledge and technological spillovers, but the strong border effects overpower the effects of technology and knowledge transfer. Hence, the impact of spillovers across the international borders are statically insignificant due to the presence of language and cultural barriers, borders and as well as impediments of various rules and regulations

E. Human Capabilities as an Absorptive Determinant of Foreign R&D Spillovers

Extending the study of Coe, and Helpman (1995) further, Engelbrecht (1997) has included human capital as another variable explaining TFP in addition to domestic and international capital stock. The inclusion of this new variable has resulted into shrinking share of international R&D spillovers by about 30 per cent while having little impact on other coefficients. Thus, human capital is found to have significant impact on TFP, as an input variable as well as a catch up variable. Engelbrecht (2002) in his another study has compared the two major approaches given by Lucas and Nelson-Phelps towards including the human capital in the growth regressions in the context of developing country models with international knowledge spillovers. This study has brought into prominence the role of human capital in absorption of embodied R&D spillovers as well as disembodied spillovers by confirming the superiority of Nelson-Phelps approach over Lucas approach which considers human capital only as a factor of production. In another study conducted by Singh (2001) underlying the significance of international growth linkages while determining the factors behind long-run economic growth has observed that these spillovers do not benefit all the economies on equal basis because human capital and learning abilities play a very important role in absorbing these spillovers. Thus, the important policy implication of the study is that to fully realize the potential of foreign spillovers, a country should emphasize on improving its human capabilities and develop basic technological capabilities. In the similar vein, Guellec, and De La Potterie (2001) has also highlighted the role of inner technological capabilities (absorptive capabilities) of a country to make the best use of foreign technology.

F. R&D Co-operation and Foreign Ownership Share

Further taking into account R&D cooperation and localization of FDI as the other two significant transmission channels of technological externalities in addition to own R&D, and R&D efforts of its trading partners. Sadraoui (2011) has tried to explore the relationship between total factor productivity and these technological or knowledge externalities for six Mediterranean countries for the period of 1970 to 2008. The results of the study reveal that impact of R&D cooperation in expanding the growth of an economy is determined by a country's internal expenditure on R&D. Although R&D cooperation in the situation of excessive competition tend to increase social welfare by augmenting the consumer as well as producer surplus, but very few spillovers effects of R&D cooperation has been noticed by this study. Thus, however in some developing economies there exists a positive relationship between R&D cooperation and economic growth but this finding cannot be generalized to all economies. Belitz, and Molders (2013) have included another two significant sources of international knowledge spillovers *i.e.*, imports of high-tech goods and internationalization of business R&D by covering both developing and industrial countries. While analyzing the impact of these two variables, they have used the foreign owned patents as a proxy for R&D activities of multinationals. The results of the study confirm the significance of import spillovers for all countries included, and the existence of additional spillovers for developing countries through the import of high-technology goods, but in case of second variable, only developed countries seemed to benefit with the diffusion of knowledge that originates through cross-border cooperation in R&D by multinationals. In a recent study by Ulku, and Pamukcu (2015), while assessing the impact of R&D intensity and five knowledge diffusion channels in augmenting the productivity of manufacturing firms in Turkey over the period of 2003-07 has found that 1 percent increase in the in-house R&D leads to 0.3 per cent increase in labor productivity across the firms having average technology capabilities. Further, analyzing the impact of five major knowledge diffusion channels on augmenting the productivity level reveal that impact of foreign ownership shares and technology licensing on firms' productivity remain consistently positive and significant, however, the impact of technology licensing become significant only after reaching a threshold level of technological capability.

Based on the review of the earlier literature on knowledge and technological spillovers arousing through different channels and ascertaining their impact on augmenting the level of TFP and growth across different economies, most of the studies revealed that trade and human capital have remained the most significant conduits for the transmission of these spillovers (Nursamsu, and Hastiadi 2015; Engelbrecht 1997). While the studies based on other diffusion channels *i.e.*, FDI and R&D co-operation have not revealed any apparent evidence regarding the impact of these channels in augmenting the level of TFP and growth across economies (Kokko *et al.* 2001; Sadraoui 2011). Thus in the present study, we have tried to enlarge the scope of earlier studies by integrating all the prominent channels of knowledge spillovers *i.e.*, trade, human capital, FDI and openness to trade and as well as their interaction with foreign knowledge spillovers as the transmission mechanisms for R&D spillovers across 19 selected developing economies over the period of 2001-2012.

III. Database and Methodology

From the above reviewed literature, role of technological progress for sustaining the long run economic growth is amply clear. However, various endogenous growth models developed by Grossman, and Helpman (1991), Aghion, and Howitt (1992) and Coe, and Helpman (1995) and Coe *et al.* (2009) has regarded the commercially-oriented innovative efforts as the prominent agent of technological progress and productivity growth. Thus, it leads to the sizeable investment in technological capability for ensuring effective use of technological knowledge and generating sizeable spillover benefits. These spillovers effects are likely to accumulate mainly by the economies having comparatively higher investment in R&D and those who are more integrated through international flows of trade. Thus, when an economy has an access to the inputs available in its trading partners, its productivity is no longer determined only by its own R&D but rather it also depends on R&D activities of its trading partners. The present study is based on the empirical evidence of trade-related international R&D spillovers mentioned by Coe, and Helpman (1995). Like Luintel, and Khan (2004), this study is also based on the assumption that elasticity of R&D to TFP is not identical across all the countries. Thus, the economies investing more in R&D are likely to get more benefits of external R&D stock.

This paper builds on the methodologies suggested by Coe, and Helpman (1995), and Singh (2004). Therefore, methodology of our study overlaps noticeably with the above mentioned studies. In the present study, we have taken the data for 19 developing economies for the period of 2001-2012 and the selection of number of countries and this time period is governed by the availability of time series data. The main sources of data are World Development Indicators (WDI) of the World Bank, UIS Statistics on Science and Technology, IMF Direction of Trade Statistics and the conference Board total economy database, 2016.

Unlike the most of cross country studies examining the output growth as an outcome of accumulation of labor and capital in addition to some other economic and political determinants, the present study focused on the growth of TFP which is the component of output growth that is not attributable to the accumulation of inputs. The present study is based on the data published by The Conference Board where the growth of Total Factor Productivity is estimated as a Tornqvist

Index.

A. Specification and Estimation

The production function of an economy is assumed to be linearly homogenous function of employed inputs. Furthermore, the quality and quantity of these inputs improves through R&D investment made by a particular economy. Thus, there exist a strong linkage between TFP and the domestic R&D capital stock of an economy.

In addition to domestic R&D capital stock, international trade in intermediate goods also enables a country to have access to all the inputs available in the rest of world. Thus, the country's TFP also becomes dependent on R&D stock of its trading partners bringing into prominence the significance of foreign R&D capital stock. Another potential determinant of TFP is human capital.

Thus, in the framework of our study, we consider a log-linear Cobb-Douglas production function transformed as follows:

$$\log(\mathrm{TFP})_{it} = \alpha_i + \beta_1 \log RD_{it} + \beta_2 \log SRDTI_{it} + \beta_3 GFCF_{it} + \beta_4 IMP_{it} + \beta_5 HC_{it} + e_{it} \tag{1}$$

Where

α_i is the intercept term

TFP_{it} stands for total factor productivity of country i in time period t.

RD_{it} is the domestic R&D stock of country i in time period t.

$SRDTI_{it}$ is international R&D stock based on weights used as share of imports of goods and services imported by i country in time period t.

IMP is the ratio of the import of total goods and services to GDP by country i in time period t

HC_{it} is human capital taken as a proxy for ratio of total secondary enrollment to secondary school age population from sample countries.

$GFCF_{it}$ is Gross fixed capital formation (as the % of GDP) undertaken in country i in time period t.

e_{it} is the random disturbance term.

B. Construction of the Variables

a) Total Factor Productivity (TFP)

The total factor productivity is the portion of output not explained by the amount of inputs used in production. As such, its level is determined by how efficiently and intensely the inputs are utilized in production (Comin 2006). The present study has used the data published by The Conference Board where the growth of Total Factor Productivity is estimated as a Tornqvist Index.

b) Domestic R&D Stock (RD_{it})

As TFP depends on the available conglomeration of intermediate inputs which further depends on past R&D investment both at the domestic and international level. Thus, to estimate domestic R&D stock based on the R&D expenditure incurred by the economies, we have employed Perpetual Inventory method as follows

$$RD_{it} = (1 - \delta)\ R_{t-1} + \mathrm{R\&D\,exp}_t$$

Where

RD_{it} is the R&D capital stock in country i in time period t

δ is the rate of depreciation which is assumed to be 5% in present study

$\mathrm{R\&Dexp}_t$ is the real R&D expenditure derived by deflating the nominal expenditure by R&D price index.

Thus, R&DPI = 0.5 WPI + 0.5 CPI

Here, WPI stands for wholesale price index

CPI is cost of living index of urban workers

Attaching weights of 0.5 to both of these indexes is guided by the assumption that half of the total R&D expenditure is incurred on the salary of scientists and engineers employed in this sector while the other half is used for utilizing the intermediaries' and equipment in R&D sector. Based on Singh (2004) study, the benchmark for the year 2001 is calculated as follows

$$R_{2001} = (\mathrm{R\&Dexp}_{2001})/(g + \delta)$$

Where, g represents trend growth rate of real R&D expenditure over the period of 2001-2012. Thus, following the above equation, the R&D stock for each of 19 developing economies have been constructed.

c) Foreign R&D Capital Stock (SRDTI)

After constructing the R&D capital stock for each of the 19 developing economies and also of their trading partners (that is, industrially advanced countries) foreign R&D capital stocks denoted by SRDTI has been constructed, where SRDTI is the sum of the R&D capital stock weighted by the bilateral import shares (total goods and services and technological leader countries (see the list of countries Appendix 1).

The bilateral import shares were calculated for each year from 2001-2012 based on the data from the IMF's Direction of Trade Statistics.

$$SRDTI = \sum_{j \neq i} \frac{m_{ij}}{m_i} RD_j$$

where, m_{ij} is the flow of imports of total goods and services of country i from country j. m_i is the total imports of country i from its trade partners. This formulation implicitly assumes that a country will reap, ceteris paribus, more international R&D spillovers if it imports more from countries with a relatively high domestic R&D capital stock.

d) Import Share (IMP_{it})

Imports of goods and services represent the value of all goods and other market services received from the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. Import share (IMP) in the present study is the fraction of imports relative to GDP for country i in time period t.

e) Human Capital (HC_{it})

HC_{it} is human capital taken as a proxy for ratio of total secondary enrollment to secondary school age population in country i in time period t.

f) Gross Fixed Capital Formation ($GFCF_{it}$)

$GFCF_{it}$ is gross fixed capital formation includes land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. According to the 1993 SNA, net acquisitions of valuables are also considered capital formation. Here, we have included GFCF as the percentage of GDP undertaken by country *i* in period *t*.

g) Foreign Direct Investment (FDI_{it})

FDI_{it} is the foreign direct investment are the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. In the present study, this series shows net inflows (new investment inflows less disinvestment) as the ratio of GDP of country *i* in time period *t*.

h) Openness to Trade ($Openness_{it}$)

Openness to trade is the sum of exports and imports of goods and services measured as a share of gross domestic product of country *i* in time period *t*.

Although, the foreign R&D capital stock SRDTI has been weighted by import shares, these weights are the fractions that add up to one and therefore do not properly reflect the level of imports. Whenever two countries have the same composition of imports and face the same composition of R&D capital stock among the trading partners, the country that imports more relative to its GDP may benefit more from foreign R&D. Therefore, a modified specification of equation (1) that accounts for the interaction between the foreign R&D capital stock and level of international trade may be preferable. Furthermore, the enhancement of technological capacity through educated human capital can lead to a better usage of their own R&D and can absorb the spillovers arising from foreign R&D resulting into higher productivity growth leading to the inclusion of another interaction term *i.e.*, human capital and foreign R&D capital in following equation. Thus, our subsequent equation has been defined as follow:

Since the regression based on non-stationary data series can results in spurious regression results, we have checked the stationary status of data by applying the unit root test *i.e.*, Levin–Lin–Chu and all the series of data is found to be stationary.

$$\begin{aligned}\log(TFP)_{it} = {} & \alpha_{\mathrm{i}} + \beta_1 logRD_{it} + \beta_2 \log SRDTI_{it} + \beta_3 GFCF_{it} + \beta_4 IMP_{it} \\ & + \beta_5 HC_{it} + \beta_6 \log SRDTI_{it} * IMP_{it} + \beta_7 \log SRDTI_{it} * HC_{it} + e_{it}\end{aligned} \tag{2}$$

We extend the equation (2) further, by including FDI and openness to trade as additional sources of international knowledge spillovers in equations (3) and (4)

$$\begin{aligned}\log(TFP)_{it} = {} & \alpha_i + \beta_1 \log RD_{it} + \beta_2 \log SRDTI_{it} + \beta_3 GFCF_{it} + \beta_4 IMP_{it} \\ & + \beta_5 HC_{it} + \beta_6 \log SRDTI_{it} * IMP_{it} + \beta_7 \log SRDTI_t * HC_{it} \\ & + \beta_8 FDI_{it} + \beta_9 Openness_{it} + e_{it}\end{aligned} \tag{3}$$

where FDI is the foreign direct investment, net inflows (% of GDP) and openness stands for the openness to trade captured by the data on Trade (% of GDP)

$$\begin{aligned}\log(TFP)_{it} = {} & \alpha_i + \beta_1 \log RD_{it} + \beta_2 \log SRDTI_{it} + \beta_3 GFCF_{it} + \beta_4 IMP_{it} \\ & + \beta_5 HC_{it} + \beta_6 \log SRDTI_{it} * IMP_{it} + \beta_7 \log SRDTI_{it} * HC_{it} \\ & + \beta_8 FDI_{it} + \beta_9 Openness_{it} + \beta_{10} \log SRDTI_{it} * GFCF_{it} + e_{it}\end{aligned} \tag{4}$$

In the above mentioned equations, we have estimated the foreign knowledge spillovers carried out through imports of total goods and services. As a country's level of productivity is determined by the composition of its imports *i.e.*, amount of intermediate and capital goods, we have separately estimated the impact of imports of capital goods on total factor productivity of these 19 selected economies in the subsequent section.

$$\begin{aligned}\mathrm{Log}(TFP)_{\mathrm{it}} = {} & \alpha_i + \beta_1 \log RD_{it} + \beta_2 \log SRDK_{it} + \beta_3 GFCF_{it} + \beta_4 IMP_{it} \\ & + \beta_5 HC_{it} + \beta_6 \log SRDK_{it} * IMP_{it} + \beta_7 \log SRDK_{it} * HC_{it} \\ & + \beta_8 FDI_{it} + \beta_9 Openness_{it} + \beta_{10} \log SRDK_{it} * FDI_{it} \\ & + \beta_{11} \log SRDK_{it} * Openness_{it} + \beta_{12} \log RD_{it} * \log SRDK_{it} + e_{it}\end{aligned} \tag{5}$$

IV. Empirical Evidence and Analysis

The data employed in the present study is a balanced panel data set of 19 selected developing economies covering the time period of 2001-2012. Table 1 reports summary statistics on the data employed in the present study. All variables are expressed as logarithms and are given as percentages except TFP for which Tornquist expression of TFP growth has been employed.

In table 1, the columns (1), (2), (3), (4), (5) and (6) show the mean and standard deviation values of TFP, R&D stock, foreign knowledge spillovers (SRD) based on imports of goods and services, foreign knowledge spillovers based on imports of capital goods, human capital in terms of gross enrolment ratio in secondary education and import shares. The column (1) displays average and standard deviation of TFP across the selected economies over the period of 2001-2012 and it reveals that average value of TFP has remained highest for Belarus followed by Azerbaijan, Bulgaria and Egypt whereas it has been least in case of Madagascar and Armenia. The column (2) reveals that average of R&D stock, which is found to be highest in case of China, followed by Brazil whereas it has remained lowest for Kyrgyz Republic. Taking the case of foreign knowledge spillovers carried through imports of total goods and services in column (3) highest value has been found out for Mexico followed by Panama, Brazil and China whereas it has remained lowest for Bulgaria. Whereas in case of foreign knowledge spillovers carried through the imports of capital goods in column (4), Romania has remained on the top with the highest average value followed by Mexico and Thailand accorded the lowest value. Looking at the another important variable *i.e.*, human capital in column (5) which is captured through gross enrolment ratio in secondary education in the present study reveal that Belarus is having highest average of human capital followed by Brazil and it has been lowest in case of Madagascar. Lastly, in case of import share in column (6), Malaysia has the highest average of import share over this period of time followed by Panama and Belarus whereas Brazil has recorded the lowest import share over this period of time. Thus, these descriptive statistics reflect that the countries having the higher level of human capital and import shares are also having the higher level of foreign knowledge spillovers, whereas TFP and domestic R&D stock do not seem to have an unambiguous relationship with foreign knowledge spillovers.

Table 1
Mean values of Key variables included in Equation (1)

Countries	TFP (1)	R&D Stock (2)	SRD (TI) (3)	SRD (K) (4)	Human Capital (HC) (5)	Import Share (Imp) (6)
India	1.54	10.99	17.17	17.30	56.66	23.03
	(0.73)	(1.40)	(1.22)	(1.13)	(7.50)	(6.17)
Pakistan	1.73	8.21	17.08	17.31	30.13	18.69
	(0.80)	(1.69)	(1.19)	(1.20)	(7.02)	(2.67)
China	1.51	11.71	17.28	17.14	73.39	24.43
	(0.74)	(0.83)	(1.11)	(1.21)	(11.13)	(3.76)
Brazil	1.66	10.87	17.54	17.25	100.60	12.63
	(0.75)	(1.64)	(1.09)	(1.10)	(7.01)	(0.99)
Thailand	1.63	8.80	17.37	12.64	74.83	62.12
	(0.76)	(1.38)	(1.13)	(1.08)	(8.83)	(5.96)
Panama	1.61	8.17	18.01	16.81	70.24	72.33
	(0.75)	(1.29)	(1.12)	(1.10)	(5.02)	(7.73)
Mexico	1.73	10.87	18.11	17.55	80.06	28.88
	(0.77)	(1.26)	(1.10)	(1.06)	(4.16)	(2.75)
Malaysia	1.63	9.78	17.49	17.39	67.86	82.62
	(0.76)	(1.20)	(1.10)	(0.81)	(2.27)	(10.26)
Madagascar	0.55	5.66	16.88	18.04	24.96	42.97
	(0.30)	(1.07)	(1.22)	(1.04)	(8.80)	(9.71)
Armenia	1.51	4.52	16.69	16.92	94.63	44.54
	(0.78)	(1.35)	(1.09)	(1.01)	(7.21)	(3.53)
Kyrgyz Republic	1.60	4.10	17.10	12.64	85.83	68.89
	(0.75)	(1.23)	(1.22)	(1.08)	(1.91)	(20.67)
Ukraine	1.50	9.06	16.61	16.72	99.06	52.77
	(0.75)	(1.15)	(1.19)	(1.18)	(4.75)	(2.81)
Azerbaijan	2.49	5.72	16.37	16.89	95.86	38.56
	(1)	(1.38)	(1.51)	(1.13)	(3.87)	(17.83)
Belarus	2.58	7.47	16.51	16.74	112.61	68.98
	(1.04)	(1.38)	(1.18)	(1.17)	(4.60)	(6.37)
Bulgaria	1.78	7.05	16.24	16.65	91.36	56.82
	(0.77)	(1.30)	(1.04)	(1.09)	(2.26)	(10.32)
Romania	1.58	7.91	16.30	23.43	89.97	41.30
	(0.77)	(1.35)	(1.11)	(2.28)	(8.03)	(2.94)
Turkey	1.63	9.53	16.85	16.92	86.04	26.76
	(0.76)	(1.44)	(1.18)	(1.16)	(3.06)	(2.98)
Egypt	1.75	7.88	17.16	17.12	77.38	28.67
	(0.78)	(1.45)	(1.10)	(1.15)	(5.06)	(5.24)
Tunisia	1.65	7.29	16.53	16.88	86.10	50.28
	(0.76)	(1.37)	(1.18)	(1.14)	(6.13)	(5.91)

Note: Figures in Parenthesis are Standard Deviation values.

To carry out further analysis, we have tried to estimate the productivity effects of a country's own R&D capital stock and, international spillover R&D stock as well as human capital and gross fixed capital formation on the individual country's productivity growth, by using a panel data set for a sample of 19 developing economies covering the time period 2001-2012. The panel data techniques *i.e.*, fixed effects and random effects models have been applied on this data by using the statistical software known as STATA 13. As, there is always a trade-off between efficiency and consistency in the random and fixed effects models, the results of Hausman test help us to accept the results of fixed or random effect model on the plea that whether the magnitude of bias from random effect model exceeds the gain in efficiency. Thus, results of Hausman test in the present study clearly reject the estimates of random effects model in the favor of fixed effects models. The results of Fixed effects models are shown in Table 2 corresponding to the four models included in the present study.

The estimated parameters obtained from equation (1) in Table 2 are highly significant except the foreign knowledge spillovers, GFCF and import shares as a proportion of gross domestic product. The parameter of share of imports is negative while for foreign spillovers, it is positive but it is not significant in equation (1).

As the rate of return to investment in R&D is also affected by accumulation of human capital in a particular economy (Sjorgen 1998) and the higher level of human capital allows tangible inputs to be used more effectively (Englebrecht 1997). Thus, human capital enhances absorptive capacity of country's innovation to both national and international spillovers. In addition to it, imports are also a major carrier for foreign knowledge spillovers. Thus, including the interaction terms of import and human capital with foreign R&D spillovers in equation (2) have turned all the variables significant except GFCF, while the coefficient for human capital has remained negative which is due to three possibilities as proposed by Prichett (2001). One, the newly created educational capital got engaged in privately remunerative but socially unproductive activities. Two, the slow growth of demand for educated labor is leading to decline in schooling. Three, the failure of the educational system to provide skills. Thus, the impact of education tends to vary widely across countries.

Furthermore, although trade has been considered as the most significant channel for the diffusion of technology spillovers across the

TABLE 2
ESTIMATED COEFFICIENT OF FIXED EFFECTS MODELS
(DEPENDENT VARIABLE IS LOG TFP)

Independent Variable \ Equations	(1)	(2)	(3)	(4)
Constant	-3.291***	2.868***	2.51***	2.028**
	(-6.99)	(3.85)	(3.34)	(2.00)
Log (RD)	0.533***	0.5449***	0.5317***	0.5365***
	(14.46)	(17.62)	(17.14)	(16.88)
Log (SRDTI)	0.013	-0.4009***	-0.379***	-0.3539***
	(0.31)	(-7.15)	(-6.77)	(-5.30)
HC	0.0066***	-0.050***	-0.048***	-0.049***
	(2.48)	(-6.69)	(-6.47)	(-6.50)
GFCF	0.00218	0.00227	0.0074**	-0.0357
	(0.62)	(0.77)	(2.09)	(-0.39)
IMP	-0.0014	-0.0327***	-0.033***	-0.0339**
	(-0.65)	(-3.41)	(-3.05)	(-3.10)
Log (SRDTI*HC)		0.0039***	0.0037***	0.0379***
		(8.05)	(7.69)	(7.71)
Log (SRDTI*IMP)		0.0019***	0.0019***	0.0019***
		(3.50)	(3.59)	(3.60)
FDI			-0.009**	-0.0099*
			(-2.23)	(-2.34)
OPENNESS			0.0011	0.00147
			(0.39)	(0.51)
Log (SRDTI*GFCF)				-0.0016
				(-0.72)
R^2	0.9218	0.9443	0.9461	0.9462
N	228	228	228	228

Notes: 1. Figures in parentheses are t-values.
2. *** significant at 1% level; ** significant at 5% level; and *significant at 10% level

countries, but after 1991 reforms, there has been a large rise in the inflow of FDI in developing economies (Gill, and Singh 2012), thus it has become an another potential channel for technology transfer and knowledge spillovers. The equation (3) of the table 2 includes the FDI and openness as another two significant channels for international knowledge spillovers. The estimated coefficients for FDI is found to be negative and significant which is backed by the reason FDI in developing economies by outward oriented MNC's are not targeted on enhancing the efficiency of locally owned firms, while for Openness it is insignificant. Further, examining the interaction of GFCF with foreign spillovers in equation (4) has negative but insignificant impact on TFP. The inclusion of this interaction term has also resulted into altering the significance and direction of other variables as coefficient of GFCF has now turned negative and also turned out to be insignificant.

However, there are several limitations of the results reported in table 2 which need to be addressed before the final conclusions are drawn. The above results are based on some fundamental assumptions that the error terms are serially uncorrelated. Thus, subsequently checking the robustness of the results reported in the table 2 for autocorrelation by using the Woolridge's test for autocorrelation in panel data confirmed the presence of autocorrelation in above results. To test the robustness of our results, we have estimated the clustered robust standard errors and the results are reported in table 3.

Further, comparing the results in table 3 with table 2, we have found that these results are slightly different from the results reported in table 2, as there has been a change in signs and relative significance of the coefficients whereas magnitude of coefficients of all the variables remained the same. The coefficients for first equation in table 3 differs from table 2 as the coefficient for GFCF has turned significant while for human capital it has turned out insignificant. But, the results reported in equation (2) does not reveal any change, while in equation (3) and (4), there has not been any major change except the change in magnitude of significance of variables.

When we compare our estimated coefficient with other studies, our estimates are corroborated and supported by several studies. It has been widely observed that most of the new technology and innovations activities are concentrated in the handful of rich industrialized countries; the developing countries have to depend largely on these advanced economies for technological spillovers (Keller 2004; Saggi 2002; Eaton, and Kortum 1999). But, in our study, we have found the negative coefficient for the impact of foreign R&D spillovers on TFP across selected sample of economies. This negative coefficient for foreign R&D spillovers is backed by number of reasons: the positive impact of these foreign R&D spillovers is conditioned by the presence of higher

TABLE 3
ESTIMATED COEFFICIENT OF FIXED EFFECTS MODELS
(DEPENDENT VARIABLE IS LOG TFP)

Independent Variable \ Equation	(1)	(2)	(3)	(4)
Constant	-3.29*** (-3.36)	2.86** (2.11)	2.51* (1.94)	2.02 (1.26)
Log (RD)	0.533*** (8.49)	0.5449*** (9.42)	0.5317*** (9.42)	0.536*** (9.43)
Log (SRDTI)	0.013 (0.20)	-0.4009*** (-4.13)	-0.379*** (-4.01)	-0.3539*** (-3.48)
HC	0.0066 (1.02)	-0.0507*** (-4.02)	-0.0489*** (-3.73)	-0.049*** (-4.09)
GFCF	0.00218* (0.43)	0.00227 (0.55)	0.0074 (1.69)	0.0357 (0.61)
IMP	-0.0014 (-0.37)	-0.0327** (-2.42)	-0.033** (-2.16)	-0.0339** (-2.26)
Log (SRDTI*HC)		0.0039*** (4.99)	0.00375*** (4.63)	0.0037*** (4.89)
Log (SRDTI*IMP)		0.0019*** (2.42)	0.0019*** (2.51)	0.00196*** (2.72)
FDI			-0.009*** (-3.51)	-0.0099*** (-3.88)
OPENNESS			0.0011 (0.21)	0.00147 (0.26)
Log (SRDTI*GFCF)				-0.0016 (-0.50)
R^2	0.9218	0.9443	0.9461	0.9462
N	228	228	228	228

Notes: 1. Figures in parentheses are t-values.
2. *** significant at 1% level; ** significant at 5% level; and *significant at 10% level

absorptive capacity on the part of an economy to manage knowledge spillovers more efficiently (Escribano *et al.* 2009). This absorptive capacity also enhances the elasticity of a country's innovation to both national and international spillovers. Further, the impact of these spillover effects also tend to get weaker for an economy, if there exist a large gap between that economy and the technological leaders (Mancusi 2008). Another crucial determinant for the reception of these foreign spillovers is the import pattern of countries, because a country that imports primarily from technological leaders is likely to receive more technology embodied in intermediate goods than another that imports primarily from follower countries (Keller 1999). In addition to that, FDI brought out by MNC's is not targeted to the development of local innovations and R&D which is an underlying reason for the negative impact of FDI on TFP across developing economies. Further, the growing geographical distance with technological leaders also adversely affect the productivity in recipient countries (Nishioka, and Ripoll 2011). Lastly, regardless of the free movement of labor and capital across the economies, there still exist the strong effects of borders on technology and knowledge transfer (Naveed, and Ahmad 2014).

The elasticity estimated for import shares individually in the table 3 in present study is found to be negative and significant, thus underlying the significance of developing countries' absorptive capacity in facilitating the effects of imports (Wang 2012). Further, the estimated elasticity corresponding to the interaction of the international R&D capital stock with both the import share and human capital are estimated to be 0.00196 and 0.0037 and are significant for both variables. These results are similar to the earlier study conducted by Engelbrecht (1997) who has specified the double role of human capital *i.e.*, the importance for domestic innovation and TFP catch-up process in his study. In other words, human capital helps to foster domestic innovation and also in the absorption of international knowledge spillovers.

The analysis in the table 3 based on equation (4) sheds the light on the mechanism through which aggregate trade is influencing the TFP of countries. But, there is a need to look beyond the simple relationship between R&D spillovers carried out by aggregate import of goods and services and their resultant impact on improving TFP across economies. As for growth of TFP, not only the aggregate level of trade matters rather than its composition of trade and the nature and quality of imports also play a very significant role. Thus, in the next estimation we have included only imports of capital goods as the carriers of knowledge spillovers.

The panel data regression results in table 4, reveals that domestic R&D stock, gross fixed capital formation and imports have positive and

TABLE 4
ESTIMATED COEFFICIENT OF FIXED EFFECTS MODELS
(DEPENDENT VARIABLE IS LOG TFP)

Independent Variable \ Equation	(1)	(2)	(3)	(4)
Constant	-3.259***	2.718***	2.59***	2.27***
	(-7.00)	(3.48)	(3.34)	(2.75)
Log (RD)	0.535***	0.58***	0.573***	0.3548***
	(13.66)	(17.26)	(17.21)	(5.26)
Log (SRDK)	0.1046	-0.4029***	-0.400***	-0.384***
	(0.24)	(-6.74)	(-6.79)	(-6.41)
HC	0.0066**	-0.047***	-0.044***	-0.0448***
	(2.43)	(-6.82)	(-6.49)	(-6.68)
GFCF	0.0022	-0.00006	0.0066*	0.094***
	(0.62)	(0.02)	(1.81)	(3.94)
IMP	-0.0013	-0.021***	-0.025***	0.083***
	(-0.60)	(-3.06)	(-3.15)	(2.64)
Log (SRDK*HC)		0.00355***	0.0033***	0.0034***
		(8.30)	(7.77)	(8.16)
Log (SRDK*IMP)		0.00146***	0.00192***	-0.0050***
		(3.31)	(4.21)	(-2.60)
FDI			-0.0134***	-0.1357***
			(-3.07)	(-4.16)
OPENNESS			-0.00038	-0.056***
			(-0.01)	(-3.56)
Log (SRDK*FDI)				0.0075***
				(3.91)
Log (SRDK*OPENNESS)				0.0035***
				(3.66)
Log (SRDK*logRD)				0.121**
				(3.33)
Log (SRDK*GFCF)				-0.0048***
				(-3.66)
R^2	0.9182	0.9413	0.9443	0.9547
N	228	228	228	228

Notes: 1. Figures in parentheses are t-values.
2. *** significant at 1% level; ** significant at 5% level; and *significant at 10% level

significant impact on total factor productivity of selected 19 developing economies in the present study. The impact of foreign knowledge spillovers of capital goods, human capital and FDI taken on individual basis is found to be negative on TFP. But, the coefficients for the interaction terms of foreign knowledge spillovers with human capital, FDI, openness and domestic R&D stock are found to have positive impact on total factor productivity while the coefficients of interaction term of foreign knowledge spillovers and imports is found to be negative.

Subsequently checking the robustness of the results reported in the table 4 for autocorrelation by using the Woolridge's test for autocorrelation in panel data confirmed the presence of autocorrelation in above results. To test the robustness of our results, we have estimated the clustered robust standard errors and the results are reported in table 5.

The results reported in the table 5 reveals that domestic R&D stock, GFCF, and the interaction terms of foreign knowledge spillovers and human capital, domestic R&D stock, FDI and openness have positive impact on TFP across the selected economies while the impact of foreign knowledge spillovers, human capital, FDI and the interaction term of foreign knowledge spillovers and imports have negative impact on the TFP of selected economies.

Further comparing the results of table 3 with table 5, where spillovers are supposed to be carried out through aggregate imports of goods and services in case of former and import of capital goods in case of latter reveals that although the impact of knowledge spillovers are found to be negative in both the cases, but the interaction term of foreign knowledge spillovers and imports have remained positive in former and in the case of latter it is found to be negative. The underlying reason behind it is that the knowledge of the foreign firms spills over through R&D activities of foreign firms, but not through their production activities. In other words, productivity of domestic firms is positively affected through R&D stocks of foreign owned firms while the impact of capital stock is found to be absent (Todo 2006).

Thus, the impact of foreign knowledge spillovers measured through imports of total goods and services exhibit the sounder effects on the TFP of these selected 19 developing economies as compared to the spillovers carried out through imports of capital goods alone. Further, assessing the impact of secondary education on TFP of these economies reveals that although the interaction term of foreign knowledge

TABLE 5
ESTIMATED COEFFICIENT OF FIXED EFFECTS MODELS
(DEPENDENT VARIABLE IS LOG TFP)

Independent Variable \ Equation	(1)	(2)	(3)	(4)
Constant	-3.259***	2.718*	2.56*	2.27
	(-3.39)	(1.91)	(1.79)	(1.31)
Log (RD)	0.535***	0.583***	0.573***	0.354***
	(8.05)	(8.55)	(8.99)	(2.24)
Log (SRDK)	0.104	-0.402***	-0.400***	-0.384***
	(0.14)	(-4.29)	(-4.28)	(-3.32)
HC	0.0066	-0.047***	-0.044***	-0.044***
	(1.00)	(-3.36)	(-3.17)	(-3.94)
GFCF	0.0022	0.00006	0.0066	0.094**
	(0.42)	(0.01)	(1.57)	(2.14)
IMP	-0.0013	-0.0213	-0.025*	0.083**
	(-0.33)	(-1.62)	(-2.17)	(2.26)
Log (SRDK*HC)		0.003557***	0.0033***	0.0034***
		(4.37)	(4.05)	(5.19)
Log (SRDK*IMP)		0.00146	0.0019**	-0.005**
		(1.86)	(2.52)	(-2.22)
FDI			-0.0134**	-0.135**
			(-3.01)	(-2.12)
OPENNESS			-0.00038	-0.056**
			(-0.01)	(-3.17)
Log(SRDK*FDI)				0.0075**
				(3.42)
Log(SRDK*OPENNESS)				0.003***
				(3.42)
Log(SRDK)*log(RD)				0.0121
				(1.61)
Log(SRDK*GFCF)				-0.00013*
				(-1.92)
R^2	0.9182	0.9413	0.9443	0.9547
N	228	228	228	228

Notes: 1. Figures in parentheses are t-values.
2. *** significant at 1% level; ** significant at 5% level; and *significant at 10% level

TABLE 6
COUNTRY-SPECIFIC, TIME VARYING ESTIMATES OF THE IMPACT OF R&D CAPITAL STOCKS ON TOTAL FACTOR PRODUCTIVITY

	Elasticity of total factor productivity with respect to			
	Foreign R&D			Domestic R&D
	2001	2006	2012	2001-2012
India	0.03	0.05	0.06	
Pakistan	0.03	0.04	0.04	
China	0.04	0.06	0.04	
Brazil	0.03	0.02	0.03	
Thailand	0.11	0.13	0.14	
Panama	0.14	0.14	0.16	
Mexico	0.05	0.06	0.07	
Malaysia	0.19	0.18	0.14	
Madagascar	0.06	0.09	0.09	
Armenia	0.09	0.07	0.09	0.53
Kyrgyz Republic	0.07	0.15	0.19	
Ukraine	0.11	0.09	0.11	
Azerbaijan	0.07	0.07	0.05	
Belarus	0.14	0.13	0.15	
Bulgaria	0.08	1.28	0.13	
Romania	0.08	0.08	0.08	
Turkey	0.05	0.05	0.04	
Egypt	0.04	0.06	0.05	
Tunisia	0.09	0.09	0.11	

spillovers and human capital has been found positive but assessing the individual impact of human capital as a proxy through secondary education has negative impact on TFP.

Table 6 depicts the estimated elasticities of total factor productivity with respect to the foreign R&D capital stocks—which are simply the estimated coefficient from Table 3 multiplied by the import share—for 2001, 2006, and 2012. These elasticities at three points of time for 19 selected economies reveal that there has been a rise in these elasticities over this period of time except Azerbaijan, Malaysia and Bulgaria where there had been decline in this intensity over these three points of time. Further, these elasticities have been found highest for Krgyz Republic followed by Panama. Thus, across all the selected economies, impact of domestic R&D stock has remained stronger as compared to foreign R&D stock which is due to their low level of human capital and large technological gap with the advanced economies.

V. Conclusions

In the context of globalization, the role of the spillovers and R&D externalities as the conduits for the economic growth and productivity have remained one of leading issue for research during the last few decades. Thus, a number of studies have been conducted in this context till now, which differs in terms of their sample selection, have found out the different impacts of these spillovers on economic growth and productivity across these economies. The present study examined the role of domestic capability of knowledge production and international knowledge spillovers in augmenting the total factor productivity (TFP) taking the case of 19 developing economies covering the period 2001-2012. The estimation procedure in obtaining the coefficients is panel data regression analysis. We have used fixed effects model for estimating the magnitude of coefficient and the choice for fixed effects is made on the basis of Hausman test. In addition to domestic and foreign R&D stock, the study has also probed the impact of human capital, trade, FDI, openness to trade and the interaction of foreign knowledge spillovers. The results of the study reveals that domestic R&D stock, gross fixed capital formation and the interaction terms of foreign R&D spillovers with trade and human capital have positive and significant impact on the TFP of these developing economies. Thus by trading with advanced countries developing economies can have access to the more advanced technologies developed in their trading partners resulting into improvement of their total factor productivity. Therefore, liberalization of trade should be stimulated by developing economies to augment their level of TFP. In addition to that, this rise in total factor productivity is also determined by improving level of human capital across these economies which facilitate the absorption of knowledge spillovers. These results are in line with the findings of the earlier studies conducted by Coe, and Helpman (1995) and Singh (2004). On the other hand, the impact of foreign spillovers and FDI and openness on TFP has been found to be negative in the present study as R&D spillovers are also determined by distance among these nations, levels of their technological capabilities, inward or outward oriented policies of MNCs and as well as various barriers of language, culture *etc*. Thus, unlike the earlier studies in which foreign knowledge spillovers just like the domestic R&D stock have positive impact on TFP of an economy, our study found that this perception is context specific instead of being universal. Later on, the results of the subsequent analysis in which foreign knowledge spillovers are measured as bilateral capital goods' import share weighted average of domestic R&D capital stock of each country's trading partner reveals that interaction term of foreign knowledge spillovers with imports of capital goods alone is found to be negative while it is positive in case of total goods and services, which is backed by the reason that developed economies tends to benefit more from the imports of capital goods while developing economies only have spillovers from imported intermediate and consumption goods (Wang, and Tang 2015).

The results of our study are supportive of the hypothesis that a country having higher ratio of imports of total goods and services tend to grow faster than the economies that are dependent on the import of capital goods only. There are important implications for developing countries *i.e.*, taking the advantage of their comparative advantage in producing labor-intensive consumer goods, developing countries can augment their economic growth (Lewer, and Berg 2003). Thus, by enhancing the level of international trade, a country can have access to a wider range of intermediate and capital inputs, which in turn facilitates more research and development or learning-by-doing activities (Lee 1995). This implies that developing countries should strengthen their technological policies that generate incentive to invest in research and development and build national innovation system.

Appendix 1
[List of Countries included in the Analysis]

Austria
Belgium
Canada
Czech Republic
Denmark
Estonia
Finland
France
Germany
Hungary
Ireland
Israel

Italy
Japan
Korea
Netherland
Norway
Poland
Portugal
Slovak Republic
Slovenia
Spain
Turkey
UK
USA
China

(Received 6 March 2017; Revised 11 July 2017; Accepted 26 July 2017)

References

Aghion, P., and Howitt, P. A. "Model of Growth through Creative Destruction." *Econometrica* 60 (No. 2 1992): 323-351.

Amann, E., and Virmani, S. "Foreign Direct Investment and Reverse Technology Spillovers: The Effect on Total Factor Productivity." *OECD Journal: Economic Studies* 2014 (No. 1 2014): 129-153.

Ang, J., and Madsen, J. B. "International R&D Spillovers and Productivity Trends in the Asian Miracle Economics." *Economic Inquiry* 51 (No. 2 2013): 1523-1541.

Basant, R., and Fikkert, B. "The Effects of R&D, Foreign Technology Purchase, and Domestic and International Spillovers on Productivity in Indian Firms." *Review of Economics and Statistics* 78 (No. 2 1996): 187-199.

Belitz, H., and Molders, F. International Knowledge Spillovers through High-TechImports and R&D of Foreign-Owned Firms. DIW Berlin Discussion Paper No. 1276, 2013.

Bottazzi, L., and Peri, G. "Innovation and Spillovers in Regions: Evidence from European Patent Data." *European Economic Review* 47 (No. 4 2003): 687-710.

Branstetter, Lee. "Are Knowledge Spillovers International or International in Scope? Micro-econometric Evidence from US and

Japan." *Journal of International Economics* 53 (No. 1 2001): 57-79.

Coe, D., Helpman, E., and Hoffmaister, A. W. "North-South R&D Spillovers." *The Economic Journal* 107 (No. 440 1997): 134-149.

______. "International R&D Spillovers and Institutions." *European Economic Review* 53 (No. 7 2009): 723-741.

Coe, David T., and Helpman, E. "International R&D Spillovers." *European Economic Review* 39 (No. 5 1995): 859-87.

Comin, D. International R&D Spillovers. New York University and NBER, 2006. Available at http://www.people.hbs.edu/dcomin/def.pdf

Dimmerman, A. J. Foreign R&D Capital Stock as a Channel for Technology Transfer Latin America and Southeast Asia, 2003. Available at https://pdfs. semanticscholar.org/efcf/5e165d9922f41db56b547f7508578c471af1.pdf.

Eaton, J., and Kortum, S. "International Technology Diffusion Theory and Measurement." *International Economic Review* 40 (No. 3 1999): 537-70.

Engelbrecht, H-J. "International R&D spillovers, human Capital and productivity in OECD economics: An Empirical Investigation." *European Economic Review* 41 (No. 8 1997): 1479-88.

______. "Human Capital and International Knowledge Spillovers in TFP Growth of a Sample of Developing Countries: An Exploration of Alternative Approaches." *Applied Economics* 34 (No. 7 2002): 831-841.

Escribano, A., Fosfuri, A., and Tribo, J. A. "Managing External Knowledge Flows: The Moderating Role of Absorptive Capacity." *Research Policy* 38 (No. 1 2009): 96-105.

Evenson, R. E., and Singh, L. Economic Growth, International Technological Spillovers and Public Policy: Theory and Empirical Evidence from Asia, Centre Discussion Paper No. 777, Economic Growth Centre, 1997. Available at http://aida.wss.yale.edu/growth_pdf/cdp777.pdf

Frantzen, D. "Innovation, international technological diffusion and the changing influence of R&D on productivity." *Cambridge Journal of Economics* 24 (No. 2 2000): 193-210.

Gill, Anita, and Singh, Lakhwinder. "Internationalization of Firms from China and India: Theory, Evidence and Policy." *Millennial Asia: An International Journal of Asian Countries* 3 (No. 1 2012): 23-44.

Gorg, H., and Greenway, D. "Much Advertisement about Nothing? Do Domestic Firms Really Benefit from Foreign Direct Investment." *World Bank Research Observer* 19 (No. 2 2004): 171-97.

Grossman, G. M., and Helpman, E. *Innovation and Growth in the Global Economy*. Cambridge: The MIT Press, 1991.

Guellec, D., and De La Potterie, B. V. P. "R&D and Productivity Growth." *OECD Economic Studies* 2001 (No. 2 2001): 103-126.

IMF, Direction of Trade Statistics, Washington D.C.: International Monetary Fund, 2016.

Joseph, K. J. "Has Trade been an Engine of Inclusive Growth? India's Experience Under Globalization." *Millennial Asia: An International Journal of Asian Studies* 4 (No. 2 2013): 135-157.

Kokko, A., Zejan, M., and Tansini, R. "Trade regimes and spillover effects of FDI: Evidence from Uruguay." *WeltwirtschaftlichesArchiv* 137 (2001): 124-149.

Kao, C., Chiang, M. H., and Chen, B. "International R&D Spillovers: An application of estimation and Inference in Panel Co-integration." *Oxford Bulletin of Economics and Statistics* 61 (No. S1 1999): 691-709.

Keller, W. "Are International R&D Spillovers Trade Related? Analyzing Spillovers among Randomly Matched Trade Partners." *European Economic Review* 42 (No. 8 1998): 1469-1481.

______. How Trade Patterns and Technology Flows Affect Productivity Growth, National Bureau of Economic Research, NBER Working Paper No. 6990, 1999.

______. "International Technology Diffusion." *Journal of Economic Literature* 42 (No. 3 2004): 752-782.

Lee, J. W. "Capital goods Imports and Long-run Growth." *Journal of Development Economics* 48 (No. 1 1995): 91-110.

Lee, Keun. *Schumpeterian Analysis of Economic Catch-up: Knowledge, Path Creation, and Middle-Income Trap*. Cambridge: Cambridge University Press, 2013.

Lewer, J., and V. den Berg, H. "Does Trade Composition Influence Economic Growth? Time Series Evidence of 28 OECD and Developing Countries." *Journal of International Trade and Economic Development* 12 (No. 1 2003): 39-96.

Lucas, R. E. "On the Mechanics of Economic Development." *Journal of Monetary Economics* 22 (No. 1 1988): 3-42.

Luintel, K., and Khan, M. "Are International R&D Spillovers Costly for the United States?" *The Review of Economics and Statistics* 86 (No. 4 2004): 896-910.

Madden, G., Savage, S. J., and Bloxham, J. P. "Asian and OECD International R&D Spillovers." *Applied Economic Letters* 8 (No. 7 2001): 431-435.

Mancusi, M. L. "International Spillovers and Absorptive Capacity: A Cross-Country cross Sector Analysis based on Patents and Citations." *Journal of International Economics* 76 (No. 2 2008): 155-165.

Naveed, A., and Ahmad, Nisar. Technology Spillovers and International Borders: A Spatial Econometric Analysis. Department of Border Region Studies.University of Southern Denmark. Working Paper No. 02/14, 2014.

Nishioka, S., and Ripoll, M. Productivity, R&D, and International Technology diffusion at the industry level. Department of Economics, West Virginia Universityand University of Pittsburgh, 2011. Available at https://editorialexpress.com/cgi-bin/conference/download.cgi?db name=NASM2011&paper_id=765.

Nursamsu, S., and Hastiadi, Faisal. "Analysis of International R&D Spillover from International Trade and Foreign Direct Investment Channel: Evidence from Asian Newly Industrialized Countries." *Journal of Economic Cooperation and Development* 36 (No. 2 2015): 125-154.

Prichett, L. "Where has all the Education Gone." *World Bank Economic Review* 15 (No. 3 2001): 367-391.

Romer, P. M. "Increasing Returns and Long-run Growth." *Journal of Political Economy* 94 (No. 5 1986): 1002-37.

______. "Endogenous Technical Change." *Journal of Political Economy* 98 (No. 5 1990): 71-102.

Sjogren, A. Human Capital, R&D and Economic Growth.Working Paper Series in Economics and Finance No. 238, Stockholm School of Economics, 1998.

Sadraoui, T. "A Co-integration Panel Data Analysis for International R&D Spillovers and R&D Cooperation: Case Study from Mediterranean Countries." *International Journal of Knowledge and Learning* 7 (Nos. 3-4 2011): 179-196.

Saggi, Kamal. "Trade, Foreign Direct Investment and International Technology Transfer: A Survey." *The World Bank Research Observer* 17 (No. 2 2002): 191-235.

Singh, L. "International R&D Spillovers and Economic Growth in Asia." In A. Guha, K. L. Krishna and A. K. Lahiri (eds.), *Trade and Industry: Essays by NIPFP-Ford Foundation Fellows.* New Delhi: NIPFP and Vikas Publishing House, pp 1-26, 2001.

______. "Domestic and International Knowledge Spillovers in Manufacturing Industries in South Korea." *Economic and Political Weekly* 3 (No. 5 2006): 498-505.

The Conference Board, The Conference Board Total Economy Database, 2016. Available at http://www.conference-board.org/data/economydatabase/on 10.08.2016.

Todo, Y. "Knowledge Spillovers from Foreign Direct Investment in R&D: Evidence from Japanese Firm-Level Data." *Journal of Asian Economics* 17 (No. 6 2006): 996-1013

Ulku, H., and Pamukcu, M. "The Impact of R&D and Knowledge Diffusion on the Productivity of Manufacturing Firms in Turkey." *Journal of Productivity Analysis* 44 (No. 1 2015): 79-95.

UNESCO, UIS Bulletin on Science and Technology Statistics, Montreal: UNESCO Institute of Statistics, 2014.

Wang, L., and Tang, Y. "Imports, R&D Spillovers and Productivity Growth: Cross-Country Evidence." Proceedings of the International Conference on Transnational Corporations and Emerging Markets, 2015. Available at http://www.tnc-online.net/pic/20161122205800249.pdf.

Wang, Y. "Openness and Productivity: The Role of Imports, FDI and International Telecommunications." *Latin American Journal of Economics* 49 (No. 1 2012): 125-145.

World Bank, World Development Indicators, Washington, DC: The World Bank, 2015. Available at http://data.worldbank.org/data-catalog/world-development-indicators.

Zhu, L., and Jeon, B. N. "International R&D Spillovers: Trade, FDI and Information Technology as Spillover Channels." *Review of International Economics* 15 (No. 5 2007): 955-976.