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Foreign direct investment and reverse technology spillovers: The effect on total factor productivity

by
Edmund Amann *and* Swati Virmani*

The paper analyses the "feedback effect" of Foreign Direct Investment (FDI) on Total Factor Productivity (TFP) growth in emerging economies via technology spillovers across borders. We study the effect of R–D spillovers resulting from outward FDI flows from 18 emerging economies into 34 OECD countries over the 1990-2010 period, comparing the impact with that of spillovers resulting from inward FDI flows. The result confirms that FDI enhances productivity growth; however the impact is much larger when R-D-intensive developed countries invest in the emerging economies than the other way round. Country-specific bilateral elasticities also support this outcome.

JEL classification: F21, F43, F62, O47.

Keywords: Outward FDI, Inward FDI, Reverse technology spillovers, Total factor productivity.

* The authors are Reader in Development Economics and Head of Economics (Teaching and Operations); and PhD Student, Economics, School of Social Sciences, respectively, at the University of Manchester, UK. They would like to thank Bruno Van Pottelsberghe de la Potterie and Giuseppe Nicoletti for comments on a previous version. The opinions expressed and arguments employed in this paper are the responsibility of the authors and do not necessarily reflect the official views of the OECD or of the governments of its member and partner countries.
Email: edmund.amann@manchester.ac.uk; swati.virmani@postgrad.manchester.ac.uk.

1. Introduction

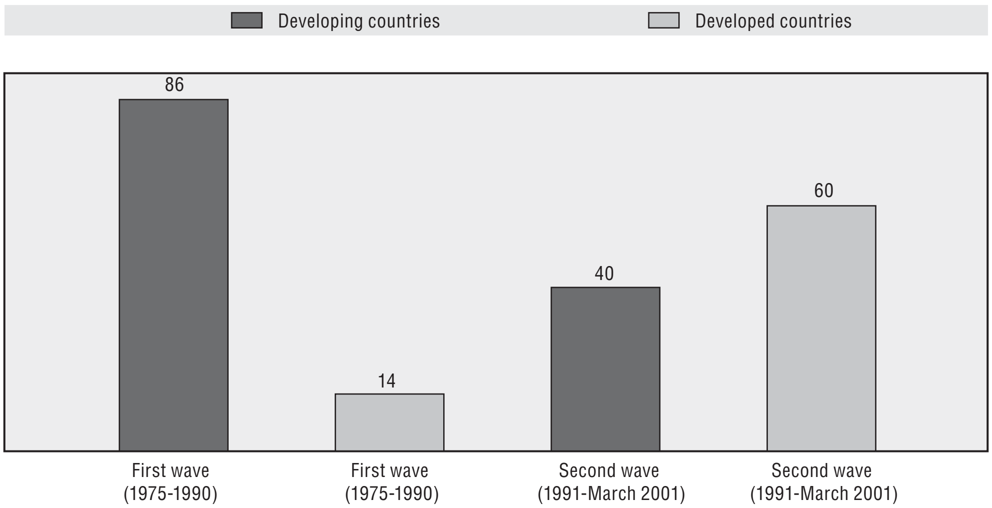
The term "knowledge spillover" refers to the process by which one inventor learns from the research outcomes of others' projects and is able to enhance their own research productivity without fully compensating the other inventors for the value of such learning (Branstetter, 2006). True knowledge spillovers have the potential to allow for further innovation. In pursuit of such spillovers, it is possible that firms may take investment decisions so as to learn from other firms' research activities. This is especially true for a developing and emerging country undertaking Outward Foreign Direct Investment (OFDI) in R-D intensive developed countries. While the advanced country firms, such as those of Japan and Korea, have set up their own technological profiles and brands over long periods of time, newly emerging nations often tend to leapfrog by acquiring a well-established corporation, or setting up R-D centres in areas of excellence.

The literature identifies two waves of outward investment: the first during the 1960s and 1970s, and the second from 1980 onwards (UNCTAD, 2007). In the second wave, a diversified pattern of investment was emerging, with an increasing participation of developing nations undertaking OFDI in developed nations. The aim here was to attain strategic assets and markets, acquiring brands, and accessing technologies. Such an OFDI played a mediating role in the "knowledge spillover", that was traditionally unidirectional, taking place from an innovation-driven developed nation investing in a developing country. In other words, outward investment from a less capital intensive developing nation was now acting as a channel for transferring technology. Dunning recognises this second wave of OFDI as resulting from liberalisation of markets, globalisation of economic activity and dramatic technological advancement within sectors; factors that have affected the structure of the world economy. He also postulates that during this period the countries that came out in front were those that had moved along the Investment Development Path (IDP),[1] and experienced rapid economic growth and restructuring (UNCTAD, 2005b).

In the case of India, for example, the second wave began in the 1990s when enterprises were mostly using Mergers and Acquisitions (M&A) to venture abroad in order to access technology. The lion's share of such investment was in developed countries, dominated by the United States (24%) and the United Kingdom (27%) (UNCTAD, 2007). Indian companies such as Infosys, Aditya Birla and HCL Technologies invested in the United States. Figure 1 shows the diversity between the first and second phase of India's investment in terms of the geographical distribution.

Overall, during this period, OFDI from emerging economies rose from USD 149 billion in 1990 to USD 1.4 trillion in 2005, accounting for 13% of world OFDI stock in 2005 (UNCTAD, 2007). More economies became global players, and among the strongest were from Asia. Enterprises from East Asia (China), South-East Asia (Malaysia, Thailand and Singapore), and South Asia (India) were the most active. Following them were the developing regions of Latin America and the Caribbean (Brazil and Argentina). Also,

Figure 1. **India's OFDI flows by geographical distribution in first (1975-90) and second (1991-March 2001) waves (in %)**



Source: UNCTAD, 2007.

enterprises from the transition economies were engaged in OFDI (Russian Federation). Table 1 highlights the OFDI flows from four major host countries for emerging multinationals, the BRIC.

Table 1. **OFDI flows in USD million, 1990-2010**

	Brazil	Russia	India	China	BRIC, % of World
1990	624.6	-	6	830	0.605
1991	1 015	-	-11	913	0.968
1992	136.7	1 566	24	4 000	2.826
1993	492.3	1 022	0.35	4 400	2.438
1994	689.9	281.37	82	2 000	1.064
1995	1 095.64	605.78	119	2 000	1.052
1996	-469.06	922.82	240	2 114	0.706
1997	1 115.56	3 183.91	113	2 562.49	1.461
1998	2 854.01	1 269.75	47	2 633.81	0.987
1999	1 690.41	2 207.62	80	1 774.31	0.529
2000	2 281.59	3 176.78	514.45	915.78	0.562
2001	-2 257.59	2 532.58	1 397.44	6 885.40	1.145
2002	2 482.11	3 532.65	1 678.04	2 518.41	1.932
2003	249.3	9 727.13	1 875.78	2 854.65	2.577
2004	9 806.99	13 782.03	2 175.37	5 497.99	3.377
2005	2 516.70	12 767.47	2 985.49	12 261.17	3.436
2006	28 202.49	23 151.00	14 284.99	2 1160	6.134
2007	7 066.66	45 915.5	19 594.36	22 468.86	4.324
2008	20 457.07	55 593.5	19 256.5	52 150	7.488
2009	-10 084.23	43 665	15 927.1	56 530	9.024
2010	11 587.57	52 523	13 151	68 811	10.064

Notes: FDI includes the three following components: equity capital, reinvested earnings and intra-company loans. Data on FDI flows are presented on net bases (capital transactions' credits less debits between direct investors and their foreign affiliates). Net decreases in assets or net increases in liabilities are recorded as credits, while net increases in assets or net decreases in liabilities are recorded as debits. Hence, FDI flows with a negative sign indicate that at least one of the three components of FDI is negative and not offset by positive amounts of the remaining components. This is called reverse investment or disinvestment.
Source: UNCTAD Stat.

A key driver of such outward investment has been the competitive pressure along with a number of home and host country factors, such as home market growth constraints, lower production costs and availability of natural resources in the host nations. But recently during the current wave of internationalisation, building of brand names, accessing most sophisticated and advanced technologies, and acquiring R-D facilities through OFDI have become more notable features amongst the emerging nations. Moreover, the research-linked investments in the centres of innovation in the developed countries have been an important source of rapid technology diffusion. Good examples here are Lenovo's (China) acquisition of IBM's personal computer division (United States) and Cordlife's (Singapore) acquisition of Cytomatrix (United States) (UNCTAD, 2007). China has considered the Joint Ventures as an important source of new foreign technology and management skills ever since 1979 when the Law of Joint Ventures was promulgated. In the case of Brazil, Embraer linked up with Aeritalia and Aermacchi of Italy in 1981 to manufacture the sophisticated AMX-fighter bomber (Tolentino, 1993). This form of investment is a part of the cumulative process through which developing countries' firms gain access to advanced technology, and further combine and localise it with their indigenous technological capabilities.

Accessing foreign technology may also take the form of establishing R-D centres in developed countries. Looking at some of the Chinese companies, Huawei Technologies and ZTE Corporation established their R-D centres in Sweden; Guangdong Glanz Group Co. set up an R-D centre in Seattle, and Haier has an R-D centre in Germany and a design centre in Boston (United States). Amongst the Indian companies, Ranbaxy Laboratories has set up R-D centres in various countries including the United States (UNCTAD, 2004). The Metal Leve firm of Brazil established a research centre in Ann Arbor, Michigan, to acquire the latest technology for manufacturing auto engine pistons (Tolentino, 1993).

Our argument of strategic asset seeking behaviour is an extension to the literature supporting the "learning by exporting" effect (Bernard and Jensen, 1999; Clerides et al., 1998). OFDI enables firms to not just enter into new markets but also to gain access to foreign technology, and as a result, the entire domestic economy benefits due to increased efficiency of the investing firms and the associated spillovers to the local firms at home (Herzer, 2012). Thus, OFDI benefits the home country at least in terms of the technology transfers that it generates.

In contrast to a plentiful literature on R-D spillovers, there is only a fragmented body of work on the effects of such technology transfers on the home country. Research here is based on the impact of FDI flows from developed countries into developing ones (North-South FDI). Moreover, previous studies have been restricted to individual firms or industries and have not captured the overall macroeconomic effects on the economy as a whole. In addition, those studies are mostly based on firm level data for manufacturing that excludes the FDI in the service sector.

Against this background, this paper's contribution centres on highlighting not only the technology diffusion effect of OFDI, but also the productivity-enhancing effect on emerging economies at the macroeconomic level. The basic objective is to explore whether OFDI serves as a means of generating knowledge flows that affect the growth of TFP. Furthermore, the study entails a comparison of whether FDI transfers technology in both directions, i.e. if a country's productivity is increased not only when R-D-intensive countries invest in it, but also when it invests in R-D-intensive foreign countries. In other words, the paper tries to distinguish between the impact of R-D spillovers resulting from North-South and South-North FDI flows.[2]

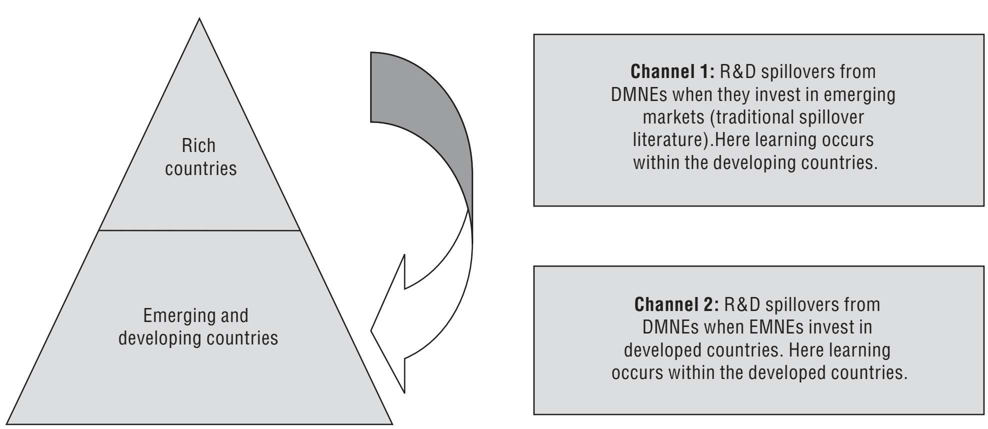
The analysis involves looking at the OFDI flows from 18 emerging economies into 34 OECD countries over the 1990-2010 period and Inward FDI (IFDI) flows into those 18 emerging economies from the OECD nations. We apply the methodology suggested by Van Pottelsberghe de la Potterie and Lichtenberg (2001). However, unlike their study – which looks at FDI flows between 13 industrialised countries (i.e. North-North FDI only) – our paper contributes more extensively by studying both South-North and North-South FDI flows. We also extend the analysis by including catalytic factors that affect TFP, such as human capital, in order to get better estimates of output elasticity of foreign R-D spillovers. According to the UNESCO (1993) *Statistical Year Book*, R-D-expenditures in OECD member countries amounted to 96% of the entire R-D world expenditures in 1990, thus justifying the choice of OECD nations as the investing partners for our analysis.

The paper is structured as follows: Section 2 describes how FDI is linked to technology spillovers. It also discusses the mechanisms that drive the spillovers. Section 3 then provides an overview of the "feedback effect", i.e. the impact on TFP growth. Section 4 highlights the methodology and data, Section 5 outlines the results, and finally, Section 6 concludes the study with policy implications.

2. Foreign direct investment and R-D spillovers

A vast literature surrounds how firms from developed countries generate technology spillovers for developing country firms. Figure 2 identifies two main channels for such R-D spillovers, both focusing on the trickling down of technology from developed to developing countries. The first channel is based on IFDI into the emerging economies from developed countries' firms. This is called the Traditional Channel. The second channel entails the OFDI flows from the emerging economies into the developed countries. As the figure illustrates, the traditional channel overlooks the possibility that Emerging Market Multinational Enterprises (EMNEs) could also capture spillovers from Developed Country Multinational Enterprises (DMNEs), when the former invest in the developed countries. In other words, learning could also occur in the developed economy as a result of investment from EMNEs that are motivated by the desire to obtain intangible assets, such as technology. However, in both cases, the DMNEs act as the so-called "teacher".

Figure 2. **Two channels of R-D spillovers**



Note: EMNEs = Emerging Market Multinational Enterprises, DMNEs = Developed Country Multinational Enterprises.
Source: Author's elaboration and Govindarajan and Ramamurti (2011).

This new spillover channel is based on the recent identification of the investing country learning from local firms in the host country and acquiring knowledge spillovers at the host sites. This could be especially true in the case of an outward investment into a host country that is more capital or R&D-intensive than the home country. The technology-sourcing occurs mainly when firms try to gain access to foreign technology by either acquiring foreign firms or establishing R-D facilities in "Foreign Centers of Excellence" (Herzer, 2012). These firms then acquire new technological know-how and transfer it to the parent company in the home country.

A number of case studies have been carried out, empirically substantiating these knowledge flows, as summarised in Table 2.

Table 2. **Summary results of previous studies**

	Author(s) and year of study	Findings
1.	Pradhan and Singh (2009)	Examined OFDI in the Indian Automotive Industry during 1988-2008 and suggested a favourable impact on the R-D intensity. Their study supported that OFDI is an important factor determining domestic R-D performance, more so in the case of a joint-venture.
2.	Wei and Ling (2008)	Addressed the case of China's OFDI between 1985 and 2004, and found that inverse technology spillovers exist when Multinational Enterprises (MNEs) invest abroad and transfer technology from overseas subsidiaries to parent companies at home.
3.	Deng (2007)	Showed in the case of China that firms used their asset seeking FDI behaviour to obtain strategic resources that were available in more advanced foreign markets but limited in their own country and to access host countries' centres of innovation.
5.	Branstetter (2006)	Used "patent citation data" to infer knowledge spillovers at the firm level. The results of the study indicated that with an increase in acquisitions in the United States by Japanese firms, the latter showed a greater tendency to cite US patents as "prior art" in their US patent application. Thus, OFDI was a channel for providing Japanese firms access to foreign technology networks.
6.	Pradhan and Abraham (2005)	Indicated that one of the main motivations behind Indian firms' overseas acquisitions was to acquire firm specific intangibles such as technological skills. Because the Indian manufacturing sector is more research intensive and has greater absorptive capacity, it allowed them to integrate acquired foreign capital assets.
7.	Makino, Lau and Yeh (2002)	Observed that firms invest more in capital intensive developed nations than in developing countries in order to fulfil their quest for strategic capabilities.
8.	Van Pottelsberghe de la Potterie and Lichtenberg (2001)	Investigated econometrically the technology transfers through FDI, and pointed out that such transfers do take place if a country invests in R-D-intensive foreign nations. Countries such as Japan, Germany and France have benefitted from the US R-D capital stock through outward investment.

Source: Authors' compilation.

These studies thus point towards a positive correlation between OFDI and knowledge spillovers, and that the strategic assets acquiring motive could be realised through technology seeking outward investment.

Focusing, in particular, on the OFDI from emerging countries as the channel for R-D spillovers, diverse mechanisms drive such spillovers. One of these is "sharing of the R-D expenditure"; wherein the host and home country firms jointly undertake technological research. The second method is the "feedback mechanism", in which foreign subsidiaries of the MNCs transfer knowledge to their home base. Then there is the "mechanism of reverse technology transfer", i.e. acquiring knowledge through direct investment, particularly effective when firms carry out asset seeking FDI through mergers and acquisitions and joint ventures. As a result, firms obtain advanced technologies and enhance their core competitiveness. Finally, there is a fourth way where parent companies "outsource R-D activities" and relocate them overseas (Zhao and Liu, 2008).

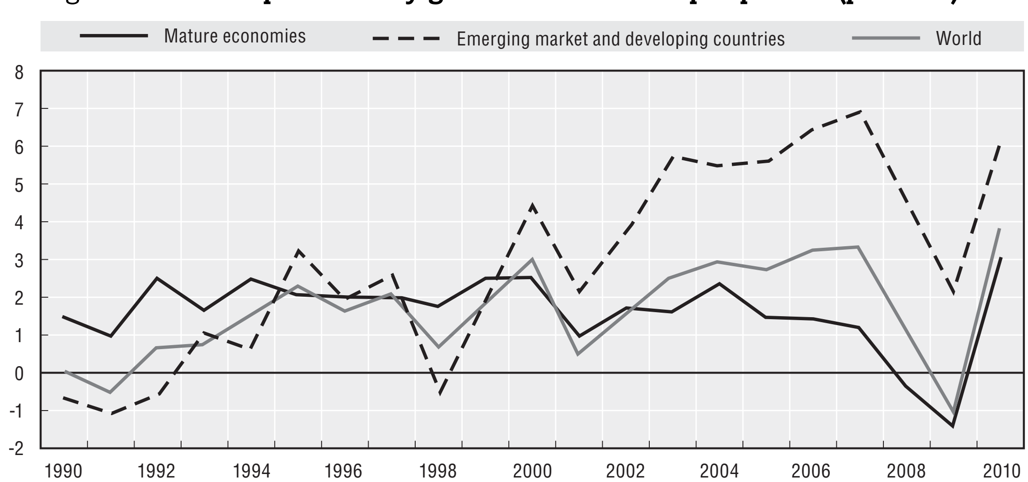
For example, looking at the Indian case, the main mechanism of acquiring technology has been to engage in strategic asset seeking investment, mostly directed towards developed nations, and enhance one's own technological innovation capacity. Pradhan and Singh (2009) explored the Indian firm's OFDI in the auto industry and suggested a significant impact of OFDI on auto firm's R-D intensity. Also, NIIT Ltd., a leading service sector Indian MNE, has been involved in strategic asset seeking investment through brown field investment. In 2002-03, it undertook several acquisitions such as Osprey Systems in March 2002 and Cognitive Arts in February 2003. With these acquisitions, NIIT gained strategic advantage in the US corporate knowledge solution market (Pradhan, 2006).

Given this background about R-D spillovers resulting from FDI, the following section highlights the main objective of our study – the "feedback effect" of such technology spillovers on the growth of domestic productivity of emerging economies.

3. The impact on total factor productivity growth

Recent trends show that the emerging and developing economies have been experiencing rapid TFP growth[3] since the early 2000s. Compared with the advanced economies where the growth rate dropped from 0.4% per year between 1995 and 2005 to -0.1% between 2005 and 2008, the emerging economies have witnessed an improvement from 1.0% in 1995-2005 to 2.2% in 2005-2008 (the Conference Board, *Total Economy Database*). However, the level of productivity in developing countries is still much lower than advanced countries, indicating scope for strengthening and catching up. Looking at the labour productivity growth trend (Figure 3), the worldwide long-term trend is towards faster productivity growth with the emerging and developing economies leading the way. It was during this period that outward investment from developing countries rose, indicating a possibility of a positive effect of OFDI on productivity growth.

Figure 3. **Labour productivity growth trend – GDP per person (per cent)**



Source: The Conference Board, *Total Economy Database*, January 2014, *www.conference-board.org/data/economydatabase/*.

One of the sources of interdependence between OFDI and domestic productivity in the long run is the Strategic Asset Seeking motive (Herzer, 2011). Firms undertake asset seeking investment in order to gain access to the assets that are unavailable in the home country. Such a type of investment also includes the technology sourcing FDI, which transfers knowledge across borders and it is this transfer of technological know-how, attained by foreign affiliates, to the parent companies, that facilitates the increase in productivity at home. Thus OFDI affects TFP growth through R-D spillovers, as productivity changes are critical signals of technology upgrading.

Moreover, it is important to note that OFDI not only affects the productivity of the investing firm but also of the economy as a whole (Blomstrom and Kokko, 1998). The investing firms could well be a source of advanced technology to local firms, which may benefit by copying or through labour turnover. Also, the benefit could be from the high quality intermediate goods produced by the investing firm that may now be available to the local firms at lower prices. Domestic firms may even take the advantage of economies of scale, as OFDI opens up the opportunity for the investing firm to grow larger than would have been possible with production in just one nation. In addition, it is obvious that the increased competition between the MNCs and the domestic firms would be an impetus for the latter to run more efficiently.

However, there are a few considerations related to the impact of knowledge spillovers resulting from OFDI. First of all, the learning ability of the investing firm matters. If the firms have low technological capacity, as is true for firms in developing countries, it may be difficult to effectively exploit the foreign technology. Furthermore, OFDI could reduce domestic capital accumulation and hence productivity when the investors invest the scarce domestic resources abroad. Finally, it may well be argued that significant spillovers to developing nations take place only if a substantial portion of investment goes to more developed countries, which have a higher technological expertise.

A number of studies provide empirical evidence for the possible impact of OFDI on domestic productivity. Kimura and Kiyota (2006) analysed panel data on Japanese firms for the period 1994-2000, and suggested that OFDI increases productivity. Their key finding was that, on average, firms that invest abroad have 1.8% higher growth than those that do not engage in FDI. Barba and Castellani (2004) considered a sample of Italian firms between 1993 and 1998, and reported a positive causal effect of outward investment on the home country's TFP growth, output and employment. They also compared the multinational firms that invested abroad with the domestic firms, and found that the former outperform.

Herzer (2011) examined the long-run relationship between OFDI and TFP for a sample of 33 developing countries over the period 1980-2005 and found that on average a positive effect is prevalent. However there is considerable heterogeneity explained by the cross-country differences, mainly due to labour market regulations. Bitzer and Gorg (2009), on the other hand, found an overall negative effect of OFDI on TFP, using panel data for 17 OECD countries over 1973-2001. But there were large country differences, for example, South Korea observed the largest negative effect, though countries such as France, the United Kingdom and the United States witnessed higher factor productivity due to OFDI.

Therefore, the impact of OFDI on domestic productivity could be mixed, differing significantly across countries. It may be particularly true that the effect does not necessarily depend on the motive of investment but on a number of other factors such as technological capacity, government policies, and level of financial development. More importantly, human capital stock is a crucial factor. Benefits from international R-D spillovers could be greater when the labour force in developing countries is more educated and skilled, termed as the "absorptive capacity" by Keller (1996). Also, how well the diffused technology is absorbed and implemented could be reflected in the increase in number of patent applications filed by the residents.

We now attempt to provide evidence of the effect of OFDI from EMNEs into the developed countries on the productivity growth of the home country through R-D spillovers using an empirical model. We also evaluate and compare this effect with that of spillovers resulting from IFDI from resource rich countries into the emerging economies – the traditional channel.

4. Empirical framework

In this study we assess the impact of FDI on TFP growth through technology flows across borders by employing a generalised version of the methodology suggested by Van Pottelsberghe de la Potterie and Lichtenberg (2001).[4] Our paper contributes constructively to the literature by focusing on the impact of FDI generated R-D spillovers from developed to developing countries during recent years, i.e. technology transfers through North-South bilateral FDI. We consider panel data for 18 emerging economies over the 1990-2010 period, and investigate the impact of R-D spillovers resulting from FDI flows to and from the 34 OECD member countries as the investing partners (Appendix A and B, respectively, list the 18 emerging and the 34 OECD nations). We also extend the specification by including catalyst terms, such as human capital, as control variables.

4.1. Model specification

Equation [1] is the basic econometric model; it states that the domestic TFP growth of a country is a function of its domestic R-D capital stock and of foreign R-D capital stock:

$$lnTFP_{it} = \alpha_i + \alpha^f lnRD^f_{it} + \alpha^d lnRD^d_{it} + \varepsilon_{it} \quad [1]$$

where $i = 1 \ldots 18$ is a country index; $t = 1990 \ldots 2010$ is a time index; $lnTFP$ is the natural logarithm of TFP;[5] RD^f represents the foreign R-D capital stock; RD^d represents the domestic R-D capital stock; α_i is a country-specific intercept; α^f is the elasticity with respect to the foreign R-D capital stock; α^d is the elasticity with respect to the domestic R-D capital stock; and ε is the error term.

The two different foreign R-D capital stock terms are constructed as follows. The first one, the foreign R-D capital stock embodied in OFDI from country i to country j, RD^{fo}_{it}, is given as:

$$RD^{fo}_{it} = \sum_{j=1}^{34} \frac{OFDI_{ijt}}{GDP_{jt}} RD^d_{jt} \quad [2]$$

here, $i = 1 \ldots 18$ emerging economies and $j = 1 \ldots 34$ OECD countries. $OFDI_{ijt}$ is the OFDI flow from country i into country j in year t, GDP_{jt} is the GDP of country j in year t, RD^d_{jt} is the domestic R-D capital stock of country j in year t, i.e. RD^d_{jt} / GDP_{jt} is the degree of R-D intensity of country j in year t. Thus, RD^{fo}_{it} is the foreign R-D spillover for each country i, given as the weighted average of R-D intensity of its investing partner j with OFDI flow from country i into country j.

The second one, the foreign R-D capital stock embodied in IFDI to country i from country j, RD^{fi}_{it}, is computed as:

$$RD^{fi}_{it} = \sum_{j=1}^{34} \frac{IFDI_{ijt}}{GDP_{jt}} RD^d_{jt} \quad [3]$$

here, $IFDI_{ijt}$ is the IFDI flow into country i from country j in year t, hence RD^{fi}_{it} is the foreign R-D spillover for each country i, given as the weighted average of R-D intensity of its investing partner j with IFDI flow into country i from country j.

A further specification, Equation [4], includes "Human Capital" and "Number of Patent Applications filed by Residents" as two catalyst terms included with the purpose of getting better estimates of output elasticities of domestic and foreign R-D capital terms. These two variables are not only important channels of productivity growth, but also capture the level of indigenous capacity of the home country. We therefore include these control variables in order to avoid any bias in the estimation.

$$lnTFP_{it} = \alpha_i + \alpha^f lnRD^f_{it} + \alpha^d lnRD^d_{it} + \alpha_1 lnPA_{it} + \alpha_2 lnH_{it} + \varepsilon_{it} \qquad [4]$$

where PA_{it} = number of patent applications filed by residents in country *i* in year *t*, and H_{it} = human capital, proxied as "Average years of total schooling (age 25+)" in year *t*.

Thus, the two main hypotheses that would be examined are:

1. Whether the growth of an economy's productivity is affected by foreign R-D efforts when it undertakes OFDI in technologically-advanced countries. This can then be compared with the impact of spillovers generated when R-D-intensive countries invest in it.
2. Whether the inclusion of the economy's indigenous technological capability measured in terms of skilled workforce and level of innovation, the latter reflected by number of patent applications, results in improved estimation of the effect of foreign R-D spillovers.

4.2. Data Sources

The data source for OFDI and IFDI flows[6] to and from, respectively, the 34 OECD countries under study between 1990 and 2010 is the *OECD International Direct Investment Database*. Data on GDP and number of patent applications filed by residents[7]is drawn from the World Bank data series (*www.databank.worldbank.org*) and data on R-D intensity is drawn from the *OECD Factbook* 2010. We have collected data on TFP from the Conference Board: *Total Economy Database*. For the average years of total schooling (age 25+), we interpolate from the five yearly data given by Barro and Lee, extracted from the education statistics of the World Bank data series (*www.databank.worldbank.org*).

Before we discuss the results, an important issue must be addressed. As we are looking at the overall macroeconomic picture, it is necessary to show a match-up between the FDI flows into major sectors and the R-D intensity in the respective sectors in order to justify the R-D spillovers approach. This is important to rule out the criticism that FDI could possibly be going into those sectors where there is minimal R-D expenditure, and also to support the rationale behind creating the R-D spillover term and the motivation for developing countries investing to acquire strategic assets. Such accordance is essential, more in the case of OFDI from developing economies into the R-D intensive countries, aimed at attaining technological knowledge, than in the case of IFDI from technology intensive DMNEs. This is so because DMNEs are themselves advanced, and when they invest in emerging economies to enhance their own technological base, they also diffuse knowledge to the local EMNEs in the process.

Therefore, to substantiate this argument, we take the example of OFDI flows from eight major emerging economies under study, and look at the major destination/host countries where they invest. We further classify the investment on the basis of major sectors, and then focus on how much R-D expenditure the host countries undertake in those specific sectors (Table 3).

Looking, for example, at the case of China (Table 3), its major destinations are the United States, Japan, Germany and Australia and the major sectors are Trade and Services,

Table 3. **Matching sectoral distribution of OFDI with the sector specific R-D expenditure in the major destinations**

Investing/ home country	Major sectors	Major destinations (host country)	R-D expenditure in major sectors as a % of total sectoral R-D expenditure in the host country	R-D expenditure in the major sectors as a % of GDP in the host country
India	Pharmaceuticals, agricultural inputs, software, IT and broadcasting	US, Russia, Sri Lanka, Southeast Asia, UK	US: 19.97 UK: 29.24	US: 0.36 (1.89) UK: 0.31 (1.13)
China	Trade and services, manufacturing, resource extraction (oil, gas and minerals), IT	Hong Kong, US, Japan, Australia, Germany	US: 75.28 Japan: 90.31 Germany: 92.82 Australia: 61.55	US: 1.36 (1.89) Japan: 1.55 (1.73) Germany: 1.28 (1.53) Australia: 0.51 (0.93)
Brazil	Energy, mining, services	US, UK, Portugal, Netherlands	US: 29.04 UK: 19.24 Portugal: 41.83 Netherlands: 17.54	US: 0.52 (1.89) UK: 0.20 (1.13) Portugal: 0.17 (0.35) Netherlands: 0.15 (0.98)
Russia	Resource extraction (oil, gas and metal), manufacturing, telecommunication	European Union, US, CEE	US: 71.40 Germany: 92.65 Hungary: 77.54 Netherlands: 81.77 Portugal: 56.92	US: 1.28 (1.89) Germany: 1.27 (1.52) Hungary: 0.46 (0.60) Netherlands: 0.68 (0.98) Portugal: 0.18 (0.35)
Argentina	Oil and gas, iron and steel, food, pharmaceuticals, telecommunications	US, Europe, Japan	US: 11.77 Japan: 11.97	US: 0.21 (1.89) Japan: 0.21 (1.73)
Malaysia	Oil and gas, finance, real estate, construction, trade, hotels and restaurants	US, Singapore, ASEAN	US: 13.12	US: 0.24 (1.89)
Singapore	Finance, transport, manufacturing, real estate, construction	UK, Netherlands, Germany, Australia	UK: 94.02 Netherlands: 91.07 Germany: 98.34 Australia: 76.33	UK: 1.01 (1.13) Netherlands: 0.76 (0.98) Germany: 1.36 (1.53) Australia: 0.64 (0.93)
South Africa	Mining and natural resources, trade, finance, business activities, wood and wood products, machinery	US, UK, Netherlands, Germany, Australia	US: 9.85 UK: 8.99 Netherlands: 16.75 Germany: 11.77 Australia: 30.43	US: 0.18 (1.89) UK: 0.09 (1.13) Netherlands: 0.14 (0.98) Germany: 0.16 (1.53) Australia: 0.27 (0.93)

Notes: CEE = Central and Eastern Europe, ASEAN = Association of Southeast Asian Nations. Parentheses in column 5 = Total sectoral R-D expenditure/GDP. All figures in columns 4 and 5 are averaged across the 1990-2010 period.
Source: OECD STAN Database, *World Bank Data Series*, UNCTAD 2007.

Manufacturing, and Resource Extraction. Calculating the percentage of R-D expenditure in these sectors, the United States spends 75.28% of its total R-D expenditure in these three sectors only. Japan spends 90.31%, Germany spends 92.82%, and Australia spends 61.55%. The last column expresses R-D expenditure in these three major sectors as a percentage of GDP of host countries, i.e. the R-D intensity of those sectors. These figures clearly demonstrate that FDI from developing and emerging economies does take place in those sectors where the host countries are primarily undertaking R-D, and justify the asset seeking behaviour of emerging economies. In other words, host country sectors that have higher R-D intensity attract significant levels of FDI from home countries.

5. Results

We use a Fixed-Effects (FE) regression[8] to analyse the impact of variables that vary over time. We also estimate the model based on a change specification (1st difference), in order to take into account trend and non-stationarity. Further, to check whether there is a long-run cointegration between the variables under study and that the estimated regression is non-spurious, we carry out Pedroni's (1999) cointegration tests for panel data. The seven tests, as suggested by Pedroni, are applied to the basic specification in level and in 1st difference.

Table 4a and 4b summarise the estimation and the cointegration test results, respectively, for our main specification (equation [1]). The 1st two columns of Table 4a present the "within" estimates and the last two columns are the "1st difference" estimates. Regressions (i) and (ii) show the estimated output elasticities of domestic R-D, and of the foreign R-D capital stock incorporated alternatively into one of the two types of technology transfer channels. In both cases, the estimated elasticity of domestic R-D capital stock is positive and significant. Regression (i) concentrates on the foreign R-D capital stock embodied in OFDI, and the estimated elasticity is positive and significant (3.24). This result supports our main hypothesis that OFDI allows EMNEs to source foreign technological bases, thereby increasing the growth of TFP in their home country.

Table 4a. **Total factor productivity estimation results – outward FDI and inward FDI 1990-2010, 378 observations**

	Within		First difference	
	(i)	(ii)	(iii)	(iv)
Domestic R-D				
$LnRD^{d}$	15.2089*	14.3067*	5.1028	7.4502*
	(3.57)	(4.53)	(1.08)	(2.10)
Foreign R-D				
$LnRD^{fo}$ (outward FDI)	3.2429*	-	0.3868	-
	(6.83)		(1.29)	
$LnRD^{fi}$ (inward FDI)	-	6.1523*	-	1.0649*
		(12.36)		(2.65)

Table 4b. **Pedroni's cointegration test results [equations (i) to (iv)]**

Statistic	(i)	(ii)	(iii)	(iv)
Panel v-Statistic	-2.3776*	-0.5152	-2.5095*	-2.1592*
Panel rho-Statistic	6.1019*	6.0915*	4.2799*	5.7028*
Panel PP-Statistic	3.4670*	1.8119**	-2.6126*	-1.8483**
Panel ADF-Statistic	5.4676*	1.1434	3.1352*	0.4989
Group rho-Statistic	7.2695*	7.3411*	5.2867*	6.9358*
Group PP-Statistic	2.3469*	-0.8474	-2.9220*	-5.2221*
Group ADF-Statistic	4.0912*	-2.5403*	4.2913*	-29.9276*

Notes: Figures in parentheses give t-statistics. * denotes significance at the 5% level, ** denotes significance at the 10% level. RD^{d} = Domestic R-D capital, RD^{fo} = Foreign R-D capital embodied in OFDI, RD^{fi} = Foreign R-D capital embodied in IFDI. The cointegration tests reject the null hypothesis of no cointegration.

Comparing the impact of technology spillovers embodied in OFDI with that of spillovers embodied in IFDI, regression (ii) shows that the magnitude of impact is much larger in the latter case (6.15). This suggests that IFDI from OECD countries into the

18 emerging economies induces more substantial technology transfers compared with OFDI from those 18 emerging economies into OECD countries. One possible explanation for such diversity could be that when MNEs from R-D intensive countries invest in developing countries, the former aim at exploiting their own technological innovations and in this process they diffuse the technological knowledge to the host country firms either through "copying" or "labour turnover". Also, when developed countries undertake offshore production to take advantages of factors such as lower wages in developing countries, the host countries benefit more from externalities emanating from foreign companies. However, when firms from emerging countries invest in R-D intensive developed countries, their low technological capacity may not allow them to fully exploit the knowledge spillovers, hence resulting in a comparatively lower impact on the growth of TFP. But nonetheless, OFDI from EMNEs has a positive effect, thus supporting the premise that if foreign companies intend to copy domestic knowledge in the host countries, their home country is likely to benefit from potential spillovers (Van Pottelsberghe de la Potterie and Lichtenberg, 2001).

Looking at the 1st difference estimates, in equations (iii) and (iv), they broadly confirm the level estimates in terms of the sign of coefficients, though the magnitudes are much lower. Also, the elasticities are now significant only in the case of regression equation (iv) that takes into account the R-D spillovers embodied in IFDI. Almost all the cointegration tests suggest that each of the regression equation is cointegrated in the long run (Table 4b).

Table 5 investigates the time stability of the estimated elasticities. Regressions (i) and (ii) are the same as the within estimates of Table 4a, giving the elasticities for the whole period 1990-2010. Regressions (iii) and (iv) present the results for the 1990-2000 period, and regressions (v) and (vi) give the estimates for the 2001-10 period. Clearly, the impact of domestic R-D capital is driven by the 2001-10 trend, as the coefficient for the 1990-2000 series is negative and insignificant. In the case of the impact of foreign R-D capital embodied both in OFDI and IFDI, the emerging economies benefitted significantly only during 2001-10. Though the impact was positive in the 1990s, the effect was insignificant. These figures point out that the practice of technology transfers intensified only during the 2000s, also the phase when FDI flows to and from the EMNEs saw an increasing trend.

Table 5. **Time stability of the output elasticities with respect to domestic and foreign R-D capital**

	1990-2010		1990-2000		2001-2010	
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Domestic R-D						
$LnRD^{d}$	15.2089*	14.3067*	-4.2690	-2.8086	16.4131*	18.4966*
	(3.57)	(4.53)	(-0.79)	(-0.71)	(2.26)	(3.50)
Foreign R-D						
$LnRD^{fo}$ (outward FDI)	3.2429*	-	0.3948	-	2.1016*	-
	(6.83)		(0.66)		(3.39)	
$LnRD^{fi}$ (inward FDI)	-	6.1523*	-	0.8556	-	4.1619*
		(12.36)		(1.05)		(6.88)

Notes: Figures in parentheses give t-statistics. * denotes significance at the 5% level. RD^{d} = Domestic R-D capital, RD^{fo} = Foreign R-D capital embodied in OFDI, RD^{fi} = Foreign R-D capital embodied in IFDI.

Table 6a and 6b focus on the estimation that includes the number of patent applications filed by residents and human capital as control variables. Looking at

Table 6a. **Estimation results – including control variables**

	Within		First difference	
	(i)	(ii)	(iii)	(iv)
Domestic R-D				
*LnRD^d^*	7.8671	11.2084*	7.1945	8.7365*
	(1.62)	(2.97)	(1.37)	(2.24)
Foreign R-D				
$LnRD^{fo}$ (outward FDI)	2.2107*	-	0.3054	-
	(3.88)		(0.97)	
$LnRD^{fi}$ (inward FDI)	-	5.5842*	-	1.0354*
		(9.47)		(2.50)
Control variables				
LnPA	-2.3279	-1.6351	1.2986	1.2099
	(-1.26)	(-1.07)	(1.10)	(1.12)
LnH	56.4557*	27.0407*	-127.5859	30.8099
	(3.63)	(2.15)	(-1.43)	(0.45)

Table 6b. **Pedroni's cointegration test results [equations (i) to (iv)]**

Statistic	(i)	(ii)	(iii)	(iv)
Panel v-Statistic	-2.0030**	-0.3709	-1.4516	-2.8329*
Panel rho-Statistic	5.9899*	7.0537*	3.4346*	6.9614*
Panel PP-Statistic	0.4269	3.2941*	-0.6211	-0.9215
Panel ADF-Statistic	6.1345*	4.8593*	2.1958*	1.9081**
Group rho-Statistic	7.1583*	8.4405*	4.1801*	8.3704*
Group PP-Statistic	-5.4812*	-5.0593*	-1.8470**	-5.7148*
Group ADF-Statistic	5.5249*	-0.8882	2.9465*	-0.9036

Notes: Figures in parentheses give t-statistics. * denotes significance at the 5% level; ** denotes significance at the 10% level. RD^d = Domestic R-D capital, RD^{fo} = Foreign R-D capital embodied in OFDI, RD^{fi} = Foreign R-D capital embodied in IFDI, PA = Number of patent applications filed by residents, H = Human capital defined as the average years of total schooling (age 25+). The cointegration tests reject the null hypothesis of no cointegration.

equations (i) and (ii) in Table 6a, the impact of domestic R-D capital is now significant only in the case of equation (ii). The elasticities of RD^{fo} (2.21) and RD^{fi} (5.58) are positive and significant, though the magnitudes are lower compared with the results obtained in Table 4a. Looking at the coefficients of control variables, the number of patent applications filed by residents does not have a significant impact on growth of TFP[9]. However, the human capital term has a substantial positive and significant effect. The latter result implies that skilled and educated workforce is an essential factor contributing towards improvement in efficiency, and not properly taking into account such factors leads to an upward bias in the output elasticity of foreign R-D capital stock. Again, the cointegration tests suggest the presence of a long-run relationship (Table 6b).

Further, we carry out an additional analysis to exploit the heterogeneity within the data set. We test whether the impact of FDI embodied spillovers is greater when emerging economies deal with larger investing partner countries than smaller. To do this, we introduce a dummy for the larger industrialised countries (G-7) in our sample of 34 OECD countries in order to investigate the difference in the estimated parameters. The results of this analysis are included as Appendix C.

We also compute two matrices of bilateral elasticities of growth of TFP with respect to foreign R-D capital terms, using the estimated parameters from regressions (i) and (ii) of

Table 4a. We follow a similar methodology as suggested by Van Pottelsberghe de la Potterie and Lichtenberg (2001) to compare our results. In case of OFDI embodied spillovers, the elasticity of country i's TFP growth with respect to country j's domestic R-D capital may be expressed as follows:

$$\alpha_{ij}^{fo} = \frac{\delta LnTFP_i}{\delta LnRD_j^d} \qquad (i = 1 \ldots 18 \text{ emerging economies}, j = 1 \ldots 34 \text{ OECD nations})$$

$$= \frac{\delta LnTFP_i}{\delta LnRD_i^{fo}} * \frac{\delta LnRD_i^{fo}}{\delta LnRD_j^d} = \alpha^{fo} * \frac{\delta LnRD_i^{fo}}{\delta LnRD_j^d} \qquad \left(LnTFP_{it} = \alpha_i + \alpha^d LnRD_{it}^d + \alpha^{fo} LnRD_{it}^{fo} + \varepsilon_{it}\right) \qquad [5]$$

$$= \alpha^{fo} * \frac{\delta RD_i^{fo}}{\delta RD_j^d} * \frac{RD_j^d}{RD_i^{fo}}$$

now: $$RD_i^{fo} = \sum \frac{OFDI_{ij} * RD_j^d}{GDP_j} \ldots \qquad (\text{definition of } RD^{fo}) \qquad [6]$$

therefore: $$\frac{\delta RD_i^{fo}}{\delta RD_j^d} = \frac{OFDI_{ij}}{GDP_j} \qquad [7]$$

hence: $$\alpha_{ij}^{fo} = \alpha^{fo} * \frac{OFDI_{ij}}{GDP_j} * \frac{RD_j^d}{RD_i^{fo}} \qquad [8]$$

implying that elasticity of country i's TFP growth with respect to country *j*'s domestic R-D capital is an increasing function of OFDI from country *i* to country *j*, and of country *j*'s R-D intensity. Similarly, the elasticity of country *i*'s TFP growth with respect to country *j*'s domestic R-D capital, embodied in IFDI (country *j* investing in country *i*) may be obtained.

The computed bilateral elasticities for the two channels of R-D spillovers – OFDI and IFDI – are given in Table 7a and 7b, respectively. The figures indicate, for example, that a 1% increase in US R-D intensity raises the TFP of India by 1.31% through OFDI flows from India to the United States, and by 1.99% through IFDI flows into India from the United States. This implies that, in case of bilateral FDI flows between India and the United States, technology transfers are more intense when the United States undertakes investment in India than when India undertakes FDI in the United States. Of the 18 emerging economies under study, the TFP growth elasticity for 13 nations is higher when the United States invests in them than when they invest in the United States. In other words, the United States is an important R-D spillover generator when it undertakes FDI in developing and emerging countries.[10]

Comparing a subset of bilateral elasticities between BRICS and their six main OECD destination countries, namely the United States, the United Kingdom, Japan, Germany, Portugal and the Netherlands, it is clear that the major emerging economies benefit more when the R-D intensive developed countries invest in them than the other way round. For Brazil and China, their bilateral elasticities with all the six OECD investing partners are higher when spillovers are generated through IFDI. Russia, India and South Africa also attain greater productivity growth by acting as host nations, with much larger IFDI embodied elasticities with respect to three, four and five investing partners, respectively.

Overall the elasticities between all the 18 emerging economies and their 34 OECD investing partners, we observe that in the case of 22 OECD countries the TFP growth elasticity of foreign R-D capital embodied in IFDI flows from those 22 nations into the 18 emerging economies is higher than the elasticity embodied in OFDI flows in the reverse direction. Thus, the impact of technology spillovers from R-D intensive foreign countries is

Table 7a. **Output elasticities of foreign R-D capital embodied in OFDI flows**

Emerging → OECD ↓	India	China	Brazil	Russia	Argentina	Malaysia	Singapore	Thailand	Bulgaria	Indonesia	Latvia	Lithuania	Peru	Philippines	Romania	South Africa	Ukraine	Venezuela
Australia	−0.0011	0.0293	0.0000	0.0090	0.0000	0.5038	0.1317	0.0138	0.0000	0.1161	0.0000	0.0000	0.0000	0.7816	0.0000	0.1123	0.0000	0.0000
Austria	0.0066	0.0599	0.1637	0.3985	1.9791	0.0318	−0.0443	−0.8845	−1.2746	−0.0097	−2.0409	0.0638	0.0000	0.0042	−0.2031	0.2323	1.0121	−0.0048
Belgium	0.0388	−0.0446	1.1916	−0.0083	−8.1135	−0.2487	0.4845	0.1584	0.7081	−0.7862	0.5497	−0.0392	0.0164	−0.0930	−0.0807	0.0859	−0.0484	−0.0029
Canada	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Chile	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Czech Republic	0.0154	0.0167	0.0031	0.0360	−0.0021	0.0051	0.0012	0.0111	−0.0129	0.0031	0.0086	0.0550	0.0000	0.0000	−0.1252	−0.0002	0.3434	0.0000
Denmark	0.0180	0.0408	−0.0663	0.1658	−38.1271	0.0424	−0.0191	0.2360	0.1188	0.0277	4.5718	1.8405	0.0000	0.0120	0.0136	0.0036	−1.4514	−0.0019
Estonia	−0.0006	0.0010	−0.0004	0.1075	0.0033	−0.0001	0.0005	−0.0006	0.0399	−0.0035	−2.0205	1.9169	0.0000	−0.0001	−0.0019	−0.0001	0.2228	0.0001
Finland	−0.0127	0.0240	−0.0048	0.5325	−0.0821	0.0037	−0.0015	0.0112	0.0000	0.0102	−1.3337	−0.2951	−0.0254	−0.0025	0.0042	−0.0168	−0.7074	0.0000
France	0.0687	0.1185	0.0568	0.7654	10.9926	0.0586	0.1059	0.2216	−0.1379	1.7178	4.9012	0.6668	0.0210	0.1331	2.0648	0.0149	0.2306	−0.1253
Germany	0.1029	0.4168	0.0077	1.1571	−9.2466	0.2435	0.0403	0.2400	−0.4196	−0.5752	−0.4358	0.1452	−0.0239	0.0170	0.6989	0.7265	−0.3638	−0.7418
Greece	0.0000	−0.0001	0.0000	0.0033	−0.0035	0.0000	0.0000	−0.0002	−0.0236	0.0006	0.0305	−0.0769	−0.0002	0.0000	0.0057	0.0000	−0.0052	0.0000
Hungary	−0.0009	−0.0045	0.2589	0.1138	0.0789	0.0108	0.0062	−0.0146	−0.1893	−0.0174	−0.0618	0.0464	−0.0051	0.0054	0.0752	0.0082	−0.7620	−0.0002
Iceland	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6937	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ireland	−0.0076	−0.2405	0.0513	0.1159	2.8945	0.0082	0.0610	−0.2055	0.0120	−0.0256	0.2584	−0.0654	0.0541	−0.4176	−0.0327	−0.0274	0.0197	−0.0167
Israel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Italy	0.0134	0.0389	0.0931	0.4357	9.2928	−0.0002	0.0022	0.2784	1.4987	0.0486	0.8394	0.0714	−0.0320	0.0056	0.4091	0.0057	0.0997	−0.0386
Japan	0.0081	0.0386	0.0009	0.0016	6.7840	0.0059	0.6125	−0.0235	0.0000	0.1735	0.0000	0.0000	0.0000	0.0163	0.0000	0.0000	0.0000	0.0000
Korea	0.0251	0.3298	0.0022	0.0078	0.0754	1.9055	0.1603	0.0740	−0.0017	0.0411	0.0000	0.0000	−0.0047	0.0208	0.0004	0.0013	0.0020	−0.0015
Luxembourg	−0.0088	0.4629	0.4345	−2.5374	24.9766	0.0094	0.0161	0.0950	3.3539	−0.0480	−3.3822	0.2561	−0.1268	2.6714	0.8055	0.6815	2.4995	0.0001
Mexico	0.0185	0.0049	0.0102	0.0001	6.7485	0.0007	0.0076	0.0160	−0.0004	0.0008	0.0000	0.0043	−0.0225	0.0008	0.0001	0.0001	0.0004	−0.0060
Netherlands	0.1825	0.0123	0.1799	0.1243	4.6648	0.1383	0.0970	3.1122	−0.5115	1.5740	0.7021	0.3655	−0.0744	0.1817	0.0187	0.0109	0.1341	−0.0309
New Zealand	0.0000	−0.0053	0.0000	0.0000	−0.0119	0.0194	0.0088	−0.0085	0.0000	0.2490	0.0000	0.0000	0.0000	0.0004	0.0000	−0.0003	0.0000	0.0000
Norway	0.0014	1.7128	0.0124	0.0008	−0.0890	0.0161	−0.2634	−1.2396	0.0000	0.0020	0.0252	0.0481	0.0935	0.0000	−0.0378	0.0114	0.0821	−0.0049
Poland	0.0031	0.0066	−0.0075	−0.1495	0.0048	0.0108	0.0024	0.0176	0.0212	−0.0258	1.0210	0.2537	0.0000	0.0060	−0.0562	0.0000	1.7002	−0.0001
Portugal	0.0038	−0.0018	0.0748	0.0058	0.0189	0.0000	0.0000	0.0000	0.0001	0.0000	0.0181	0.0889	0.0000	0.0000	−0.0068	0.0044	0.0058	−0.0098
Slovak Republic	0.0000	−0.0006	0.0088	−0.0072	1.6857	0.0023	0.0002	0.3329	−0.0032	−0.0002	0.0160	0.1483	0.0000	0.0000	−0.0077	0.0001	−0.0015	0.0000
Slovenia	0.0000	0.0000	−0.0001	0.0017	−0.0157	0.0000	0.0001	−0.0002	0.0323	0.0001	0.0418	0.0109	0.0000	0.0000	−0.0016	0.0000	−0.0189	0.0000
Spain	0.0007	0.0023	0.1816	0.4616	−36.0857	0.0176	0.0025	0.0041	0.0344	0.0072	0.0000	0.0000	−0.5373	0.0032	0.0060	0.0005	0.1858	−0.2346
Sweden	−0.0352	−0.0784	−0.0116	−0.3946	−0.1504	−0.0219	0.0250	−0.4524	0.0861	−0.1256	−1.5478	−2.5290	0.0306	−0.0106	−0.1379	0.2624	−0.1046	0.0126
Switzerland	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Turkey	0.0089	0.0003	0.0392	0.2412	0.0000	0.0060	0.0013	0.0433	−0.0629	0.0000	0.4411	0.2348	0.0000	−0.0006	0.0139	0.0002	0.2161	0.0002
United Kingdom	1.4836	0.0373	0.0029	0.0487	0.0905	0.0912	0.1176	0.1028	−0.0143	0.0200	0.0000	0.0000	0.0000	0.0029	0.0046	1.0925	0.0000	0.0000
United States	1.3072	0.2622	0.5568	1.6029	24.8770	0.3801	1.6836	1.1010	−0.0133	0.8655	−0.0558	0.0290	3.8768	−0.0979	−0.1890	0.0301	−0.0510	4.4471

Note: Estimated TFP growth elasticity in the country column with respect to the R-D capital in the row country, based on regression equation (i) of Table 4a.

Table 7b. **Output elasticities of foreign R-D capital embodied in IFDI flows**

Emerging → OECD ↓	India	China	Brazil	Russia	Argentina	Malaysia	Singapore	Thailand	Bulgaria	Indonesia	Latvia	Lithuania	Peru	Philippines	Romania	South Africa	Ukraine	Venezuela
Australia	−0.0042	−0.0032	0.0004	0.0003	0.0045	0.0001	0.0597	0.0074	0.0000	0.0004	0.0000	0.0000	0.0000	0.0196	0.0000	0.0004	0.0000	0.0000
Austria	0.0352	0.0866	0.0223	0.6556	0.0044	0.0138	0.0345	0.0125	2.8723	0.0128	0.5706	0.0697	0.0000	0.0007	2.1403	−0.0459	0.5067	0.0029
Belgium	0.0355	−0.0040	0.1669	0.1788	−0.0896	0.0180	0.5933	0.0355	0.2007	0.0099	0.0443	0.0241	0.1293	−0.0588	0.9163	0.0558	0.0391	0.0326
Canada	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Chile	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Czech Republic	0.0024	−0.0001	0.0000	0.0072	0.0000	0.0000	0.0001	0.0000	0.1634	0.0000	0.0056	0.0005	−0.0003	0.0000	0.1058	0.0000	0.0048	0.0000
Denmark	0.0464	0.0739	0.0408	0.0006	0.0568	0.0319	0.1181	0.0060	0.0456	0.0142	0.5254	0.3432	0.0075	−0.0052	0.0188	0.0592	−0.0221	0.0557
Estonia	0.0000	0.0000	0.0000	0.0026	0.0000	0.0000	0.0000	0.0002	0.0163	0.0000	2.5967	1.1439	0.0000	0.0000	0.0020	0.0001	0.0243	0.0000
Finland	0.2260	0.2497	0.0189	0.2782	0.0029	0.0237	0.0937	−0.0181	0.0061	0.0046	−0.9229	0.0860	0.0121	0.0024	0.0569	0.0156	0.0388	0.0115
France	0.3608	0.2695	0.7758	0.5749	0.5537	0.0697	0.2585	0.2098	0.3263	0.2306	0.0991	0.5222	0.5689	0.2206	0.5789	0.2286	0.2083	0.5892
Germany	0.9096	0.8207	0.3743	1.0354	0.2640	0.3104	0.1066	0.2855	0.8692	0.2985	0.9294	−0.1046	0.3147	0.1689	0.9396	0.5017	3.5681	0.6030
Greece	0.0000	0.0000	0.0001	0.0011	−0.0001	0.0000	0.0000	0.0000	0.0564	0.0000	−0.0010	−0.0001	0.0006	0.0000	0.0229	0.0001	0.0098	0.0000
Hungary	0.0013	−0.0001	0.0029	0.0214	0.0004	0.0022	0.0006	0.0000	0.2289	0.0000	0.0000	0.0085	−0.0002	0.0000	0.0345	0.0000	0.1734	0.0000
Iceland	0.0121	0.0010	0.0000	0.0099	0.0000	0.0000	0.0000	0.0001	0.0219	0.0005	0.4858	0.0553	0.0000	−0.0022	−0.0008	0.0001	0.0017	0.0000
Ireland	0.0130	0.0028	−0.0001	0.0019	0.0005	0.0001	0.0005	−0.0001	0.0000	0.0000	0.0000	0.0008	0.0000	0.0000	0.0000	0.0007	−0.0004	0.0000
Israel	0.0000	0.0029	0.0018	0.0000	0.0015	0.0000	−0.0140	0.0009	0.0000	0.0000	0.0000	0.0000	0.0113	0.0000	0.0063	0.0000	0.0000	0.0000
Italy	0.1126	0.0414	0.0959	0.0872	0.1010	0.0152	0.0043	0.0025	−0.0314	0.0074	0.0270	0.0680	0.0257	0.0188	0.2428	0.0337	0.1344	0.0682
Japan	0.7417	1.9582	0.6241	0.0463	0.1576	2.2146	0.7625	3.2390	0.0505	3.1225	0.0000	0.0000	0.4004	3.7303	0.0137	0.2253	0.0128	0.1095
Korea	0.1154	0.5644	0.0259	0.0345	0.0126	0.0684	0.0709	0.0904	0.0127	0.1429	0.0125	0.0003	0.5283	0.2118	0.0201	0.0136	0.0755	0.0103
Luxembourg	0.0080	0.0113	0.1203	0.2149	−0.0220	0.0034	0.2829	−0.0003	0.1016	0.0311	0.7264	0.0889	0.0106	0.0243	0.0076	0.2796	−0.0146	−0.0026
Mexico	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Netherlands	0.2368	0.1122	0.4195	0.7458	0.1289	0.2020	0.4169	0.3343	0.0547	0.0416	0.0778	0.0680	−0.1857	0.7517	0.4533	0.1377	0.1539	0.3661
New Zealand	0.0001	0.0000	0.0000	0.0000	−0.0003	0.0007	0.0060	0.0001	0.0000	0.0025	0.0000	0.0000	−0.0025	−0.0001	0.0000	0.0000	0.0000	−0.0016
Norway	0.0046	−0.0007	0.0161	0.1311	−0.0001	0.1078	0.3368	−0.0038	0.0165	−0.0002	0.1079	−0.0361	−0.0788	−0.0224	−0.0074	−0.0003	0.1096	−0.2046
Poland	0.0042	0.0003	0.0000	0.0128	0.0000	−0.0009	0.0009	0.0001	0.0095	0.0004	0.0076	0.8794	0.0000	0.0000	0.0134	−0.0001	0.0806	0.0000
Portugal	0.0013	0.0001	0.1152	0.0004	0.0027	0.0000	0.0000	0.0000	0.0011	0.0000	0.0015	0.0000	0.0000	0.0000	0.0226	0.0156	0.0110	−0.0061
Slovak Republic	0.0000	0.0000	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0003	0.0000	0.0000	0.0001	0.0000	0.0051	0.0000
Slovenia	0.0000	0.0002	0.0001	0.0239	0.0006	−0.0001	0.0000	0.0000	0.0180	0.0003	−0.0002	0.0000	−0.0001	0.0000	0.0002	0.0012	−0.0018	0.0000
Spain	0.0483	0.0258	0.7760	0.0409	1.9446	0.0113	0.0003	0.0120	0.1987	−0.0005	0.0000	0.0000	1.1386	−0.0191	0.1860	0.0229	0.0028	−0.0344
Sweden	0.2190	0.0705	0.0086	0.5755	−0.0038	0.2623	−0.0218	0.0150	0.6607	0.0059	1.0555	2.8989	0.2934	0.0062	0.1089	0.1366	0.4204	0.1050
Switzerland	0.0554	0.0205	0.0202	0.0217	0.0177	0.0276	0.1578	0.0407	0.0063	0.0179	0.0000	0.0000	0.1821	0.0085	0.0358	0.0031	0.0573	0.0644
Turkey	0.0017	0.0001	0.0001	0.0055	0.0001	0.0000	0.0001	0.0000	0.0057	0.0001	0.0020	0.0000	0.0000	0.0000	0.0052	0.0001	0.0059	0.0000
United Kingdom	0.9728	0.2739	0.4276	0.7111	0.5062	1.0309	0.1064	0.4673	0.0517	0.3307	0.2451	0.0011	0.6274	0.7393	0.0983	3.6281	0.2170	0.5632
United States	1.9900	1.5719	2.0963	0.7298	2.5052	1.7371	2.7743	1.4130	0.1863	1.8760	−0.4461	0.0315	2.1667	0.3546	0.1280	0.8365	0.3274	3.8178

Note: Estimated TFP growth elasticity in the country column with respect to the R-D capital in the row country, based on regression equation (ii) of Table 4a.

much greater when the developing and emerging economies act as host countries for the IFDI flows than as home countries undertaking OFDI. These country specific figures are consistent with our overall result given in Table 4a, showing a higher impact of RD^{fi} compared with RD^{fo}.

6. Conclusion and policy implications

An important dimension of the "going-out" strategy is provided by reverse technology spillovers through various mechanisms, one of which is the "strategic asset seeking" motive of OFDI. In this study, we examine the impact of such technology spillovers on the growth of TFP of the home country and, in contrast with some of the previous studies, the paper deals with the overall macro-effect of OFDI. We then compare the effect of spillovers embodied in OFDI with that of spillovers embodied in IFDI, and also analyse the role of human capital and the number of patent applications filed by residents as control variables to improve the estimation of output elasticity. To carry out the analysis, we apply the generalised version of Van Pottelsberghe de la Potterie and Lichtenberg Model (2001). We create the foreign R-D spillover variable based on outward and inward investment, focusing on the OFDI flows from 18 emerging economies into 34 OECD countries over the 1990-2010 period, along with the IFDI flows into the 18 emerging economies from the 34 OECD countries.

The results confirm that OFDI from the emerging economies into OECD countries has a positive and significant impact on the TFP growth of the former. The effect here is mitigated through a transfer of foreign R-D capital, but the magnitude of the impact is smaller than that of R-D spillovers resulting from IFDI flows in the opposite direction. This result is also confirmed by our country-specific bilateral elasticities, showing that developing countries benefit more when technology-rich nations invest in them than the other way round. However, our results are contrary to what Van Pottelsberghe de la Potterie and Lichtenberg (2001) suggested.[11] They found that IFDI is more intended to take advantage of the technological base of the home country than to diffuse the technology that originates in the home country. Thus, there is an insignificant impact on the growth rate of host countries' productivity. Such a contrast might occur because of the difference in the coverage of countries. Van Pottelsberghe de la Potterie and Lichtenberg focus on FDI flows between 13 industrialised nations, whereas our study concentrates on IFDI flows from technologically-rich OECD countries into the emerging and developing economies. As a result, it may well be the case that technology transfers are more visible and have a significant impact for North-South FDI rather than North-North FDI.

Overall, the study provides evidence of a productivity-enhancing effect of FDI felt through foreign R-D spillovers. Further, the cointegration tests suggest the presence of a long-run relationship between TFP growth and the R-D spillovers through two channels – OFDI and IFDI. The inclusion of control variables highlights the importance of catalyst terms, such as human capital, in reducing the upward bias in the output elasticity of foreign R-D capital stock. We thus address two main subjects concerning the impact of FDI: the cross border flow of technology – through the traditional channel when DMNEs invest in emerging economies, and the more recent channel when EMNEs invest in advanced economies. Next, and more importantly, our analysis combines this flow of technology to explain the effect on TFP growth of emerging economies.

The theoretical framework of this paper therefore has much in common with the Schumpeterian premise that the economic growth of a nation depends upon the creation of new technology or diffusion of technology (Tolentino, 1993). Since developing countries have limited technological capabilities, the transfer of technology across borders through direct investment provides the initial basis for technological development. Such transfers therefore assist the developing countries in narrowing down the technological gap, and hence attain profitable improvements in productivity and efficiency. However, the success of technology transfer depends on a number of factors. On the one hand, factors such as the ability of the country to adapt and develop the transferred technology could pose a challenge. This requires the development of human resources and a better absorption and implementation of advanced techniques through innovation. On the other hand, adequate infrastructure, such as scientific and technical training institutions, R-D facilities, and socio-economic environment play an important role in influencing the absorption of new and advanced technology. It is therefore imperative that government policies directed towards effective assimilation of foreign technology are set in motion.

It is often considered that OFDI enhances the interests of multinational corporations only; however the paper brings out opportunities for the economy as a whole by way of factors such as technology and productivity spillovers. With the understanding that OFDI has a positive impact for developing economies, the study encourages a high quality institutional environment to offer favourable conditions for running business, and hence make the business entities strong and competitive for foreign expansion. Given that OFDI constantly adds to the knowledge stock through reverse technology spillovers, and thereby affects productivity, the link between institutions and OFDI could be seen as a channel through which institutions promote productivity growth. In other words, the research suggests the need to devise strategies to develop a common lobby of interests between MNEs and policymakers in enhancing the positive effects of globalisation for growth and development of the country.

Notes

1. Dunning's IDP model suggests that a country's outward and inward FDI are partly a function of its level of development, and that countries go through different stages as their economy develops.
2. We consider technology transfers from resource rich to emerging economies. A number of reasons could be identified for why we take into account only FDI embodied spillovers, and not import embodied spillovers. First of all, it may be difficult to validate that the emerging economies are importing from advanced countries mainly to acquire strategic assets. Also, emerging economies such as India and China are rising exporters. Therefore by taking into account only FDI, we have concentrated on the increasing levels of outward investment from developing countries mainly aimed at fulfilling their asset-seeking motive. Further, two countries could import homogeneous goods from another country j, and such imports may benefit one country more than another. It may be difficult to ensure that goods sold by country j to country i were embodied by R-D intensity substantially different from the R-D intensity of goods sold to another country (Griliches and Lichtenberg, 1984). However, the FDI based weighting matrix that we attach embodies different R-D intensity for different i and j (as M&As, Greenfield investment, Joint Ventures are country specific). Also, even if FDI is classified as a technology flow matrix (rent spillover), the hierarchical clustering analysis shown in studies such as Van Pottelsberghe de la Potterie (1997) reflects that it is more likely to catch up knowledge spillovers than the Input-Output (IO) matrices because of a much closer clustering of the former to the technology proximity matrices. Lastly, studies have shown that knowledge spillover matrices yield higher returns than the IO matrix (Goto and Suzuki, 1989; Vuori, 1997; Verspagen, 1997).
3. TFP growth – measured as the change in GDP growth over the compensation-share weighted growth of combined factor inputs (labour and capital inputs, adjusted for change in their quality).
4. Modified versions of this methodology have also been tested and employed by Coe and Helpman (1995), Lichtenberg and Van Pottelsberghe de la Potterie (1998), and Zhu and Jeon (2007).

5. We use the TFP index values. These values are generated using the growth rates obtained from the *Total Economy Database* (the Conference Board). We do so to avoid the loss of observations [as $ln(X)$ is undefined for $X < 0$] in using TFP growth rates.
6. Statistical data on FDI flows are more readily available than stocks. It is difficult to construct the stock values due to missing data and heterogeneous methodologies adopted in different countries.
7. Our source of data on Patent Applications is the *World Bank Database*, defined as – "Patent applications are worldwide patent applications filed through the Patent Cooperation Treaty (PCT) procedure or with a national patent office for exclusive rights for an invention". PCT is an international treaty providing a unified procedure for filing patent applications, and incorporates both priority and second filings. Statistics based on PCT applications are less subject to geographic bias, eliminate any institutional bias, and the timeliness of the indicator is also good. Also as defined, in addition to PCT, the World Bank data also incorporate data from the National Patent Office. But as we are looking at emerging economies the bias of using domestic filings is subsided. This is because the home offices attract the majority of priority filings, as in the case of patents by inventors from developing countries such as Brazil, China, Russia (de Rassenfosse et al., 2013).
8. We carried out the Hausman test to select between the Fixed and Random Effects Model. The Hausman Test tests the null hypothesis that the coefficients estimated by the Random Effects Estimator are the same as the ones estimated by the Fixed Effects Estimator. If they are (insignificant P-value) then it is safe to use the Random Effects Model. However, if the P-value is significant, then the Fixed Effects Model is used. We obtain a significant P-value for the estimated equation, therefore justifying the use of the Fixed Effects Regression Model for our analysis.
9. A few drawbacks could be identified about the Patent Applications series used in this study. First of all, under PCT applications usually are of higher value, thus filtering out low value patents. As a result, it may put developing economies at a disadvantage. Also, companies (particularly small companies) are less likely to target foreign markets and mainly carry out inventions of local relevance. Overlooking these local patents therefore precludes a full view of the inventive activity of developing countries. This could also be a possible reason for an insignificant coefficient in our result. Further, PCT counts could be highly correlated with other counts such as USPTO, EPO and triadic. Therefore, as suggested by de Rassenfosse et al. (2013), the worldwide indicator that improves the measurement of inventive activity, especially in the case of emerging economies (because of no geographic bias and no filter on patent value) could be used to improve the estimation. However, as the main aim of this paper is not to focus on a detailed examination of patent counts, we tried to stick to using World Bank data to maintain a consistency for the countries under study.
10. The United States is a large industrialised country, and greater magnitudes of output elasticities of R-D spillovers embodied in OFDI and IFDI flows signify a much higher impact compared with other smaller OECD investing partners. This is consistent with the findings of previous studies (Van Pottelsberghe de la Potterie and Lichtenberg, 2001) that suggest a larger effect of FDI induced R-D spillovers for larger economies such as G7 countries.
11. Other than studying a different set of countries, our paper also differs from Van Pottelsberghe de la Potterie and Lichtenberg (2001) in terms of the definition of the key spillover variable. Unlike our study, they use a four year moving average of the flow of FDI. Also, the denominator of their spillover term is gross fixed capital formation of country *j*, whereas we use GDP of country *j*. These factors also explain differences in our results.

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APPENDIX A

List of 18 emerging economies

Argentina
Brazil
Bulgaria
China
India
Indonesia
Latvia
Lithuania
Malaysia
Peru
Philippines
Romania
Russia
Singapore
South Africa
Thailand
Ukraine
Venezuela

APPENDIX B

List of 34 OECD countries

Australia
Austria
Belgium
Canada
Chile
Czech Republic
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Iceland
Ireland
Israel
Italy
Japan
Korea
Luxembourg
Mexico
Netherlands
New Zealand
Norway
Poland
Portugal
Slovak Republic
Slovenia
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

APPENDIX C

Summary results for larger industrialised (G7) partner countries

Estimation results – including dummy for G7 countries

	Within	
	(i)	(ii)
Domestic R-D		
$LnRD^{d}$	12.4063*	12.2284*
	(2.75)	(3.76)
Foreign R-D		
$LnRD^{fo}$ (outward FDI)	1.9862	-
	(1.52)	
$LnRD^{fi}$ (inward FDI)	-	7.5333*
		(7.60)
Larger countries		
$LnRD^{fo}$ * G7	2.3661**	-
	(1.85)	
$LnRD^{fi}$ * G7	-	-1.0824
		(-1.04)

Notes: Figures in parentheses give t-statistics. * denotes significance at the 5% level, ** denotes significance at the 10% level. RD^{d} = Domestic R-D capital, RD^{fo} = Foreign R-D capital embodied in OFDI, RD^{fi} = Foreign R-D capital embodied in IFDI.

The table shows the results that allow output elasticities with respect to foreign R-D capital stock to differ between G7 and other countries. The additional variables $LnRD^{fo}$* G7 and $LnRD^{fi}$* G7 are created by including a dummy that takes value one for G7 countries in the construction of foreign R-D spillovers term. This is done to test whether the estimated parameters are different for larger than for smaller investing partner countries.

The results clearly indicate that in the case of foreign R-D embodied in OFDI from the 18 emerging economies, the impact is much greater and significant when these economies undertake investment in the larger industrialised countries. However, the reverse is true for the spillovers embodied in IFDI flows into the emerging economies.