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Abstract

One of the most intriguing aspects of the recent empirical literature on FDI-related spillover effects is the increasing identification of mixed results. A few studies, particularly in advanced countries have found positive effects; however, a more common scenario in recent studies is the prevalence of insignificant or even negative effects. This is despite the fact that theory predicts substantial positive effects in association with a supposed technological superiority of MNCs relative to domestic firms, particularly in the context of less advanced countries. In this paper, by distinguishing subsidiaries according to their orientation to carry out creative vs. exploitation activities in the host economy, we are able to distinguish situations with positive and negative spillover effects, and we explain why they may be emerging. More specifically, we find that only subsidiaries that are oriented to technologically creative activities have significant and positive effects in India. In contrast, subsidiaries oriented mostly to technologically exploitative activities generate negative effects in some circumstances. The implications for theory and policy are discussed.

Key Words: *technological spillovers, MNCs, emerging economies, subsidiaries, heterogeneity*

JEL Codes: *O1, O3, O5*

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INTRODUCTION

Research on spillover effects from FDI in host economies has been dominated for many years by a particular view of the MNC. From Caves (1974) and Hymer (1976), to Haskel et al. (2002), Blomström and Kokko (2003) and Javorcik (2004), three assumptions have underpinned this research: (1) that MNCs exist because they are able to develop, accumulate and take advantage of a unique set of technological assets, such as particular product innovations and superior management or marketing techniques; (2) that these unique technological assets are originated in the home country of the MNC and transferred to subsidiaries via FDI; and (3) that technology transfer takes place easily between MNC units, so assets and technology can be easily moved across different departments and branches within the MNC, or from headquarters to local subsidiaries (Hymer, 1976; Markusen, 1995; Haskel et al., 2002; Blomström and Kokko, 2003; Driffield and Love, 2007). The combination of these conditions provides the basis for a *'pipeline model'* of spillover effects (Marin and Bell, 2006) in which spillovers of superior technology are supposed to be delivered from MNC parents, via subsidiaries, to domestic firms, but without local subsidiaries mediating in any important way.

In the face of weak empirical evidence (see Javorcik, 2004 for a discussion of the empirical literature and Crespo and Fontoura, 2007 for a recent survey), it has often been argued that the absence of spillovers is due to one or more of three factors: the limited capabilities of locally owned firms to absorb potential spillovers (Kokko, 1994; Konings, 2001; Girma, 2005); heterogeneity in the strategies of MNCs in terms of what is transferred to subsidiaries (Wang and Blomström, 1992; Buckley et al., 2007; Driffield and Love, 2007; Javorcik and Spatareanu, 2008); or the lack of inclusion of potential vertical effects (Javorcik, 2004; Kugler, 2006). Subsidiaries are assumed to play no role in the process. Within these perspectives and in the absence of positive effects, it is still

presumed that a 'knowledge pipeline' does exist, running from the MNC parent companies via international technology transfer, to the subsidiaries, so creating at least a potential for spillover effects.

But recent theorising on MNCs in the international business (IB) literature questions this view in two ways. First, this literature questions the idea that MNC ownership advantages emerge exclusively from the technological assets created by MNCs in the home country. It argues that technologically active subsidiaries, with their knowledge activities dispersed across diverse locations, are playing increasingly important roles in the process of advantage creation within MNCs (Cantwell, 1995; Birkinshaw et al., 1998; Feinberg and Gupta, 2004). Second, the MNC literature questions whether the technological assets that sustain these advantages can be transferred easily, smoothly and without cost across different branches of the MNC. Instead, technologically active subsidiaries are key in ensuring that this technology transfer takes place effectively (Teece, 1977; Szulanski, 1996; Gupta and Govindarajan, 2000).

In line with these ideas in the IB literature, a new wave of spillover studies has started to explore how quantitative differences in subsidiaries' technological activity in the host economy affects the generation of spillover effects – developing 'subsidiary-centred' models of spillover estimations (e.g. Marin and Bell, 2006; Todo and Miyamoto, 2006; Castellani and Zanfei, 2007). These studies all converge in indicating the same pattern: only subsidiaries that carry out substantial technological efforts in the host economy generate positive effects, questioning the *"pipeline model"* of spillover generation. In this paper we contribute to this new direction of research by exploring how heterogeneity across subsidiaries with respect to the <u>type</u> of technological activity they carry out in the host economy affects spillovers. More specifically, we distinguish two types of technological activity by subsidiaries: 'competence creating' – oriented to the creation of new knowledge assets in the host economy – and 'competence

exploiting' – oriented to the exploitation of existing MNC technological assets in the host country. Thus, we develop hypotheses that link heterogeneity in the type of technological activity of subsidiaries with the significance and sign of spillover effects. In this way we address one of the more intriguing aspects of the recent spillovers literature, the increasing identification of negative effects (Aitken and Harrison, 1999; Djankov and Hoekman 2000; Gorg and Strobl, 2004; Merlevede and Schoors, 2006; Liu, 2008).

We examine spillover effect as it is common practice, modelling spillovers within the familiar production function framework. However, we include a novel methodological step in the main analysis to estimate the spillover effects of heterogeneity among subsidiaries. We concentrate on horizontal spillovers – i.e. the effects of MNCs on domestic firms operating in the same industry as the subsidiary. The estimation uses data covering the period 1994-2002 from Prowess, a database provided by the Centre for Monitoring Indian Economy (CMIE). The sample covered by this database represents a substantial share of manufacturing activity in India (70 percent).

Our results are striking. Like many previous studies in emerging economies, we found that MNC-related spillovers did not arise in India simply from FDI flows, as the pipeline model predicts, a result that holds even after introducing the possibility of differences in the absorptive capability of domestic firms. Instead, they were strongly associated with the nature and intensity of technological activity of the subsidiaries in the host economy. More specifically, and in accord with our hypotheses, we found that significant positive spillovers only emerge in association with the technological activities of competence creating subsidiaries. In contrast, subsidiaries mostly oriented to exploitative activities did not generate any effect, or generated even negative effects in some circumstances. These results suggest that there seems to be important potential for exploring the effects of different aspects of

subsidiaries' heterogeneity on spillover effects. They also provide useful insights to think about more efficient and effective policies for FDI, which focus on subsidiaries' activities, rather than on inflows of FDI in general.

India provides an ideal context for our research for two reasons. First, the country has very recently become an FDI-intensive economy. Second, India is one of the emerging economies that has most benefited from the increased decentralisation of innovative tasks by MNCs. Since the regime was liberalised at the beginning of the 1990s, important MNCs such as Astra AB of Sweden, Akzo of the Netherlands, and Eli Lilly, Du Pont, Abbott Laboratories, Parke Davis and SmithKline Beecham of the USA among others have set up R&D facilities in India (Reddy, 1997; Kumar, 2005; Mrinalini and Wakdikar, 2008). Furthermore, there is evidence that these facilities are not only dedicated to carry out product adaptations to the local market but also, in many cases, to carry out creative activities, developing technologies for the corporation (Kumar, 2005). We expect therefore that variability in our dataset would capture differences across subsidiaries (creative vs. exploitative) which are meaningful for our empirical analysis.

The paper is organised as follows. The next section discusses the background and develops our hypotheses about the association between MNC subsidiaries' knowledge activities, and spillover effects. This is followed by a discussion of the issue in the context of FDI flow in India. Then the data and the methodology of the study are explained. The results are discussed along with a few concluding remarks and policy implications in the end.

A SUBSIDIARY-DRIVEN MODEL OF SPILLOVER EFFECTS: BACKGROUND AND HYPOTHESES

i. Background

Dominant Ideas in the Spillovers Literature

Since the mid-1980s a great deal of work has focused on MNC-related technological spillovers in host economies (e.g. Blomström and Person, 1983; Blomström, 1986; Haddad and Harrison, 1993; Blomström and Sjoholm, 1999; Haskel et al., 2002; Kathuria, 2002; Liu and Wang, 2003; Javorcik, 2004; Alvarez and Molero, 2005; Girma, 2005; Chang and Xu, 2008; Javorcik and Spatareanu, 2008). The earlier studies – usually conducted at the country- or industry-level – confirmed the expectation that MNCs generated spillover effects in the host economy based on their technological superiority (e.g. Caves, 1974; Blomström and Wolf, 1994; Kokko, 1994). More recent studies, however, using firm-level data and panel data analysis, have identified mixed results and, in an attempt to account for these, the literature has explored alternative explanations. One strand of literature, for instance, has focused on the heterogeneity among local recipient firms, studying their capacity to absorb knowledge spillovers from FDI (Kokko, 1994; Konings, 2001; Girma, 2005). Another strand has pointed to the importance of considering vertical (inter-industry) spillovers, next to horizontal (intra-industry) ones (Javorcik, 2004; Kugler, 2006). Results remain mixed[1] and what is striking is that most of this literature, even in the absence of spillover effects, has not questioned the pioneers' ideas about the workings of the process on the 'supply side'. Spillovers from MNCs to domestic firms continue to be hypothesised to arise almost automatically from technological assets

[1] The absorptive capability model has not provided conclusive results, as the role of technological distance for the absorptive capacity of local firms remains an issue of debate (see for instance Kathuria, 2002; Kinoshita, 2001; Konnings, 2001; Patinbandla and Sanyal, 2005; Marin and Bell, 2006); and the estimation of vertical spillovers has provided positive as well as non-significant results (see for instance Kugler, 2006 and Javorcik and Spatareanu, 2008 for positive results and Merlevede and Schoors, 2006 and Yudeva et al., 2003, for non-significant results).

created centrally in the MNC headquarters (Blomström and Person, 1983; Javorcik, 2004; Chang and Xu, 2008).[2] The technological activities of the subsidiaries in the host economy are often not given credit for playing a role in this process.

Changes in MNC Theory

These ideas within the spillovers literature correspond to very traditional views of the MNC in the MNC literature (Kindleberger, 1962; Vernon, 1966; Caves, 1974; Hymer, 1976; Lall, 1979; Rugman, 1981). These views, that reflected the reality of many MNCs during the 1970s and 1980s, conceptualised subsidiaries as mere extensions of the parent firm abroad with the purpose of exploiting in host economies technologies created centrally by MNC headquarters (see for instance Rugman, 1981).

Things have, however, changed substantially since the late 1980s, and the MNC literature has, by and large, reflected those changes. MNCs are increasingly seeking advantages originated in the global spread of the firm rather than just exploiting centrally-created technological assets. Thus, subsidiaries have become central players in the process of knowledge and technology creation within MNCs. Alongside these changes the MNC literature has begun to focus on subsidiaries as a separate unit of analysis (see for instance, Ghoshal and Bartlett, 1990; Birkinshaw and Hood, 1998; Cantwell and Janne, 1999; Kuemmerle, 1999; Papanastassiou and Pearce, 1999; Pearce, 1999; Zander, 1999; Kumar, 2001; Le Bas and Sierra, 2002; von Zedwitz and Gassman, 2002; Cantwell and Iammarino, 2003). Several studies have highlighted different types of heterogeneity in their roles, and have developed a number of typologies emphasising different aspects of this heterogeneity.

[2] Three exceptions are the studies by Marin and Bell (2006) for Argentina, Todo and Miyamoto (2006) for Indonesia, and Castellani and Zanfei (2007) for Italy.

A Central Typology of Subsidiaries

One typology that has become very popular is based on a distinction between two possible roles played by the dispersed technological activities of subsidiaries: supporting the exploitation of existing MNC technological assets in host country contexts; and the creation of new knowledge assets for the MNC (Dunning and Narula, 1995). The first type has been called "asset-exploiting", and the second type "asset-augmenting" (Dunning and Narula, 1995; Narula and Zanfei, 2005).[3]

Asset-exploiting technological activities by subsidiaries aim to improve the way in which existing assets are utilised in particular contexts, responding to specific foreign location conditions (Narula and Zanfei, 2005). Asset-augmenting activities in subsidiaries are prompted by a perceived need by MNCs to protect these assets or create new ones (Dunning and Narula, 1995). MNCs use this second type of activity to take advantage of the knowledge resources available in different locations and also to capture localised technological spillovers created by local firms and institutions in foreign locations, which are unique to these locations (Dunning and Narula, 1995; Kuemmerle, 1999; Feinberg and Gupta, 2004).

Following these ideas, Cantwell and Mudambi (2005) identified a distinction between two types of subsidiaries: 'competence exploiting' or 'competence creating' subsidiaries. Competence creating are those that receive or gain mandates to develop new products or technology for their

[3] Kuemmerle (1999) refers to 'home-base exploiting' or 'home-base augmenting' FDI. This terminology however is more consistent with early conceptualisations of the MNC which see activities in subsidiaries as being exclusively driven by MNC motivations and strategies and are less concerned with subsidiary-level strategies, as in more modern flexible approaches to the MNC.

MNC.[4] Competence exploiting subsidiaries are those with more traditional mandates, to exploit existing assets of the corporation in the host economy (Cantwell and Mudambi, 2005).

In the next sub-section we draw on this distinction to develop hypotheses linking subsidiaries' activities in the host economy and spillover effects.

ii. Incorporating Heterogeneous Subsidiaries in Models of Spillovers: Hypotheses

We believe that this diversity of roles – or orientations[5] – across subsidiary types is likely to have important implications for spillover effects. In particular, we expect that 'competence creating' (CC) subsidiaries engaged in exploration activities will be more likely to generate positive spillover effects in less advanced contexts than competence exploiting (CE) subsidiaries. This is because the knowledge resources that could potentially 'leak' from them to domestic firms are superior or more valuable for domestic firms in emerging countries relative to the ones they typically possess. Exploration activities include things such as 'search, variation, risk taking, experimentation, play, flexibility, discovery, and innovation' (March, 1991: 71)*;* and these kinds of activities, together with the capabilities associated with them, are much less frequent in firms in less advanced contexts (Bell and Pavitt; 1993; Kim, 1997). The literature on innovation in firms in industrialising countries has clearly documented how difficult it is for firms in less advanced contexts, which often enter new industries by using technologies developed by firms in advanced contexts, to move from

[4] Birkinshaw (1997) has emphasised that some subsidiaries, although not having explicitly received this mandate from the parent company, might evolve to more creative roles through their own initiative, thus gaining rather than being given a mandate to develop products and technologies, instead of only using them.

[5] Subsidiaries may indeed combine both types of activities, some of them more or less oriented to exploration vs. exploitation activities.

exploitation capabilities to exploration capabilities – or from imitation to innovation in the words of Kim (Bell and Pavitt; 1993, Kim, 1997; Figueiredo, 2003).[6]

We expect therefore that the localisation of CC subsidiaries, which possess explorative capabilities, or the capabilities associated with innovation, is much more likely to have a significant impact on innovation and productivity growth in domestic firms in less advanced contexts than the localisation of CE subsidiaries. This is because they will potentially diffuse capabilities which are less common and therefore more valuable for host country firms.

Another reason why CC subsidiaries could make a more significant spillover-based contribution to the productivity growth of domestic firms than CE subsidiaries is because of their orientation to tap into local sources of knowledge, including domestic firms. Subsidiaries engaged in knowledge augmenting activities consider local contexts as sources of competences and of technological opportunities (Narula and Zanfei, 2005). They tend therefore to be more embedded in the local innovation system (Cantwell and Mudambi, 2005). In their eagerness to connect to local sources of knowledge, therefore, it is likely that they would diffuse some of their superior knowledge and capabilities to domestic firms.

Some of the ways in which spillovers in association with the activities of CC subsidiaries may occur include:

1. movement of scientists trained in R&D tasks. This is potentially a very valuable channel because scientists in emerging economies,

[6] An indication of this fact is provided by the following figures: in 2002 only 12 per cent of world patents were issued to developing country firms and developing countries accounted for less than 10 per cent of total world R&D expenditure, while these countries contained 89 per cent of the total world population (World Development Indicators, 2005).

although well trained in basic research often lack the skills to transform their substantial basic scientific and engineering knowledge into tangible products and processes[7] (Reddy, 2005),

2. transfer of R&D capabilities to domestic firms. A good example of this possibility is the transfer of capabilities to develop DNA recombinations that occurred in India between Astra Zeneca and Genei (Gene India), a domestic firm that started to develop and commercialise biotechnology products for the subsidiary and to export these products worldwide (for a good description see Reddy, 2005),
3. through joint ventures with or subcontracting to domestic scientific institutions, which can then transfer more widely the knowledge acquired via interactions with affiliates to other domestic firms,
4. emergence of spin-offs by former employees who have learned exploration capabilities. Parallax Research of Singapore is a good example of this possibility. This company, which provides R&D services for several MNCs in Singapore, was created by a former employee of Hewlett Packard (for a description see Reddy, 2005),
5. subcontracting domestic suppliers which will develop unique capabilities necessary to meet the specific demands of CC subsidiaries;
6. via demonstration effect which will contribute to developing a commercial and entrepreneurial culture in the domestic scientific community. In the case of R&D labs in Shanghai, China, for instance, it has been documented how the practice of developing joint ventures with local universities, common in foreign affiliates with a CC mandate, has diffused to large domestic firms via demonstration effects (Reddy, 1997, 2005; Yun-Chung Chen, 2008).

[7] There could be a negative effect if subsidiaries attract the best trained scientists, leaving domestic firms without access to them. However, this potential negative effect would be mitigated in less advanced countries if as often occurs in emerging economies scientists are under utilised – given that firms rarely engage in exploration activities – and also because of the large mobility of workers within the country.

In contrast, 'Competence exploiting' subsidiaries would have less to offer. They may have superior technology embedded in machinery, tools and products, as well as the capabilities to operate them, and even to adapt or improve them for domestic market conditions. However, domestic firms in emerging economies have often already learnt these capabilities (Bell and Pavitt; 1993, Kim, 1997; Figueiredo, 2003). They will be less likely, therefore, to benefit from the diffusion of superior, or otherwise unavailable, capabilities when CE subsidiaries are localised in their host country. In addition, this type of subsidiary is typically market-seeking. They are therefore more likely than CC firms to compete with domestic firms for domestic markets, and produce negative market-stealing effects (Aitken and Harrison, 1999). This negative effect is less likely to emerge in the case of competence creating subsidiaries because they are more likely to be oriented towards external markets.[8]

Based on the ideas discussed above we propose the following two hypotheses:

Hypothesis 1: *Competence creating subsidiaries are more likely than competence exploiting subsidiaries to generate positive spillover effects because they are more likely to own and therefore diffuse technological capabilities that are valuable relative to those that exist in less advanced host countries.*

[8] Indeed, CE subsidiaries are also more likely than 'competence creating' subsidiaries to become actual competitors of domestic firms, which increases the possibilities that these effects take place. This is because they are more likely than 'competence creating' subsidiaries to share 'resource similarity' and 'market commonality' with domestic firms (Chen, 1996). Competence exploiting subsidiaries are likely to have resource similarity with domestic firms in less advanced contexts because they will both be oriented more to exploitation than to exploration (see note 7). They are more likely, therefore, to adopt similar strategies, serve similar types of markets and become direct competitors (Teece et al., 1997; Chang and Xu, 2008).

Hypothesis 2: *Competence exploiting subsidiaries are more likely than competence creating and passive subsidiaries to have a negative effect on domestic firms because they are less likely to spread superior knowledge resources and, at the same time, they are more likely to compete with domestic firms for the same markets and redirect demand away from domestic firms, pushing up their costs.*

In a recent UK study, Driffield and Love (2007) postulated what might be seen as a contrasting hypothesis to ours in relation to the association between spillovers and the exploitation vs. exploration activities of MNCs. Focusing more on MNC motivations and less on subsidiaries' heterogeneity, they distinguish two types of FDI: technology sourcing and technology exploiting investment. They propose that technology sourcing FDI will be less likely than technology exploiting FDI to generate spillovers because, in their view, FDI motivated by technology sourcing, which typically is conducted by 'MNCs without advantages' (Fosfuri and Motta, 1999) will have less to offer. We do not endorse this view.

We believe that this assumption probably applies to MNCs from less advanced contexts (see, e.g., Buckley et al., 2007). However, most foreign R&D, and indeed FDI, is carried out by MNCs from advanced contexts, and evidence shows that the more advanced and complex the MNC the more likely it is that this will conduct R&D abroad as a way of increasing its knowledge assets (see, e.g., Zejan, 1990; Håkanson, 1992). It is very likely, therefore, that these MNCs would have substantial capabilities and resources that would benefit host country firms.

THE CONTEXT: FDI INFLOWS IN INDIA

India provides an excellent setting to examine our hypotheses for two reasons. First, the country has very recently become a FDI-intensive economy. Until 1990, the Indian economy was characterised by strict controls and regulations on foreign capital and ownership. As a result,

MNCs had only a limited presence and were mostly confined to plantation and mining activities, which accounted for nearly 80 per cent of total FDI. However, the unprecedented economic crisis that occurred in 1991 forced India's policy makers to make transformations to this highly regulated regime and the liberalised regime since 1991 dismantled the industrial licensing system and removed restrictions on foreign equity participation. Since then, the Indian economy has witnessed a substantial surge in FDI, going from less than US$500 million to more than US$3000 million between the first half of the 1990s and the first half of the 2000s (Figure 1). The composition of FDI has also undergone drastic changes; plantation and mining saw a sharp decline and FDI became more focused on the manufacturing sectors. By the end of the 1990s, manufacturing accounted for 85 per cent of total FDI stock.

Second, at the same time India turned out to be a centre for global innovative activity for many MNCs. According to a recent survey conducted by UNCTAD, India has become the third preferred location for R&D activities by MNCs after China and the USA (UNCTAD, 2005). The TIFAC (Technology Information, Forecasting and Assessment Council, India) has reported that after the liberalisation of the regime in the early 1990s more than 100 MNCs have opened up research centres in India (Mrinalini and Wakdikar, 2008). Some of these research centres are mostly involved in the traditional activities of support of production facilities; to adapt products and processes introduced to India by their MNCs. However, an increasing number such as Texas Instruments, General Electrics, IBM, Du Pont, Astra AB, Abbott Laboratories, Parke Davis and SmithKline Beecham are engaged in developing products and technologies for the global corporation as reported by case study evidence (see for instance Reddy, 1997; Kumar, 2005; Mrinalini and Wakdikar, 2008). This evidence is consistent with competence creating activity by subsidiaries in India.

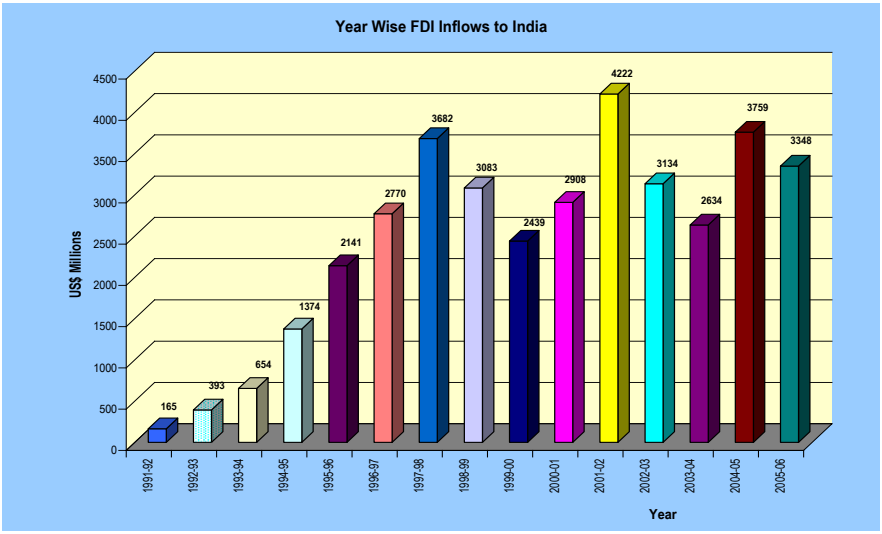

Figure 1: FDI inflows to India[9]

One example of these research centres is AstraZeneca in Bangalore. This is one of the four R&D labs of the company (the others are in Sweden, the USA and Japan); it employs more than ninety scientists, and dedicates most of its activities to developing new chemical entities for the treatment of infectious diseases in developing countries, i.e. products/technologies that can then be used by the corporation in other parts of the world. Another example is the John F. Welch Technology Centre in Bangalore, the first General Electric multidisciplinary research centre outside the USA, which employs around 2400 scientists from India (one third returned from the USA) and dedicates its activities to the development of medical equipment, aviation engines and consumer durables for GE global (Mrinalini and Wakdikar, 2008). Another example is Motorola's Indian software subsidiary. This subsidiary has transformed itself since its inception in 1991, from a unit for which sales were one hundred per cent derived from traditional service projects, into one unit with two thirds of its revenues coming

[9] **Source:** SIA Newsletter (various issues) available at http://dipp.nic.in

from new products and services in 2001. This transformation has involved substantial increases in the R&D efforts of the subsidiary and a complete change in organisation and orientation of the subsidiary which has increased substantially its linkages with the global activities of Motorola (case described by Ramachandran and Dikshit, 2002).

Studies in India have described specific positive effects of this type of subsidiary on the domestic economy (see for instance Reddy, 1997, 2005). However, there is not yet any systematic evidence on the extent to which this type of orientation in subsidiaries is affecting host country firms more in general (Kumar, 2005; Mrinalini and Wakdikar, 2008), and relative to the more conventional type of subsidiaries. In this paper we contribute to the understanding of this phenomenon by exploring the effects of CC vs. CE activities in subsidiaries on host country domestic firms' productivity growth.

METHODOLOGY

i. The Database

Data for the analysis is obtained from the PROWESS database. PROWESS is a firm level dataset maintained by the Centre for Monitoring Indian Economy (CMIE), an independent economic think-tank with headquarters in Mumbai, India. It includes all the companies listed on India's stock exchanges and others such as the central public sector enterprises. Although the dataset is not meant to be representative of all Indian manufacturing activity, it covers most of the organised industrial activity,[10] accounting for 75% of all corporate taxes collected by the

[10] According to the government, "The organised sector comprises enterprises for which the statistics are available from the budget documents or reports, etc. (Informal Sector in India: Approaches for Social Security, Government of India, page 2).

Indian government (or formal sector), more than 95% of excise duty and 60 per cent of all savings of the Indian corporate sector.[11]

The PROWESS dataset contains around 5000 firms belonging to the manufacturing sector in India (CMIE). Firms are categorised according to the NIC 1998 code. Data for the manufacturing firms belong to Sectors 15 to 36 in the National Industrial Classification (NIC). As per the norms laid down by the Indian Companies Act 1956, incorporated firms are required to disclose heads of expenditure of more than 1 per cent of the turnover in their annual reports. The PROWESS database compiles and provides detailed quantitative information from the income statements and balance sheets of the listed companies, such as sales, added value, exports, imports, sales, wages and salaries, incorporation year, etc, for the period 1994-2002 and these data permit the computation of various performance indicators (e.g. productivity levels and growth rates). In addition, it provides comparable information about technological activities (R&D, capital goods imports, royalties and licensing expenses) at the firm level and this allows the computation of different measures of technological behaviour with respect to both foreign and domestic firms.

The present analysis makes use of unbalanced panel data. The use of unbalanced panel data is justified on the grounds that very few firms exit from the dataset. The dataset had to be cleaned to avoid misreporting and typing errors while inputting data. We followed two truncation rules during the cleaning process. First, those firms which report zero and negative value added figures and second, those firms

[11] The PROWESS database was used by previous studies on spillovers from foreign firms (Kathuria, 2002) and technology behaviour of foreign affiliates (Kumar and Aggarwal, 2005) in Indian manufacturing industries.

which report data after a gap are excluded from the analysis.[12] After eliminating these firms, the final dataset varied between 2696 and 2720 firms during the study period. Firms with foreign equity greater than 10 per cent held by a foreign parent company were classified as MNC affiliates. Twelve per cent of the firms in this sample are foreign subsidiaries. The number of sample firms used in the final analysis is similar to earlier studies (Balakrishnan et al., 2000; Topalova 2004) pertaining to Indian manufacturing using the PROWESS.

ii. The Variables

We distinguish subsidiary types based on the following two indicators provided by PROWESS:

1. ***R&D expenditure*** measures the systematic efforts undertaken by firms in order to increase the stock of knowledge, and the use of this stock of knowledge to devise new applications. Although not all ***R&D*** is dedicated to creative activities it is generally accepted that this is a good indicator of the creative efforts of firms.

2. ***Export intensity*** is the ratio of exports to sales and measures the share of output that is exported to other countries.

Table 1 shows descriptive statistics for subsidiaries in India with respect to these indicators. Subsidiaries spend on average 0.5 per cent of their revenues in R&D in India, 0.7 per cent in royalties and 2.7 per cent in capital good imports. They export 11 per cent of their sales.

[12] Those firms which are dropped during the cleaning process do not report or provide any information about their economic activity. Therefore, we assume that those firms are non-performing and excluding them does not seriously affect the representativeness of the sample firms.

Table 1: Technological Activity of Subsidiaries in India: Descriptive Statistics

Indicators*	R&D Intensity (%)	Export intensity (%)	Royalties Intensity (%)	Imports Capital Goods Intensity (%)
Mean	0.5	11	0.7	2.7
Std. Dev.	0.025	0.17	0.022	0.087
Distribution of firms				
1%	0.0	0.0	0.0	0.0
5%	0.0	0.0	0.0	0.0
10%	0.0	0.0	0.0	0.0
25%	0.0	0.10	0.0	0.0
50%	0.0	4.5	0.0	0.2
75%	0.4	15	0.5	1.5
90%	1.2	31	2.2	5.8
95%	2.0	47	4.0	12.1
99%	6.3	87	9.3	50.1

* All indicators are intensities; R&D, exports, royalties and imports of capital goods with respect to total sales.

iii. Identifying Competence Creating and Exploiting Subsidiaries

Definition

Our interest is not so much to distinguish "pure" types of CC from "pure" types of CE subsidiaries, which are perhaps very rare, but to identify which subsidiaries are more or less oriented to competence or asset creating activities in the host economy, in order to be able to evaluate their effects. Following this:

1. ***Competence creating*** (CC) subsidiaries are defined here as the subsidiaries that invest heavily in R&D and which have a high export intensity (see e.g. Cantwell and Mudambi, 2005; Cantwell and Smeets, 2008).
2. ***Competence exploiting*** subsidiaries make up the rest; the subsidiaries that invest less intensively in R&D and export a smaller share of their production.

Rationale

a. R&D

We are aware of the fact that not all R&D activities in subsidiaries are oriented to create new assets or competences. Competence exploiting (CE) subsidiaries also carry out some R&D activities to be able to absorb and adapt existing assets/competences of their MNCs to the local context. With the purpose of increasing our likelihood of capturing those subsidiaries that carry out asset or competence creating activities in the host economy therefore, we concentrate on the highest possible intensities of R&D (the top quartile and the top 10 per cent of each distribution). It is expected that competence or asset creating subsidiaries will be substantially more R&D-intensive than competence or asset exploiting subsidiaries for three reasons: 1) they are by definition more oriented to creative or explorative activities, which very often are funded via R&D expenditures, so a significant part of their activity should be dedicated to R&D; 2) they are typically interested in capturing localised spillovers from other firms or institutions in the host economies, which requires substantial investments in their own R&D capabilities (Cohen and Levinthal, 1990); and 3) their R&D activities will often be independent of their production activities in the host country, unlike the R&D activity of competence exploiting activities which tends be sequential, and linked to (to support) the existing production facilities of the subsidiary in host economies (Dunning and Narula, 1995).

Thus, the higher the R&D intensity or ratio of R&D to output or sales of the subsidiary, the more likely is the subsidiary to be oriented to create competences or assets for its corporation, independently of its scale of production in the host economy. A study by Cantwell and Mudambi (2005) confirms this idea. They analysed the relationship between R&D intensity in subsidiaries and their output mandates in the UK, which was classified as 'Competence creating' or 'Competence exploiting' and found that the R&D intensity of CC subsidiaries was almost twice as large as that for CE subsidiaries.

b. Export Intensity

According to the International Business literature, subsidiaries that have a mandate to develop new assets – products or knowledge more generally – are in general more oriented to international markets (Birkinshaw, 1997; Birkinshaw et al., 1998). Birkinshaw (1997) and Birkinshaw et al. (1998) for instance, defined entrepreneurial subsidiaries – i.e. those subsidiaries that have evolved to gain higher responsibilities within their corporations, included innovation – in part based on the extent of subsidiaries' exports. Cantwell and Smeets (2008) considered the outward orientation of subsidiaries (or the lack of an explicit local market orientation) as the main indicator of a CC mandate in subsidiaries (or technology seeking). In line with these studies we use export intensity in combination with R&D intensity to identify competence creating subsidiaries.

We are confident that R&D intensity and export intensity constitute two good proxies for identifying CC activities in subsidiaries since they have been identified in previous studies as two key dimensions that characterise CC subsidiaries. In fact, our study constitutes an advance with respect to existing studies (see for instance Driffield and Love (2007)) which have empirically distinguished between technology sourcing and technology exploiting FDI exclusively on the bases of R&D intensity differentials between the home and the host country per industry.[13]

Classification Mechanisms

Since we cannot be sure what constitutes a high R&D intensity and export intensity in the context of India, we experiment with two cut-off

[13] Driffield and Love (2007) for instance assume that if R&D intensity is higher in the host country relative to the home country, FDI will be directed towards sourcing technology in the host country, and that if R&D intensity is lower in the host country relative to the home country, the reverse will be true.

points: the top quartile and the top 10 per cent of each distribution (see Tables 2 and 3) (the top 5 per cent is excluded because it leaves us with a very reduced number of subsidiaries, namely seven). We define CC in two alternative ways: 1) CC1 are those with R&D *and* export intensity higher than the 25 per cent of R&D and export intensity distribution (higher than 0.4 per cent and 15 per cent, see Table 1), and 2) CC2 are those with R&D and export intensity higher than the top 10 per cent (higher than 1.2 and 31 per cent).

Compared to the study by Cantwell and Mudambi (2005), in our case, with a cutting point of 25 per cent, CC subsidiaries have a R&D intensity four times higher than CE subsidiaries and, with a cutting point of 10 per cent, this difference is eight to one in favour of CC subsidiaries. Furthermore, despite the fact that R&D intensity is in general much lower in emerging economies than in advanced economies, the average R&D intensity of our CC subsidiaries in India, when they are defined with a cutting point of 10 per cent, does not differ substantially from the average R&D intensity of the CC subsidiaries identified by Cantwell and Mudambi (2005) in the UK. Cantwell and Mudambi (2005) found that CC subsidiaries in the UK spent on average 4.2 per cent of their sales in R&D, and our CC subsidiaries in India when they are defined using the top 10 per cent cutting point, have an average R&D intensity of 4 per cent.

CE subsidiaries are those that spent less than the top 25 per cent (CE1) and 10 per cent (CE2) on R&D and export intensity distribution. Table 2 shows the distribution of subsidiaries across types using the top 25 per cent of R&D and export intensity distributions (columns 1 and 2). Defined using the top 25 per cent of R&D and exports (see Table 2), 12 per cent (32) of the 272 subsidiaries in our database are CC and 88 per cent (240) are CE. Defined using the top 10 per cent of R&D and exports, 8 per cent (21) are CC and 92 per cent (251) are CE.

Table 2: Distribution of Subsidiary Types

Subsidiary type	Top 25% of R&D and export intensity		Top 10% of R&D and export intensity	
	Frequency	%	Frequency	%
	(1)	(2)	(3)	(4)
Competence Exploiting	240	88	251	92
Competence Creating	32	12	21	8
Total	*272*	*100*	*272*	*100*

Table 3 shows descriptive statistics of subsidiary types.

Table 3: Descriptive Statistics of Subsidiary Types - Defined using top 25% of R&D and Export Intensity

Subsidiary Type	Sales	Added Value	Labour	R&D (Intensities in %)	Export
Competence Exploiting	190	32	66	0.3	10.6
Competence Creating	99	31	76	2.1	27.9
Total	178	33	66	0.5	10.6

Note: Sales and added value are expressed in Rs.Crores (I crore = 10 million), Labour in efficiency wages.

Table 4 provides the distribution of subsidiary types across industries. CE subsidiaries are, on average, substantially larger than CC with respect to sales, but with respect to number of employees they are smaller than CC subsidiaries (see Table 3). CC and CE have similar added value. CC subsidiaries spend around seven times more than CE subsidiaries on R&D. Interestingly, investment in imports of capital goods of CE subsidiaries is 1.5 times more than that for CC subsidiaries, which is a good indication of the different nature of these two types of subsidiaries. Intensity of payments for royalties is very similar between CC and CE subsidiaries.

Table 4: Distribution of Subsidiary Types across Industries - Defined using top 25% of R&D and Export Intensity

Industry	Competence exploiting	Competence Creating	Total
Food and kindred products	22 (85%)[9%]	4(15%)[11%]	26 (100%)[10%]
Tobacco industries	3 (100%)[1%]	0 (0%)[0%]	3(100%)[1%]
Textile mill products	12(86%)[5%]	2(14%)[5%]	14(100%)[5%]
Apparel and other finished products	2(100%)[1%]	0(0%)[0%]	2(100%)[1%]
Leather and leather products	1(100%)[0%]	0(0%)[0%]	1(100%)[0%]
Paper and allied products	8(89%)[3%]	1(11%)[3%]	9(100%)[3%]
Printing, publishing and allied products	1(100%)[0%]	0(0%)[0%]	1(100%)[0%]
Petroleum refining and related	3(75%)[1%]	1(25%)[3%]	4(100%)[1%]
Chemicals and allied products	50(81%)[21%]	12(19%)[32%]	62(100%)[23%]
Rubber and miscellaneous	16(89%)[7%]	2(11%)[5%]	18(100%)[7%]
Stone clay glass and concrete	13(100%)[6%]	1(8%)[3%]	13(100%)[5%]
Primary metal industries	16(94%)[7%]	2(12%) [5%]	17(100%)[6%]
Fabricated metal products	5(83%)[2%]	1(17%)[3%]	6(100%)[2%]
Machinery and equipment	33(92%)[14%]	3(8%)[8%]	36(100%)[13%]
Computer and office equipment	1(50%)[0%]	0(0%)[0%]	2(100%)[1%]
Electronics	8(73%)[3%]	2(18%)[5%]	11(100%)[4%]
Communication equipments	8(73%)[3%]	2(18%)[5%]	11(100%)[4%]
Precision, photographic medical,	7(100%)[3%]	0(0%)[0%]	7(100%)[3%]
Motor vehicles and equipment	23(88%)[10%]	3(12%)[8%]	26(100%)[10%]
Transportation equipment	3(100%)[1%]	0(0%)[0%]	3(100%)[1%]
Miscellaneous	2(100%)[1%]	0(0%)[0%]	2(100%)[1%]
Total	235(86%)[100%]	38(14%)[100%]	273(100%)[100%]

Figures in parentheses (), are row % and figures in brackets [] are column %.

Finally, regarding distribution across sectors, CC subsidiaries are in almost all sectors, except Tobacco, Leather, Printing and Publishing, and Miscellaneous (see Table 4). But the sector with the highest concentration of CC subsidiaries is Chemicals with 32 per cent of total CC

subsidiaries in the sample; then follows Food and kindred products (11 per cent), Machinery (9 per cent) and Motor vehicles (8 per cent). In the first two sectors CC subsidiaries are overrepresented, (i.e. the proportion of CC subsidiaries within the Chemical sector is higher than the proportion of chemical subsidiaries in the total of subsidiaries), but in the latter three sectors, CC are underrepresented. Other sectors where CC subsidiaries are overrepresented are Electronics and Communication Equipment.

iv. Estimating Spillover Effects

Our estimation of spillover effects involves two steps. In the first step, we calculate the production functions per sector to obtain measures of total factor productivity (TFP). In the second, we relate TFP to proxies for FDI participation.

First Step

We use two approaches to estimate TFP:

(1) A log-linear transformation of a Cobb-Douglas production function:

$$\ln Y^{d}{}_{ijt} = \alpha + \beta_1 \ln K^{d}{}_{ijt} + \beta_2 \ln L^{d}{}_{ijt} + \beta_3 \ln M^{d}{}_{ijt} + \varepsilon_{i\,jt} \qquad (1)$$

where Y^{d}_{ijt} denotes the real output of firm *i*, operating in sector *j*, at time *t*; *d* denotes domestic firms, K^{d}_{ijt} is the value of fixed assets; L^{d}_{ijt} is expressed as efficiency units, calculated by dividing salaries and wages at firm level by the average wage rate of each firm's industry[14] and M^{d}_{ijt} is

[14] Prowess does not provide the number of employees at firm level. We used information on wages and salaries to calculate man-days of work for each firm. Man-days at firm level are calculated using the formula: No. of man-days per firm = salaries and wages/average wage rate. We obtained the average wage rate from Annual Survey of Industries (ASI) data, which provide information on total emoluments as well as total man-days for relevant industry groups. At the time of this study, ASI data were available up to 2001; therefore, we had to extrapolate values for the year 2002. We obtained the average wage rate by dividing total emoluments by total man-days (Average wage rate = total emoluments/total man-days.

the value of materials. Nominal values are deflated using wholesale prices per industry obtained from the Central Statistical Organisation (India).

(2) The semi-parametric approach suggested by Levinsohn and Petrin (2003) corrects for endogeneity in the determination of inputs. This method allows for firm-specific productivity differences that exhibit idiosyncratic changes over time and, thus, addresses the simultaneity bias between productivity shocks and input choices (for a discussion see Levinsohn and Petrin, 2003).

Second Step

In the second step we relate the two measures of TFP to proxies for foreign participation in the same five-digit industry. Equation (2) below describes our method to estimate the pipeline model, which assumes that all subsidiaries have in principle the same potential to generate spillover effects. Equation (3) describes our method to estimate the effects of a subsidiary's heterogeneity on spillover effects (or the subsidiary-driven model).

FDIpart measures the scale of the MNC's presence in each sub-industry *j* and it is introduced here with two period lags, to capture spillover effects. In equation (2) this measure of *FDIpart* is calculated for all subsidiaries. In equation (3) we include a measure of FDI participation for each type of subsidiary. We calculated a measure of FDI participation (in employment, capital and output) per 5-digit industry for Competence Creating, Competence Exploiting Active and Competence Exploiting Passive subsidiaries.

$$\ln TFP_{ijt}^{d} = \alpha_0 + \alpha_1 FDIpart_{jt-2} + \alpha_2 Concentration_{jt} + \alpha_3 Imports_{ij} \quad (2)$$
$$+ \alpha_4 Age_{ij} + \alpha_5 Age_{ij}^{2} + \alpha_6 R\&D\text{int}_{ijt} + T_t + \nu_i + \mu_{it}$$

$$\ln TFP_{ijt}^{d} = \alpha_0 + \alpha_1 FDIpartCC_{jt-2} + \alpha_2 FDIpartCEA_{j,t-2} + \alpha_3 FDIpartCEP_{j,t-2} \quad (3)$$
$$+ \alpha_4 Concentration_{jt} + \alpha_4 Imports_{ij} + \alpha_5 Age_{ij} + \alpha_6 Age_{ij}^{2} + R\&D\text{int}_{ijt} + T_t + \nu_i + \mu_{it}$$

In both cases, we try three different indicators of MNC presence, in line with recent works which pointed out the importance of distinguishing different indicators of MNC presence: i) share of MNCs in total employment, ii) the share of MNCs in total capital and, iii) the share of MNCs in total output. More specifically, we calculate *FDIpart* as the share of total employment/capital/output in the 5-digit sub-industry *j* that is accounted by the employment/capital/output of foreign-owned firms in that sub-industry. Very often studies on spillover effects aggregated data at 2 digits (divisions). We work with FDI participation at 5 digits (subclasses). This provides greater variability and increases the possibility of identifying the desired effects.

T 's are the time dummies, and *Z* includes a set of control variables that may affect the TFP of domestic firms. To increase our ability of isolating the effect of FDI on productivity increases in domestic firms, we introduce two types of control variables.

1. Two measures of competition: 1) the Herfindahl index (calculated as the sum of squared establishment shares of the industry's total gross output) to measure the degree of concentration in different industries and 2) import penetration to measure potential competition from the external sector. These variables are included to capture differences in competition across sectors which might have promoted greater efficiency in the domestic industry.[15]

[15] This is important because, as noted earlier, during the period analysed important pro-market reforms were introduced and developed in India.

2. Two firm-level determinants of TFP: Age and R&D expenditures. Previous studies have found a significant quadratic association between age and TFP and also, that internal R&D expenditures positively affect TFP (Griliches, 1991). By including these control variables therefore, we expect to reduce the possibility of bias due to non-included variables that change across domestic firms and over time (Kathuria, 2000; 2001; 2002).

Table 5 includes summary statistics and Table 6 pair wise correlations.

Several Aspects of Estimation Methods

First, we use fixed effects to control for unobserved heterogeneity. This, for instance, controls for differences in productivity levels across firms and industries, which might affect the level of foreign direct investment. Second, to address the identification problem highlighted by Aitken and Harrison (1999) (i.e. endogeneity between FDI and productivity growth), we introduce the variable measuring two-period lagged FDI participation. Third, to take into account the potential correlation between the error terms for firms in the same industry, we cluster standard errors in industry-year combinations. Since data are aggregated at both 2 and 5 digits, we explore the effects of clustering both at 2 and 5 digits.

This estimation method should reduce the potential problems arising from the omission of unobservable variables that might undermine the relationship between FDI and productivity growth of domestic firms. In particular, by using fixed effects, we remove plant-specific, industry and regional fixed effects such as heterogeneous long-term strategies of the firms, and differences in the regional infrastructure and/or technological opportunity of the industries.[16]

[16] This also removes other factors that, even when they are not fixed over time, might be roughly constant over our period, such as the level of education, or regional policies.

Table 5: Summary Statistics

Variables	Observations	Mean	Std dev.
Firm-specific variables			
Levels			
Output	17402	185	1.907
Fixed Capital	17402	77	575
Labour	17402	38	183
Materials	17402	122	593
Age	17402	19	18
R&D			
TFP (OLS)	17607	0.16	0.60
TFP (Levinsohn-Petrin)	17607	0.42	0.61
Industry-Specific Variables			
Horizontal all subsidiaries (employment)	318	0.18	0.14
Horizontal all subsidiaries (capital)	318	0.15	0.10
Horizontal all subsidiaries (sales)	318	0.078	0.054
Horizontal all subsidiaries (output)	318	0.16	0.12
Horizontal competence creating (employment)	318	0.021	0.041
Horizontal competence creating (capital)	318	0.044	0.04
Horizontal competence creating (sales)	318	0.014	0.028
Horizontal competence creating (output)	318	0.019	0.038
Horizontal competence exploiting active (employment)	318	0.16	0.14
Horizontal competence exploiting active (capital)	318	0.14	0.09
Horizontal competence exploiting active (sales)	318	0.15	0.10
Horizontal competence exploiting active (output)	318	0.14	0.11
Horizontal competence exploiting passive (employment)	318	0.019	0.026
Horizontal competence exploiting passive (capital)	318	0.056	0.016
Horizontal competence exploiting passive (employment)	318	0.027	0.0041
Horizontal competence exploiting passive (capital)	318	0.027	0.0035
Concentration: Herfindahl	22	0.26	0.25
Import penetration	22	0.2	0.16

Table 6: Pair wise Correlation Table

Variables	lnTFPLP	FDI part CC	FDI part CE	Concentration	Import P.	Age	Age2	R&D int
lnTFPLP	1							
FDI part CC	0.3101	1						
FDI part CE	0.1859	0.1508	1					
Concentration	-0.0433	-0.0256	0.1018	1				
Import P.	0.1281	-0.0042	-0.2011	0.0462	1			
Age	0.0232	0.0235	0.0719	0.0048	-0.0675	1		
Age2	-0.0089	0.0087	0.0702	-0.0115	-0.0578	0.9448	1	
R&Dint	0.1204	0.0571	0.0293	0.0615	0.011	0.2182	0.1633	1

However, there could still be a bias in the estimators if there are important unobservable variables excluded from the model that change across firms and over time (such as the managerial abilities of domestic firms). By introducing among the control variables under Z a variable that changes across firms and over time we expect to minimise this possibility.

RESULTS

In this section we report the empirical results of our empirical estimations of spillover effects in India under different specifications.

i. The Pipeline Model: with and without the Effects of Absorptive Capabilities

The results reported in Table 7 are derived from a specification similar to that used in much of the early work on spillover effects, in which FDI is expected to generate spillover effects without differentiating among subsidiaries. We proceeded in two steps. First, we ran estimations using the simple 'knowledge pipeline' model. Second, we controlled for the absorptive capacity of domestic firms.

Columns 1, 2 and 3 report the results of the first step. Column (1) shows the results of our estimation when we use the FDI share in

labour, Column 2 shows the results obtained when using the FDI share on capital and Column 3 the results obtained for the FDI share in output. The results obtained using the three indicators all converge indicating the same pattern, that the coefficient of the FDI variable is not significant. Thus, similar to most existing studies in emerging economies we find no evidence of technological spillovers from FDI in India to domestic firms in the same 5-digit industries as the subsidiaries (see Crespo and Fontoura, 2007 for a recent survey of the empirical literature).

It is interesting to note however that, among the controls, the variables controlling for R&D intensity, import penetration, and age are significant and have the expected signs. The R&D intensity of domestic firms has a positive impact on TFP, import penetration has a negative impact and the square of age has a negative and significant impact. We next explore whether our results hold for domestic firms with different absorptive capabilities or a technology gap (see columns 4, 5 and 6 in Table 6). As already discussed, when results are not significant the spillovers literature often attributes this to the lack of absorptive capabilities in domestic firms. Since it is assumed that MNCs own and transfer superior technology, reasons for the absence of spillovers in host economies are typically seen as the inability of domestic firms to absorb the superior knowledge and skills that MNCs deliver to their subsidiaries.

We investigate whether this could be the reason for our non-significant results in the 'pipeline model'. We use R&D intensity by domestic firms as an indicator of their absorptive capability. The interaction term under the heading: *Absorptive capability of domestic firms and spillover effects* in Table 6 captures the combined effects of domestic firms' absorptive capability and FDI increases.

Table 7: Spillovers in the Pipeline Model – Controlling by the Absorptive Capability of Domestic Firms

Independent Variables	***Pipeline Model***					
	Simple Form			***With Absorptive Capability of domestic firms***		
	(1) As a share in labour	(2) As a share in capital	(3) As a share in output	(1) As a share in labour	(2) As a share in capital	(3) As a share in output
Spillover effects						
FDI All types of subsidiaries	0.15	0.3	-0.34	0.14	0.29	-0.34
	(0.27)	(0.53)	(-1.7)*	(0.49)	(1.51)	(-1.73)*
FDI all types of subsidiaries*Domestic firms' R&D				0.0059	0.036	0.0038
				(1.53)	(.54)	(1.42)
Control variables						
R&D	0.10	0.10	0.10	0.10	0.10	0.10
	(5.61)***	(5.65)***	(5.47)***	(5.44)***	(5.46)***	(5.45)***
Age	0.038	0.039	0.041	0.039	0.039	0.041
	(0.56)	(0.58)	(0.62)	(0.59)	(0.61)	(0.62)
Age squared	-0.0004	-0.0004	-0.0004	-0.0004	-0.0004	-0.0004
	(-3.3)***	(-3.23)***	(-5.46)***	(-5.58)***	(-5.46)***	(-5.47)***
Δ Concentration	-0.19	-0.2	-0.19	-0.19	-0.20	-0.19
	(-1.3)	(-1.37)	(-1.8)	(-1.79)*	(-1.84)*	(-1.79)*
Δ Imports	-0.21	-0.22	-0.2	-0.21	-0.22	-0.20
	(-1.88)*	(-1.89)*	(-2.76)***	(-2.85)***	(-2.98)***	(-2.76)***
No. of observations	12443	12443	12443	12442	12442	12442
R-square	6.9%	6.9%	6.9%	7%	7%	7.1%

1. The dependent variable is TFP (expressed as a natural logarithm) of an Indian firm *i* at time *t*, derived from sector-specific production functions estimated using the Levinsohn-Petrin approach. All specifications include a constant, and year fixed effect. Standard errors reported in parentheses are corrected for autocorrelation, heteroskedasticity and for clustering for industry-year combinations (5 digits). We try clustering at both 2 and 5 digits and the results do not change significantly. * denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.
2. Here we report only the results based on Levinsohn and Petrin. OLS results are very similar. They are available from the authors on request.
3. Competence Creating subsidiaries are those subsidiaries that invest in R&D and export above the top 25%. Competence Exploiting Active spend less and export less than the top in R&D and export, but invest something in royalties and machinery; Competence Exploiting Passive subsidiaries are subsidiaries that do not invest in technology in India at all, i.e. they have zero expenditures on R&D, Royalties and Machinery.
4. Columns (1) and (4) report the results obtained for a fixed effect estimation using FDI participation in labour at 5-digit industry level, columns (2) and (5) report the results obtained using FDI participation in capital, and columns (3) and (6) the results obtained using FDI participation in output.

The results in Columns 4, 5 and 6 are again not significant indicating that, even allowing for differences in the absorptive capability of domestic firm spillovers, the 'pipeline model' does not provide significant results for India. We conclude therefore that, as in other situations (especially in industrialising economies), the process of international knowledge diffusion via FDI does not seem to have delivered the spillover effects expected by the pipeline model to domestic firms in India.

ii. A Subsidiary-Driven Model

We now turn to spillovers in the 'subsidiary-driven' model. In the earlier discussion, we proposed that certain kinds of the technological activities carried out by subsidiaries would be more likely than others to generate spillovers. More specifically, in Hypothesis 1, we propose that 'competence creating' subsidiaries would be more likely to generate positive effects or spillovers than 'competence exploiting' or passive subsidiaries. The results shown in Tables 8 and 9, arising from the 'subsidiary-centred' model confirm our hypotheses. Table 8 shows the results obtained when we use the top 25 per cent of R&D and export intensity to identify 'competence creating' subsidiaries.[17]

[17] Competence Creating subsidiaries invest in R&D and export above the top 25%. Competence Exploiting Active invest less than the top 25% in R&D and export, but invest in royalties and machinery more than zero; Competence Exploiting Passive subsidiaries are subsidiaries that do not invest in technology in India at all, i.e. they have zero expenditures on R&D, Royalties and Machinery. Columns (1) and (4) report the results obtained for a fixed effect estimation using FDI participation in labour at 5-digit industry level, columns (2) and (5) report the results obtained using FDI participation in capital, and columns (3) and (6) the results obtained using FDI participation in output.

Table 8: Spillovers in the Subsidiary-Driven model with Absorptive Capability–using top quartiles of R&D and exports

Independent Variables	***Subsidiary-Driven Model –above top quartile R&D and exports***					
	Simple Form			***With Absorptive Capability of domestic firms***		
	(1) As a share in labour	(2) As a share in capital	(3) As a share in output	(4) As a share in labour	(5) As a share in capital	(6) As a share in output
Spillover effects						
FDI competence creating	0.68 (2.09)**	0.7 (3.08)***	0.20 (0.73)	0.68 (2.09)**	0.69 (3.07)***	0.17 (0.61)
FDI competen. exploiting	0.11 (0.39)	0.2 (1.03)	-0.39 (-1.96)**	0.10 (0.37)	0.19 (1)	-0.39 (-1.97)**
Controlling by absorptive capability of domestic firms						
FDI competence creating * Domestic firms' R&D				-0.00088 (-0.10)	0.0015 0.35)	0.02 (0.39)
FDIcompet. exploiting *Domestic firms' R&D				0.007 (1.46)	0.0032 (1.2)	0.0021 (0.74)
Other control variables						
R&D	0.10 (5.4)***	0.10 (6)***	0.10 (5.43)***	0.10 (5.32)***	0.10 (5.55)***	0.10 (5.4)***
Age	0.041 (0.63)	0.038 (0.59)	0.042 (0.65)	0.041 (0.63)	0.038 (0.59)	0.042 (0.65)
Age squared	-0.0004 (-5.5)***	-0.0004 (-5.51)***	-0.0004 (5.45)***	-0.0004 (-5.52)***	-0.0004 (-5.53)***	-0.0004(-5.47)***
Δ Concentration	-0.19 (-1.77)*	-0.19 (-1.77)*	-0.19 (-1.77)*	-0.19 (-1.76)*	-0.19 (-1.78)*	-0.19 (-1.77)*
Δ Imports	-0.21 (-2.92)***	-0.22 (-3.07)***	-0.21 (-2.92)***	-0.21 (-2.91)***	-0.22 (-3.06)***	-0.21 (-2.92)***
No. of observations	12443	12443	12443	12442	12442	12442
R-squared	7.1%	7.1%	7.1%	7.1%	7.1%	7.1%

(i) The dependent variable is TFP (expressed as a natural logarithm) of an Indian firm *i* at time *t*, derived from sector-specific production functions estimated using the Levinsohn-Petrin approach. All specifications include a constant, and year fixed effect. Standard errors reported in parentheses are corrected for autocorrelation, heteroskedasticity and for clustering for industry-year combinations (5 digits). We try clustering at both 2 and 5 digits and the results do not change significantly. * denotes significance at the 10% level, ** at the 5% level, *** at the 1% level. (ii) Here we report only the results based on Levinsohn and Petrin. Results obtained with ordinary least squares (OLS) are very similar.

Table 9 shows the results obtained using the top 10 per cent. First, they show that only 'competence creating' subsidiaries, those involved in creative efforts in the host economy, have positive effects on domestic firms, in both cases when FDI share is evaluated in terms of employment and capital. Second, they show that 'Competence exploiting' subsidiaries are likely to have a negative effect on the TFP of domestic firms. The coefficient is negative and significant at 5 per cent for 'Competence exploiting' subsidiaries, when spillovers are measured with respect to share in output data.

These results do not change when we control by the absorptive capability of domestic firms (see columns (4), (5) and (6) in Table 8). As before, 'Competence creating' subsidiaries have a positive effect on domestic firms when FDI shares are calculated with respect to labour and capital, and 'Competence exploiting' subsidiaries' have negative effect when share in output is considered. But now our results are robust to differences in the absorptive capacity of the domestic firms.

Finally, robustness tests with respect to the upper limit of R&D and export intensity (top 10 per cent) to define 'Competence creating' subsidiaries, do not only corroborate but reinforce our results (see Table 9). The same pattern as before is held, but two changes appeared in the direction that one would have expected. First, coefficients and significance levels are now stronger and second, a positive and significant effect appears now for 'Competence creating' subsidiaries, when FDI share in output is considered.

Table 9: Spillovers in the Subsidiary-Driven model – using top 10% of R&D and Exports

Independent Variables	***Subsidiary Driven Model –above top 10% R&D and exports***		
	Simple Form		
	(1) As a share in labour	(2) As a share in capital	(3) As a share in output
Spillover effects			
FDI competence creating	1.08 (4.51)***	1.08 (4.48)***	0.53 (1.83)**
FDI competence exploiting	0.098 (0.33)	0.17 (0.86)	-0.51 (-2.60)***
Control variables			
R&D	0.10 (5.5)***	0.11 (5.65)***	0.10 (5.5)***
Age	0.039 (0.6)	0.037 (0.58)	0.041 (0.64)
Age squared	-0.0004 (-5.66)***	-0.0004 (-5.6)***	-0.0004 (-5.54)***
Δ Concentration	-0.17 (-1.63)*	-0.18 (-1.72)*	-0.18 (-1.71)*
Δ Imports	-0.22 (-3.05)***	-0.23 (-3.11)***	-0.23 (-3.07)***
No. of observations	12443	12443	12443
R-square	7.2%	7.2%	7.2%

(i) The dependent variable is TFP, derived from sector-specific production functions estimated using the Levinsohn-Petrin approach. All specifications include a constant, and year fixed effects. Standard errors reported in parentheses are corrected for autocorrelation, heteroskedasticity and for clustering for industry-year combinations (5 digits). * denotes significance at the 10% level, ** at the 5% level, *** at the 1% level; (ii) Here we report only the results based on Levinsohn and Petrin. (iii) Competence Creating subsidiaries are those subsidiaries that invest in R&D and export above the top 10%. Competence Exploiting Active spend less and export less than the top in R&D and export, but invest something in royalties and machinery; Competence Exploiting Passive subsidiaries are subsidiaries that do not invest in technology in India at all, i.e. they have zero expenditures on R&D, Royalties and Machinery; (iv) Columns (1) and (4) report the results obtained for a fixed effects estimation using FDI participation in labour at 2-digit industry level, columns (2) and (5) report the results obtained using FDI participation in capital, and columns (3) and (6) the results obtained using FDI participation in output.

CONCLUSIONS

We have argued that the standard approach – referred to here as the 'pipeline model' – used to explore the possibility of FDI-related spillovers typically ignores the potential role of subsidiaries' heterogeneity in the process of spillover generation. We discussed why this approach is inadequate in the light of recent evidence from the international business (IB) literature which suggests that subsidiaries are playing increasingly important roles in the process of knowledge creation, and even knowledge transfer within MNCs. We proposed then that subsidiaries should be at the centre of the spillover process.

More specifically, drawing on the IB literature, we distinguished two types of subsidiaries: 'competence creating' and 'competence exploiting'. We developed a set of hypotheses relating heterogeneity across subsidiary types in the host economy to the possibility of spillover effects. We hypothesised that competence creating subsidiaries were the most likely to generate positive effects because they were more likely to have valuable resources relative to those available in industrialising countries. Competence exploiting subsidiaries, on the other hand, were hypothesised to have negative effects, because of the presence of market-stealing effects.

Our results generally confirm our two main hypotheses: 1) competence creating subsidiaries have a positive effect on the host economy, and this effect is independent of the level of absorptive capability of domestic firms; and 2) competence exploiting subsidiaries have a negative effect, a result that holds again independently of the absorptive capability of domestic firms. Thus, interestingly, with the framework proposed in this paper we were able to distinguish positive from negative effects in association with MNCs' activities in host economies and offer a sound explanation of why they may emerge in each case. Our explanation offers an alternative to the standard ones for

the lack of spillover effects – the limited absorptive capabilities of domestic firms and the lack of consideration of vertical effects.

These results have important implications for our understanding of the process of spillovers in association with MNCs. First, in general, they add to the small but growing body of research suggesting that a simplistic, 'pipeline model' of MNCs is no longer an appropriate framework for analysing the significance of technology spillovers from FDI and that an alternative approach focusing on the role of heterogeneous subsidiaries' own technological activities is more useful.

Second, the results confirm our ideas about potential differential effects of creative vs. exploitative subsidiaries' activities in industrialising countries. In our view, the first type of activities and associated capabilities are very often absent in firms in less advanced contexts, so subsidiaries undertaking these activities would be more likely to have a positive effect on domestic firms by their potential to leak resources that are more valuable in these contexts, i.e. resources that are otherwise not available (or less likely to be available) in less developed contexts.

Third, they confirm our idea that market-stealing effects are more likely to emerge in association with the activity of subsidiaries oriented only to exploiting activities because, while they have less valuable resources to diffuse to domestic firms in emerging countries, they are also more likely to be market-seeking and to compete therefore with domestic firms in their markets.

Our results also have important implications for FDI policy. First, in general and in line with two previous studies which have questioned the pipeline model of spillover generation (Marin and Bell, 2006; Castellani and Zanfei, 2007), they raise questions about the effectiveness of costly policies, often justified in terms of the potential spillovers, that seek simply to attract FDI regardless of the innovative activities of the

subsidiaries in the host economy. Our results suggest that what is important for spillovers to take place is not so much how much or what kind of FDI is attracted. Instead, what matters much more is what subsidiaries actually do once they have been established or acquired. Second, they emphasise the importance of focusing on the type of activities carried out by subsidiaries in the host economy. Policies should concentrate on encouraging not only investments in innovation generally in subsidiaries but more specifically efforts in creative or explorative activities, because these are the ones that seem to produce positive effects. On the contrary, measures should be designed to discourage merely exploitative activities because in some circumstances they may provoke negative effects in competing domestic firms (although they may have a positive effect on suppliers).

The challenge is to translate these general objectives into specific policies. Much more research is necessary to have the elements that would allow the design effective policies in this respect. A particularly fruitful line of research in this direction seems to be to focus on understanding what encourages subsidiaries to become innovative in host emerging economies. As discussed in the above Section, conventional models of the MNC assumed that most subsidiary activities could be explained by the centralised decisions of the MNC. However, modern views of the MNC have emphasised the importance of bottom-up processes and the potentially important role that the initiative of local subsidiaries and managers can play in explaining the different role and innovative intensity of subsidiaries. Future research should explore the role of entrepreneurial subsidiaries in encouraging exploration activities and spillover in emerging economies.

Our study has two main limitations related mostly to data restrictions. First, we have not been able to trace vertical spillovers and, second, our proxies for identifying CC subsidiaries are imperfect. More detailed information about subsidiary activities in India would be

necessary to identify CC subsidiaries more precisely. A bespoke survey such as the one conducted by Cantwell and Mudambi (2005) would be ideal. However, information in this type of survey can rarely be pooled together with data on a large sample of domestic firms, which is necessary to analyse spillover effects. We hope that future research would contribute to this new direction of research in the spillovers literature by collecting more detailed information about subsidiary activities in host-emerging economies that can be related to domestic firms' activity to investigate spillover effects.

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