CONDITIONAL TECHNOLOGY SPILLOVERS FROM FOREIGN DIRECT INVESTMENT EVIDENCE FROM INDIAN MANUFACTURING INDUSTRIES*

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Abstract

This paper hypothesizes that the incidence of technology spillovers from foreign direct investment (FDI) is conditional upon the technology content of domestic firms and structure of foreign ownership in affiliates. Firstly, technology content of domestic firms is different across industries which can influence the technology spillovers from FDI. Secondly, different structure of foreign ownership in affiliates may affect the technology spillovers to domestic firms. Using a panel of Indian manufacturing firms, the paper confirms the occurrence of technology spillovers via backward linkages from foreign firms. Semi-parametric method of Levinsohn-Petrin (2003) has been employed in the paper to avoid the endogeneity bias in the estimation of productivity. The paper asserts that firms in high technology industries benefit more from technology spillovers compared to others. It also observes that minority-owned foreign firms are more prone to technology spillovers than majority-owned foreign firms. Nonetheless, it is observed that the majority-owned foreign firms benefit only firms in high technology industries.

JEL Classification: F23
Keywords: FDI; Technology Spillovers

* This paper is based on author's M.Phil dissertation on "*FDI and Technology Spillovers: A Study of Indian Manufacturing Industries*" submitted to Jawaharlal Nehru University, New Delhi in 2010. The author is grateful to P Mohanan Pillai and M Parameswaran for their help.

1. Introduction

Foreign Direct Investment (FDI) by Multi-National Enterprises (MNEs) has long been considered as an important channel for international diffusion of technology (Moran, 1998; Markusen, 2002; Keller, 2004). MNEs own, produce, and control most of world's advanced production technologies and are therefore responsible for a major part of the world's research and development (R&D) efforts (Caves, 1982). Owing to the public good characteristics, these technologies tend to spill over to domestic firms and thereby affecting the economic activities of the host country (Blomstrom and Kokko, 1998). Optimism about the technology spillovers is in fact the driving force, inter alia, led to a wide-ranging changes in national policies on FDI since 1990s (Blomstrom and Kokko, 2003).[1]

The empirical literature, however, finds a little conclusive evidence indicating that domestic firms in developing countries benefit from foreign presence in their industries (see for e.g., Haddad and Harrison, 1993; Aitken and Harrison, 1999; Djankov and Hoekman, 2000).[2] But the researchers are more sanguine about the occurrence of vertical technology spillovers, as there are several studies in developing countries confirming the plausibility of vertical technology spillovers via backward linkages.[3] The evidence on vertical technology spillovers emerges from a review of the case study literature (Moran, 2001) and firm-level econometric analyses performed by Javorcik (2004) using Lithuanian data, and Blalock and Gertler (2008) employing Indonesian data.

Studies are, however, focused mostly on unconditional technology spillovers from FDI. That is, the incidence of technology spillovers is not conditional upon any factor. But there are some factors, for example characteristics of domestic and foreign firm, which act as essential conditions for the occurrence of technology spillover from FDI. Firstly,

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[1] The United Nations Conference on Trade and Development's (UNCTAD) report on "Changes in national regulations of FDI" says that from 1991 through 2002, over 1,551 (95 per cent) out of the 1, 641 changes were introduced by 165 countries in their FDI law which were in the direction of creating more favorable environment for FDI in both developed and developing countries (UNCTAD 2003, Table 1.8).

[2] Kinoshita (1999) for China, Konnings (2000) for Bulgaria, Romania, and Poland also cast doubt on the existence of horizontal technology spillovers from FDI.

[3] See Gorg and Greenaway (2004), and Smeets (2008) for a survey of the literature.

domestic firms in the developing country are not homogenous so far as their technology content is concerned. Some are more technology intensive and some are less technology intensive, which ultimately provide different absorptive capacity to absorb the technology spillovers from the presence of MNEs (Girma et al., 2001; Girma and Gorg, 2002; Lipsey and Sjoholm, 2005). Secondly, it is believed that participation of a local shareholder in a foreign investment project reveals the multinational's proprietary technology and thus facilitates technology spillovers in the host country (UNCTAD, 2003; Blomstrom and Sjoholm, 1999). However, the majority foreign ownership in affiliates is highly prone to technology spillovers than affiliates with minority foreign ownership (Demelis and Louri, 2002). Since they have more control over affiliates which induces them to bring new or latest technologies from their parent companies and thereby resulting technology spillovers in the host country. Affiliates with minority foreign ownership, in contrast, are more linked to domestic firms in upstream and downstream and thus facilitating technology spillovers in the host country (Javorcik and Spatarenu, 2008).

Keeping the above considerations in mind, we can state that technology spillovers are not spontaneous from presence of foreign firms in the host country. Technology spillovers from FDI may rather rely upon the characteristics of foreign firms and domestic firms. The aim of this paper is to understand how the in-house technology differences among domestic firms affect the technology spillovers from FDI. This paper also tries to examine how the structure of foreign ownership in affiliates affects the technology spillovers to domestic firms in the host country.

The rest of the paper is structured as follows. The next section reviews the related literature for the purpose. It is followed by a brief discussion of FDI inflows into India. Then we present the estimation strategy, data and variable constructions, estimation of technology spillovers and the empirical results. The last section concludes.

2. Related Literature

2.1. Channels of Technology Spillovers

There are some channels through which these so-called technlogy spillovers can take places (Gorg and Greenaway, 2004; Smeets, 2008). First, domestic firms may upgrade their technology by imitating foreign companies' products and process (via reverse engineering) or managerial and organizational innovations (Das, 1987). Secondly, technology can leak out by employment turnover, i.e., employees trained in foreign firms can leave foreign firms and join the domestic firms or they can start their own business (Fosfuri et al, 2001). Thirdly, direct competition from foreign companies may compel domestic firms to use their resources more efficiently or go in search for new or advanced technologies, which thus increase the productivity of domestic firms (Glass and Saggi, 2002).

The above channels are typically meant for technology spillovers from foreign firms to domestic firms in the same industry, i.e., horizontal technology spillovers from FDI. In this case, foreign firms will have the tendency to prevent the technology leakage to foreign firms since both operate in the same industry. This can be accomplished through the protection of IPRs, paying higher wages to prevent employment turnovers, or operating only in countries or industries where the host country firms have lower imitating capacity to absorb the spillovers.[4] MNEs are also sensitive to the strength of IPRs protection in the host countries (Javorcik, 2004). So far as competition is concerned, foreign firms may specialize in the upper market segment or produce for exports, while domestic firms may focus on the local market only (Blalock and Gertler, 2008). Similarly, as argued by Kokko (1994), foreign companies may operate in 'enclaves', where neither products nor technologies have much in common with those of local firms.

These considerations have led the researchers to conclude that horizontal technology spillovers from FDI are limited. In contrast, they argue about the viability of technology spillovers via backward and forward linkages from foreign firms, i.e., vertical

[4] Several studies, viz., Aitken et al (1996) and Girma et al (2001) suggest that foreign firms pay higher wages than domestic enterprises and foreign firms, in fact instigate a "brain drain" as they lure the most capable managers away from domestic firms.

technology spillovers (Javorcik, 2004). Though, foreign firms prevent their technology leakages to domestic firms in the same industry, but they have incentives to provide technology to their suppliers and probably to their customers in upstream and downstream industries respectively (Blalock and Gertler, 2005 and 2008).

Technology spillovers via backward linkages may take place through (i) direct knowledge transfer from foreign customers to local suppliers; (ii) higher requirements for product quality and on-time delivery introduced by multinationals, which provide incentives to domestic suppliers to up-grade their production management or technology; and (iii) multinational entry increasing demand for intermediate products, which allows local suppliers to reap the benefits of scale economies (Javorcik, 2004). Similarly, technology spillovers via Forward linkages from foreign firms occur when foreign firms provide knowledge embodied in products, process, and technology to the domestic customers at the downstream industries, which help domestic firms boost up their productivity (Blomstrom and Kokko, 1998).

2.2. Technology differences across industries & technology Spillovers from FDI

Characteristics of host country may have implication on the incidence of technology spillovers from foreign firms (Kokko, 1994; Kokko et al., 1996). Domestic firms and industries are heterogeneous in nature, which enable them to react heterogeneously to the presence of foreign firms in the host country.[5] Particularly, firm's in-house technology content influences potential spillovers from the presence of foreign firms (Glass and Saggi, 1998). These technology capabilities of firms are different across industries, i.e., firms from high technology industries are more capable than firms from low technology industries. Ultimately, firms will have different absorptive capacity to access benefit arising out of foreign firms' activities. Particularly, technology differences across industries affect the vertical technology spillovers from FDI. Supplying firms in high technology industries may gains more from the presence of foreign firms compared

[5] According to a survey conducted by the World Bank among Czech and Latvian firms, 23 per cent of firms state that the presence of foreign multinational firms enhances their knowledge about new technologies, 13 per cent state the enhancement of their marketing know-how, and 5 per cent find access to better employees. Fewer than 10 per cent of firms reported that the foreign presence allows for a better input mix. In fact, about 46 per cent of multinationals firms report relying on global suppliers. However, about 29 per cent of the domestic respondents consider inward FDI to be responsible for their loss of market share (Javorcik and Spatareanu, 2005).

to same in low technology industries. Since firms in high technologies industries can meet the stringent quality and time schedule set by MNEs on the delivery of products owing to their technological advantages. Moreover, costumers or buyers from high technology industries may also gain more benefit from FDI compared to same in low technology industries, because, downstream buyers in high technology industries can decode embodied technologies in foreign products. Given the above arguments, we can hypothesize that technology differences across industries affect the vertical technology spillovers from foreign firms in India.

2.3. Structure foreign ownership in affiliates & technology Spillovers

The structure of foreign ownership in affiliates is likely to have some impact on the incidence of technology spillovers from FDI. Generally, policy makers in developing countries expect that local participations in a foreign investment project reveal multinational's proprietary technology and thus facilitates knowledge spillovers (UNCTAD, 2003; Blomstrom and Sjoholm, 1999). This may happen if the domestic partner applies the technology acquired through a joint venture to its own operation not involving the foreign shareholders or if the local partner is in charge of hiring policies and places local staff in key technical or managerial positions without taking action to limit employee turnover (Javorcik and Spatareanu, 2008). Nevertheless, the ownership sharing between foreign and domestic firms mediates the technology spillovers to domestic firms in the host country.

Full or majority ownership of MNEs in affiliates facilitates more spillovers than that of MNEs with minority ownership. When there is a risk for foreign firms to loose their intangible assets to local firms, they may hesitate to invest or bring less advanced (older) technologies to the affiliates (Mansfield and Romeo, 1980). But majority ownership in affiliates enable them more control over production and profits which induces MNEs to bring technology, management skills, and other intangible from their parent companies and there by generate spillovers in the host country (Blomstrom and Sjoholm, 1999; Muller and Schnitzer 2006). However, technological sophistication of these firms may impede technology diffusion to domestic firms operating in the same industry or related industries.[6]

Affiliates with minority foreign ownership, on the other hand, may lead to grater technology spillovers due to major local ownership. Sometimes, the MNEs look for joint venture without any formal requirements because local partners are more likely to have better knowledge of local conditions regarding factor endowments and skill of employees[7] which affect the choice of technology brought in by multinationals and thereby facilitates spillovers in the host economy. Given these arguments, we can expect larger vertical technology spillovers to be associated with affiliates with minority foreign ownership than affiliates with majority foreign ownership.

Table 1: Foreign Direct Investment Inflows in India

Year	US $ million	Growth Rate of FDI Inflows (%)
1990-91	97	-
1991-92	129	32.99
1992-93	315	144.19
1993-94	586	86.03
1994-95	1314	124.23
1995-96	2144	63.17
1996-97	2821	31.58
1997-98	3557	26.09
1998-99	2462	-30.78
1999-00	2155	-12.47
2000-01	4029	86.96
2001-02	6130	52.15
2002-03	5035	-17.86
2003-04	4322	-14.16
2004-05	6051	40.00
2005-06	8961	48.09
2006-07	22826	154.73
2007-08	34362	50.54
2008-09	35168	2.35

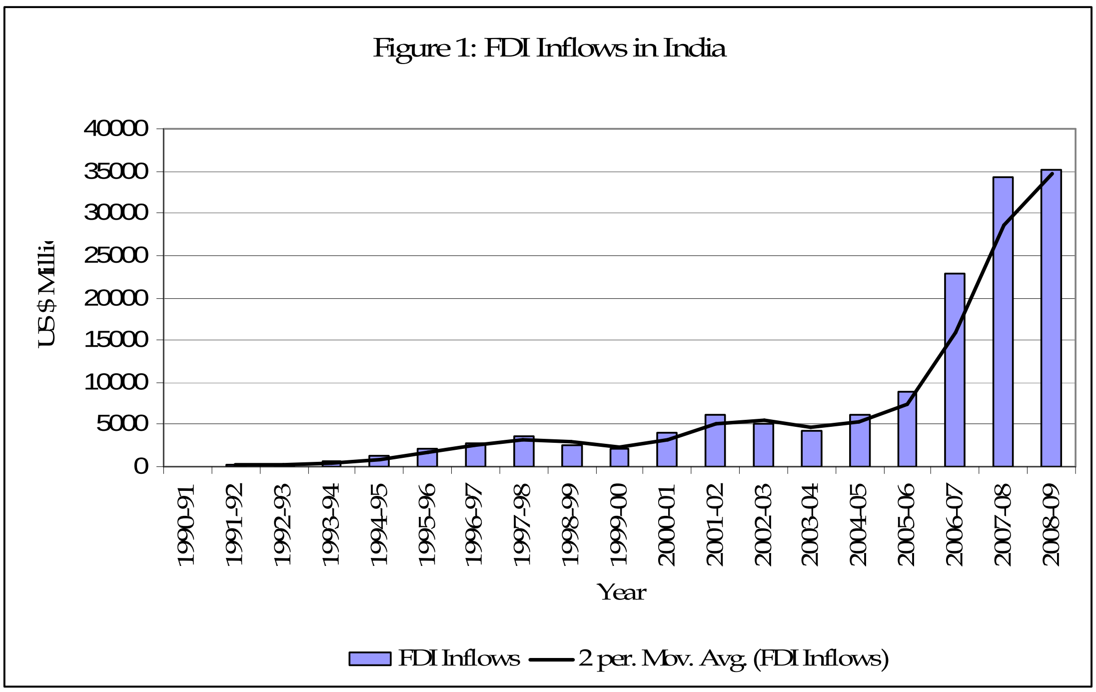
Source: RBI Database

[6] Due to lack of absorptive capacity domestic firms fail to decode the sophisticated technology embodied in the products displayed by foreign firms. Therefore, majority owned foreign firms might not cause spillovers to domestic firms in same industry. They may not generate vertical technology spillovers as well since they require more sophisticated inputs for their production, which are difficult for domestic firms to supply (UNCTAD, 2001).

[7] See, Beamish (1988), Blomstrom and Zejan (1991) find that Swedish firms with relatively brief experience of foreign production are likely to choose minority venture when they go abroad.

3. FDI in India

India pursued a dirigiste development pathway for decades after independence in which the role of FDI was restricted to fill saving-investment gap, technology gap, and balance of payments gap (Subrahmanian and Pillai, 1977 and 1979). It liberalized its FDI policy considerably in 1991, which has brought about a phenomenal increase in FDI inflows during 1990s and 2000s. FDI in India have increased significantly to US $35.168 billion in 2008-09, from a minimal US $97 million during reform year (See Table 1). Although, it is seen that the growth of FDI inflows in Indian has been volatile both during 1990s and 2000, still the trend of FDI is increasing with mild fluctuations (see figure 1).



The post liberalization period has broadened the sources of FDI inflows. An analysis of the origin of the FDI inflows into India reveals that the new policy measures broadened their sources. There were more than 100 countries, which had contributed to the FDI inflows in the year 2004 compared to only 29 countries in 1991 (SIA Newsletter, Department of Industrial Policy & Promotion (DIPP), India). It is seen that of all investing countries, only six countries (Mauritius, Singapore, U.S.A., U.K. Germany, and Netherlands) have the lion share of total FDI (i.e., more than 70 per cent of total FDI inflows in India coming from these six countries) over the period from 1991 to 2008 (see A. 1 in Appendix). However, Mauritius has been the top investors in India since 1991 and it has an increasing share in total FDI coming to India during 2000s (SIA Newsletter DIPP, India).

The economic reforms in India have not only broadened the sources of FDI inflows but also it has been accompanied with change in sectoral compositions of FDI. Prior to economic reforms, FDI inflows were concentrated in manufacturing activities because of import substituting industrialization programme, which encouraged the tariff-jumping investments to capture the protected domestic market (Joshi and Little, 1993). The trend of FDI inflows changed towards tertiary sector (encompassing mainly the service activities) after 1991. Table 2 presents a break up of FDI inflows to different sectors or activities in India during the period 1991-2008.

Table 2: Percentage Distribution of FDI in India

Year	Manufacturing Industries	Tertiary Sector	Power Sector	Mining Industry	Miscellaneous Industries	Total
1991-1999	56.25	21.80	8.75	-	13.21	100.00
2000	45.09	10.59	4.80	-	39.52	100.00
2001	38.88	35.65	10.99	-	14.49	100.00
2002	54.84	18.35	19.27	-	7.53	100.00
2003	48.69	28.32	7.76	-	15.23	100.00
2004	64.50	21.31	4.83	0.33	9.04	100.00
2005	44.46	46.76	0.79	0.14	7.85	100.00
2006	19.32	69.19	1.79	0.03	9.67	100.00
2007	22.43	62.84	1.61	2.55	10.57	100.00
2008	**28.87**	**54.51**	4.11	0.17	12.34	100.00
2000-08	31.38	51.78	4.29	0.58	11.97	100.00
1991-2008	34.09	48.52	4.77	0.52	12.10	100.00

Note: (i) value of in 1991-99 & 2000-08 are percentage of cumulative FDI.
(ii) Here year refers to calendar year (January to December)

Source: own compilation using data from SIA Newsletter, various issues.

During the 1990s FDI inflows were mainly concentrated in manufacturing industries as is visible from above table that 56.25 per cent of total cumulative FDI received by India is in manufacturing industries followed by tertiary sector attracting 21.8 per cent, miscellaneous industries attracting 13.21 per cent, and power sector attracting 8.75 per cent. The trend of FDI inflows has steadily turned towards the tertiary sector during the 2000s. FDI inflows to manufacturing industries has declined to less than 30 per cent

(28.87 per cent, for instance) in 2008, instead it has been diverted to tertiary sectors (54.51 per cent of FDI inflows coming to tertiary sector in 2008). The reason unambiguously is the departure of Indian economy from inward looking policy to market-oriented policy. Nevertheless, during the 1990s and first half of the 2000s FDI inflows were concentrated on manufacturing sectors as the cumulative figure of FDI inflows from 1991 to 2008 shows that 34 per cent of FDI inflows are into manufacturing industries.

4. Empirical Framework

4.1. Estimation Strategy

Corroborating the earlier studies, we investigate technology spillovers from FDI by regressing firm level productivity on measures of foreign presences in industries, controlling for a number of other covariates. To do so we proceed with the following regression model.

$$TFP_{ijt} = \beta_1 HZ_{jt} + \beta_2 BW_{jt} + \beta_3 FW_{jt} + \beta_4 HHI_{jt} + \beta_5 RDS_{ijt} + \beta_6 XNS_{ijt} + \beta_7 TMS_{ijt} + \varepsilon_{ijt} \qquad (1)$$

Where TFP_{ijt} is the total factor productivity of i^{th} firm in industry j in year t. HZ, BW, and FW are horizontal FDI, Backward FDI, and Forward FDI respectively and they are variables to capture horizontal and vertical spillovers from foreign firms; HHI, RDS, XNS, and TMS refer to Herfindahl index of industry, R&D intensity of the firm, export intensity of the firm, and technology import intensity of firms respectively (See next section for construction of variables).

We are interested in the effect of technology spillovers from foreign firms on TFP of domestic firms in manufacturing industries.[8] To proxy TFP we use firm-level residual from production function estimated at firm level. We estimate the TFP using output and all production inputs such as capital stock, labour input, raw materials and energy. It is well acknowledged that estimation of production function using Ordinary Least Squares (OLS) gives inconsistent and biased estimates of explanatory variables. There are likely to be a host of firm, industry, time, and region-specific influences that are unobservable to the econometrician but are known to the firm. These unobservable might influence

[8] Rationale for employing manufacturing industries is that during the study period there are large number of

the usage of production inputs and usage of inputs thus determined endogenously. Since OLS technique assumes production inputs are uncorrelated with omitted unobservable variables, it fails to address this endogeneity issues and thereby results in inconsistent and biased estimates of production function, which is otherwise known as endogeneity bias.

Marshack and Andrews (1944), and Grilliches and Mairesse (1995), among others, have explored the potential correlation between input levels and firm-specific productivity shocks in estimating production function. Olley and Pakes (1996) have outlined a semi-parametric method to handle the simultaneity problem. They use investment as proxy to control the correlation between input levels and unobserved firm-specific productivity shocks in the estimation of production function. But this methodology is applicable if plants report non-zero investment. Unfortunately, many plants in developing countries do not report positive levels of investment. For our study, there are also zero investment values. So in order to apply this method to any study, sample of the study needs to be truncated if it has zero investment values in it. However, Levinsohn and Petrin (2003) propose an alternative method to estimate the production function. They, instead, use intermediate inputs such as electricity or energy to address the simultaneity problem.[9] The method allows the analysis to proceed without reducing the sample size. Another benefit of this method compared to the use of investment proxy is its applicability to non-convex adjustment costs. "If adjustment costs lead to kink points in the investment demand function, plants may not entirely respond to some productivity shocks, and correlation between the regressors and error can remain. If it is less costly to adjust the intermediate input, it may respond more fully to the entire productivity term" (Levinsohn and Petrin, 2003, p. 318).

We have used Levinsohn and Petrin (LP) methodology to estimate firm-level production function. The detail of the estimation is as follows. We assume a Cobb-Douglas production function:

$$y_t = \beta_0 + \beta_k k_t + \beta_l l_t + \beta_m m_t + \beta_e e_t + \omega_t + \eta_t \qquad (2)$$

[9] Another method is Blundell and Bond's (2000) GMM estimator. The method uses lagged inputs for the endogeneity problem but it is not applicable with short time series data. The method can't be employable to the present study owing to short time series data.

Where y_t, k_t, l_t, m_t, and e_t are the logarithm[10] of output, capital stock, labour input, raw materials, and energy of firm respectively, ω_t denotes productivity of the firm and η_t stands for measurement error in output, which is uncorrelated with input choices. Subscripts for firm and industry in the above equation are not used for notational convenience.

We take energy as proxy to take care of the endogeneity bias. LP assume that firm's intermediate inputs (say energy) demand function, $e_t = e_t(\omega_t, k_t)$ is monotonically increasing in productivity given its capital stock. This allows inversion of energy demand function as $\omega_t = \omega_t(e_t, k_t)$. Thus the unobservable productivity term (ω_t) depends solely on two observed inputs, e_t and k_t. Rewriting equation (2) gives us:

$$y_t = \beta_l l_t + \beta_m m_t + \phi(k_t, e_t) + \eta_t$$

$$\text{Where, } \phi(k_t, e_t) = \beta_0 + \beta_k k_t + \beta_e e_t + \omega_t(k_t, e_t) \tag{3}$$

Here the error term (η_t) is not correlated with the inputs. The estimation of production function has been taken place at two stages. In the first stage, conditional moments $E(y_t \mid \mathrm{k}_{t,} e_t)$, $E(m_t \mid \mathrm{k}_{t,} e_t)$, and $E(l_t \mid \mathrm{k}_{t,} e_t)$ are estimated. Conditional moment, say, $E(y_t \mid \mathrm{k}_{t,} e_t)$, is approximated by a third order polynomial in k and e with full set of interactions. Conditional moments e.g., $E(m_t \mid \mathrm{k}_{t,} e_t)$, and $E(l_t \mid \mathrm{k}_{t,} e_t)$ are also approximated in the same way. Next we consider the following equation

$$y_t - E(y_t \mid \mathrm{k}_{t,} e_t) = \beta_l (l_t - E(l_t \mid \mathrm{k}_t, e_t)) + \beta_m (m_t - E(m_t \mid \mathrm{k}_t, e_t)) \tag{4}$$

No-intercept OLS, is then used on this equation to estimate parameters, $\hat{\beta}_l$ and $\hat{\beta}_m$. In the second stage, LP assume that productivity is governed by a first-order Markov process, $\omega_t = E(\omega_t \mid \omega_{t-1}) + \xi_t$, where ξ_t is an innovation to productivity. Now compute $\phi_t + \eta_t = y_t - \hat{\beta}_l l_t - \hat{\beta}_m m_t$ and find the estimate $\hat{\phi}_t(.)$ from the regression of $\phi_t + \eta_t$ on 3rd order polynomial of e_t and k_t with full sets of interaction terms. For the candidate

[10] Here logarithm means logarithm to the base 10.

value of β_k and β_e as β_k^* and β_e^* respectively (which we can get from OLS regression of (2)), followings can be computed.

$$\omega_t \hat{+} \eta_t = y_t - \hat{\beta}_l l_t - \hat{\beta}_m m_t - \beta_k^* k_t - \beta_e^* e_t$$

$$\omega_{t-1} \hat{+} \eta_{t-1} = \hat{\phi}_{t-1} - \beta_k^* k_{t-1} + \beta_e^* e_{t-1}$$

$E(\omega_t \mid \omega_{t-1})$ can be estimated by regressing of "$\omega_t \hat{+} \eta_t$" on fourth order polynomial in "$\omega_{t-1} \hat{+} \eta_{t-1}$". Given $\hat{\beta}_l, \hat{\beta}_m, \beta_k^*, \beta_e^*$ and $E(\omega_t \hat{|} \omega_{t-1})$, we can write the residual of the production function as

$$\xi_t \hat{+} \eta_t \ (\beta_k^*, \beta_e^*) = y_t - \hat{\beta}_l l_t - \hat{\beta}_m m_t - \beta_k^* k_t - \beta_e^* e_t - E(\omega_t \hat{|} \omega_{t-1})$$

For the estimation of coefficients in the second stage, we use two moment conditions to identify β_e and β_k. First moment condition identifies β_k by assuming that capital stock does not respond to the innovation in productivity, i.e., $E(\eta_t + \xi_t \mid k_t) = 0$; second moment condition identifies β_e by using the fact that last period's energy choice should be uncorrelated with innovation in productivity this period, i.e., $E(\eta_t + \xi_t \mid e_{t-1}) = E(\xi_t e_{t-1}) = 0$. Thus, we have only two population moment conditions given by the vector of expectations:

$$E[(\eta_t + \xi_t) Z_t]$$

Where Z_t is the vector given by

$$Z_t = \{k_t, e_{t-1}\}$$

Finally, we get the estimates of (β_k, β_e) by minimizing the GMM criterion function

$$Q(\beta^*) = \min \beta^* \sum_{h=1}^{2} \left\{ \sum_i \sum_t (\eta_{i,t} \hat{+} \xi_{i,t}(\beta^*)) Z_{i,h,t} \right\}^2$$

where i indexes firms, h indexes two instruments and t indexes time.

However, the estimation requires several steps and taking care of variances and co-variances of estimates at each stage is quite tedious job, estimates have been bootstrapped to draw inference.[11] The bootstrap technique resamples the empirical distribution of the observed data to construct new "bootstrapped" samples. The value of the statistic is computed for each of these samples and the distribution of estimates so generated provides the bootstrap approximation to the sampling distribution of the statistics. Using the estimated coefficients of production function $\hat{\beta}_l, \hat{\beta}_m, \hat{\beta}_k$, and $\hat{\beta}_e$ [12] we have estimated the $LogTFP_{ijt}$ as

$$LogTFP_{ijt} = y_{ijt} - \hat{\beta}_l l_{ijt} - \hat{\beta}_m m_{ijt} - \hat{\beta}_k k_{ijt} - \hat{\beta}_e e_{ijt}$$

4.2. Data and Variable Construction

The basic database for the study is the firm level panel data of 21 manufacturing industries in National Industrial Classification, 1998 (NIC-1998) for the period 2000-01 to 2007-08[13], obtained from the Centre for Monitoring Indian Economy's (CMIE) electronic database PROWESS. The sample is selected for the present study by various steps. In the first step, all firms in the manufacturing sectors are selected; in the second step, firms not having equity holding information are dropped; in the third step, firms for which the key variables like sales, Gross Fixed Assets (GFA), salaries and wages, raw materials, and energy are available are selected. Firms not having continuous time series of at least three years have been dropped as capital stock estimation requires continuous times series. Finally, correcting for outliers we are restricted with 11506 observations on 1897 manufacturing firms.[14]

In addition to PROWESS database, we use the industry level information from Annual Survey of Industry (ASI) of India, and Central Statistical Organization (CSO) data for input-output transaction tables and price indices.

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[11] See Horowitz (2001) for an overview of the bootstrap.

[12] See appendix A.2 for estimates of coefficient of production inputs

[13] Owing to unavailability of firm's equity holding information prior to 2000-01, we have restricted to our analysis for the period 2000-01 to 2007-08 only.

[14] To correct outliers of the sample we follow Tukey (1977). Tukey's Exploratory Data Analysis includes a resistant rule for identifying possible outliers in univariate data. Using lower and upper quartles Q_L and Q_U, it labels as "outside" any observations below $Q_L - 1.5\,(Q_U - Q_L)$ or above $Q_U + 1.5\,(Q_U - Q_L)$.

Construction of Variables

All the variables in the production function are in 1993-94 prices, obtained by deflating values reported in current prices using appropriate price indices collected from "*Index Numbers of Wholesale Prices in India, base 1993-94 = 100*" published by the Economic Adviser Ministry of Commerce and Industry, Government of India. The specific details on the construction of each variable are given below.

Output (Q): The output series are obtained by deflating reported nominal value of output, which is the sum of sales and change in stock of finished/semi-finished goods of the firm. A more disaggregated level of industry price indices is used for deflating output.

Raw materials (M): It is obtained by deflating the reported cost of raw materials consumed using raw material price indices. Raw material price index for each industry (this is also at more disaggregated level) is constructed using weights obtained from Input-Output Transaction Table of India for 2003-04, published by the Central Statistical Organization (CSO) and appropriate price indices collected from *Index Numbers of Wholesale Prices in India, base 1993-94 =100.*

Capital (C)*:* The database reports Gross Fixed Assets (GFA) of the firm in historical cost. Capital stock is constructed using perpetual inventory method by taking 2004-05 as the benchmark year. For this, we have converted the reported GFA of 2004-05 into replacement cost on the basis of a revaluation factor computed using the procedures given in Srivastava (1996). We use gross fixed asset rather than the net fixed asset, as the construction of net fixed asset needs information on the economic rate of depreciation of assets, which is not available for the Indian manufacturing industry.

Labour (L): The PROWESS database provides information on wages and salaries of the firm and provides no information on the number of employees. Therefore, we need to use this information to arrive at the number of person engaged in each firm. Number of persons engaged in a firm is arrived at by dividing the salaries and wages at the firm level by the average wage rate of the industry (two-digit) to which firm belongs. To arrive at the average wage rate we make use of the Annual Survey of Industries (ASI) data on Total Emoluments as well as Total Persons Engaged for the relevant industry. At the time of this study, ASI data was available only up to 2005-06. We have extrapolated the values for the remaining years of our study.

Energy (E)*:* The energy variable is constructed by deflating the reported energy cost[15] by an energy price index which is constructed using weights obtained from the Input-Output Transaction Table of India for 1993-94 and appropriate price indices from the Index Numbers of Wholesale Prices in India base 1993-94=100.

Technology Import Intensity (TMS): Technology import intensity controls for how the expenditure on technology imports influence the productivity of the domestic firms. Modern and advanced technologies are always priced at higher rate, higher expenditures on technology import show the firm's interest in improvement and hence there is increase in productivity of firms. Technology import intensity is measured as the ratio of firm's expenditure on technology import to its sales value in a year. The technology import expenditure includes the expenditure on the import of capital goods and foreign exchange spending on royalty/technical know-how.[16]

Export Intensity (XNS): Exporting facilitates the interaction with foreign buyers and foreign markets and the consequent learning from it which boosts up the productivity of domestic firms. Here, we are using export intensity to see the effect of export on firm's productivity. We have defined export intensity as the ratio of firm's export to its sales value.

R***&D Intensity (RDS)*****:** R&D expenditure generally signals a firm's in-house technology content and its endeavor to be on the frontier technology. So it affects the productivity of the firm. We are using R&D intensity to see the impact of R&D expenditure on the productivity of firms. R&D intensity is defined as the ratio of firm's R&D expenditure to its sales value.

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[15] Energy cost is measured by the reported expenditure on power and fuel.

[16] Foreign exchange spending on royalty/technical know-how is the expenditure on the import of disembodied technology.

***Herfindahl Index (HHI)*:** Herfindahl index is meant to capture the effect of competition in industry. It is the proxy for the level of industry concentration and it is the sum of the squared market shares of firms in a given industry. Symbolically, it is

$$HHI_j = \sum_i \left(\frac{S_i}{\sum S_i} \right)^2$$

where S_i is the sale of firm i[th] firm and j stands for industry. Higher value of HHI indicates a more concentrated industry. A more concentrated industry implies lower competition, which creates inefficiency and thereby lowers productivity of firms in the industry.

There are some variables, namely, Horizontal FDI, Backward FDI, and Forward FDI that capture the technology spillovers from FDI. They are constructed as follows.

Horizontal FDI (HZ): It measures the share of output accounted by the foreign firms[17] in the total output of the industry**.** It is defined as

$$HZ_{jt} = \frac{\sum_{i=1}^{m} Y_{it}^{f}}{\sum_{i=1}^{n} Y_{it}}$$

where Y_{it} is the output of firms i in year t and Y_{it}^{f} are output of foreign firm i in same year. n stands for total number of firms in an industry consisting of both domestic and foreign firms and m denotes number of foreign firms in an industry.

Backward FDI (BW): Backward FDI is the share of total output of an industry that is sold to foreign firms in downstream industries. To construct this variable we follow Blalock and Gertler (2005). In contrast to horizontal FDI it is not straightforward to measure rather it is more complicated. Here, we would like to measure the share of firm's output sold to foreign-owned firms. Unfortunately, this information is not available in our dataset. So, we proxy the share of the firm's output sold to foreign firms

[17] Firms having foreign equity greater than 10 per cent of total equity are classified as foreign firms or foreign owner firms, foreign affiliates.

by the share of an industry's output that is sold to foreign firms. Then, how to measure the share of an industry output sold to foreign firms in other industries? "*If we assume that a firm's share of an industry's use of a particular input is equal to its output share, then a measure of the share of an industry output sold to foreign firms is the sum of the output shares purchased by other industries multiplied by the share of foreign output in each purchasing industry*" (Blalock and Gertler, 2005).[18] Now formally we can express the Backward FDI for industry j at time t as follows.

$$BW_{jt} = \sum_{k \neq j} \alpha_{jk} HZ_{kt}$$

Where, α_{jk} is the proportion of industry j's output supplied to industry k, which is taken from the 2003-04 *industry x industry* coefficient matrix[19] at two-digit level (NIC-1998). The formula shows that inputs supplied within the sector are not included, since the Horizontal FDI captures this effect. This variable states that higher presence of foreign firms in downstream industry generates higher backward linkages to firms in upstream or supplying industry in host country.

Forward FDI (FW): Forward FDI measures the degree of forward linkages from foreign firms to domestic firms in downstream industries and it is defined as the proportion of an industry's intermediate consumption supplied by foreign-owned firms. Using the same assumption used for constructing backward FDI, we can approximate the share of an industry's intermediate consumption supplied by foreign firms as the sum of shares of intermediate input sourced from other industries multiplied by share of foreign firms' output in each supplying industry. Further, while measuring share of foreign firms' output in upstream or supplying industry, we have excluded goods produced by firms for export, since only intermediate sold in the domestic markets are relevant for construction of forward FDI. Thus the approximation for Forward FDI is

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[18] To illustrate the Backward FDI, let's consider there are 3 industries such as wheat flour milling, pasta production, and baking. Suppose that half of the wheat flour industry's output is purchased by the bakery industry and the other half is purchased by the pasta industry. Further, assume that the bakery industry does not have any foreign factories but that foreign factories produce half of the pasta industry output. The calculation of the Backward FDI for flour industry would be 0.25=0.5(0.0) + 0.5 (0.5).

[19] Industry-Industry Coefficient matrix is constructed using Input-Output Transaction Table of year 2003-04. See Appendix A for detail.

$$FW_{jt} = \sum_{w \neq j} \sigma_{wj} \left[\frac{\sum_{i=1}^{m} \left(Y_{it}^{f} - X_{it}^{f} \right)}{\sum_{i=1}^{n} (Y_{it} - X_{it})} \right]$$

where σ_{wj} is the share of inputs purchased by industry j from industry w in total inputs sourced by industry j and superscript f stands for foreign firm and the second term of right side of equation computes the share of foreign firms' output in upstream or supplying industry. For the same reason as before, inputs purchased within the sector are excluded. The value of the variable increases with increased in share of foreign firms' output in upstream industries.

As pointed out above, an important feature of this study is to see how the degree of foreign ownership in foreign firms affects the technology spillovers on domestic firms in host country. For this we have divided total foreign firms into majority-owned foreign firms and minority-owned foreign firms. Former is the firm with at least 50 per cent foreign equity participations and later is the firm with foreign equity participation above 10 per cent but below 50 per cent.[20] Accordingly, we have constructed six measures of foreign presence such as MajHZ, MinHZ, MajFW, MinFW, MajBW, and MinBW.

MajHZ: It is the share of output of majority-owned foreign firms in a given industry. Symbolically, it is as follow:

$$MajHZ_{jt} = \frac{\sum_{i=1}^{m} \left(Maj_{it} * Y_{it}^{f} \right)}{\sum_{i=1}^{n} Y_{it}}$$

Where the numerator is the total output of majority-owned foreign firms functioning in India in industry j and year t and denominator is the total output of the same industry in the same year. Maj_{it} is a dummy variable that takes the value one for majority-owned foreign firms and zero for other firms. The value of the above variable expresses the

[20] Similar approach has been used by Demelis and Louri (2002) for defining majority and minority-owned foreign firms.

proportion of total output of a given industry in a given year that is produced by majority-owned foreign firms.

MajBW: It is the share of output of an industry that is supplied to majority-owned foreign firms in downstream industry. Applying the same procedure used for backward FDI, majority-backward FDI is defined as follow:

$$MajBW_{jt} = \sum_{k \neq j} \alpha_{jk} MajHZ_{kt}$$

This variable shows that higher presence of majority-owned foreign firms in downstream industry generates higher backward linkages to firms in upstream or supplying industry.

MajFW: It is the proportion of output of an industry that is purchased from majority-owned foreign firms in upstream industry. Following the procedure applied for forward FDI, we are approximating the share of an industry's intermediate input supplied by majority-owned foreign firms as the sum of the shares of intermediate input bought from other industries multiplied by share of output of majority-owned foreign firms in each supplying industry. We have also excluded the goods produced by firms for export while measuring share of foreign firms' output in upstream or supplying industry, since only intermediate inputs sold in the domestic market are relevant for construction of majority-forward FDI. So, majority-Forward FDI is as

$$MajFW_{jt} = \sum_{w \neq j} \sigma_{wj} \left[\frac{\sum_{i=1}^{m} \left(Maj_{it} * \left(Y_{it}^{f} - X_{it}^{f} \right) \right)}{\sum_{i=1}^{n} \left(Y_{it} - X_{it} \right)} \right]$$

where the second term in the right side of the equation is the share of output of a given industry produced by majority-owned foreign firms. The measures of foreign presence such as MinBW, MinFW, and MinHZ are constructed in an analogous manner.

4.3. Estimation of Technology Spillovers from FDI

The central focus of this chapter is to examine how the technology spillovers from FDI is affected by the technology differences across industries as well as by the structure of foreign ownership in affiliates. Following the studies of Aitken and Harrison (1999) and Blalock and Gertler (2005, 2008) our study also takes contemporaneous value of the variables to estimate technology spillovers from foreign investment. However, Kathuria (1998, 2002), and Javorcik (2004), among others, have used lagged and difference value of the variables respectively for estimating technology spillovers. For our purpose, we have used the following models.

Model 1

$$LogTFP_{ijt} = \beta_0 + \beta_1 BW_{jt} + \beta_2 FW_{jt} + \beta_3 HZ_{jt} + \beta_4 HHI_{jt} + \beta_5 RDS_{ijt} + \beta_6 XNS_{ijt} + \beta_7 TMS_{ijt} + \varepsilon_{ijt}$$

Model 2

$$LogTFP_{ijt} = \beta_0 + \beta_1 MajBW_{jt} + \beta_2 MinBW_{jt} + \beta_3 MajFW_{jt} + \beta_4 MinFW_{jt} + \beta_5 MajHZ_{jt} + \beta_6 MinHZ_{jt}$$

$$+ \beta_7 HHI_{jt} + \beta_8 RDS_{ijt} + \beta_9 XNS_{ijt} + \beta_{10} TMS_{ijt} + \varepsilon_{ijt}$$

As outlined earlier, the sample of the study covers 11,506 observations of 1897 manufacturing firms over the study period. Nearly, 16 per cent of total manufacturing firms have foreign investment during the study period 2000-01 to 2007-08. After classifying foreign firms on the basis of foreign ownership, we have found that of the total manufacturing firms 6 per cent are majority-owned foreign firms and 9 per cent are minority-owned foreign firms. Further, we have also classified total firms on the basis of their technology content by industries. For classifying manufacturing industries into high technology and low technology, we follow the OECD classification, which uses R&D expenditure and output of 12 OECD countries to classify manufacturing industries (OECD, 2007) (See A. 3 in Appendix for classification of industries by technology).

Before going into estimation of above specified models, it is essential to know the behavior of the models' variables. The study has annexed the summary statistics of all the variables in the models (See Table A. 4 in Appendix). We also show two correlation matrices for both model 1 and 2 (See Table A. 5 & A. 6 in Appendix). For both the models, the correlation matrices are found not to be very problematic for running regressions. The only correlation coefficient between MinBW and MajBW is the highest among all the variables.

Further, we have restricted our sample to 9840 observations on 1640 domestic firms. Since we are interested in estimating technology spillovers from foreign firms towards domestic firms, our analysis considers only the later type of firms. The models have been estimated using a firm level fixed effect approach with full set of year dummies.[21] In fixed effects specification, heteroscedasticity and serial correlation are always the potential problem. The possible bias is larger the longer the time horizon. Since we have short time series and a large cross-section, it is appropriate to use cluster sample methods (Arellano, 1987; Wooldridge, 2003) to estimate the fixed effect models. Cluster sample methods are generalization of White's (1980) robust covariance matrices. The obtained robust variance matrix estimator is valid in the presence of heteroscedasticity and serial correlation provided that, as in our case, time period is small relative to the number of groups (Wooldridge, 2002, PP. 262-263, and 2003). The fixed effects panel estimation control for the unobserved heterogeneity among the firms in the sample.

4.4. Estimation Results

We examine both the occurrence of vertical and horizontal technology spillovers from FDI in model 1. In model 2, we contrast between technology spillovers from minority-owned and majority-owned foreign firms. In both the models we also show how the domestic firms with different technology intensity are affected from FDI.

(a) Horizontal and Vertical Technology Spillovers from FDI

Column (i) of the Table 3 shows the estimation of model 1 based on full sample of domestic firms. The estimate of coefficient of backward FDI is positive and statistically significant which suggests that TFP of domestic firms increases over 35 per cent due to one unit increase in output of foreign firms in downstream industries. This implies that the presence of foreign firms in downstream industries benefits domestic firms through linkages. In contrast, foreign firms in supplying industries and in same industry do not

[21] A Hausman test run on preliminary regressions clearly rejected random effect models in favor of fixed effect models.

have any significant spillovers on the productivity of domestic firms, as the coefficients of FW and HZ are statistically insignificant at conventional level. All the firm-specific and time-variant control variables, namely R&D intensity, export intensity, technology import intensity, and industry specific control variable such as Herfindahl index don't also have any significant effect on domestic firms in India. This finding is similar to those found by Schoors van der Tol (2002), Javorcik (2004) and Blalock and Gertler (2005) who have affirmed the occurrence of vertical technology spillovers from FDI via backward linkages.

Table 3: Regression Results of Domestic Firms for period 2000-01 to 2007-08.
Dependent Variable: LogTFP

Independent Variables	All Firms (i)	Low Technology Firms (ii)	High Technology Firms (iii)
BW	0.350*** (0.125)	0.571*** (0.123)	1.311* (0.705)
FW	0.042 (0.105)	-1.858** (0.780)	-0.449** (0.151)
HZ	-0.095 (0.058)	-0.083 (0.063)	-0.024 (0.109)
HHI	0.166 (0.211)	-0.112 (0.250)	-0.433 (0.424)
RDS	-0.003 (0.003)	0.002 (0.001)	-0.480 (0.258)
XNS	0.034 (0.030)	0.035 (0.037)	-0.005 (0.050)
TMS	-0.092 (0.068)	-0.165 (0.104)	-0.011 (0.037)
Constant	3.827*** (0.028)	3.894*** (0.040)	3.764*** (0.089)
Year Dummies	Yes	Yes	Yes
Firm Dummies	Yes	Yes	Yes
R^2	0.061	0.031	0.156
F - Statistics	18.46***	8.39***	21.11***
Observations	9840	5527	4313

Note: (1) Robust standard errors are in parentheses.
(2) *, **, and *** are significant at 10 per cent, 5 per cent, and 1 per cent respectively

(b) Technology differences across industries & technology Spillovers from FDI

To assess the influence of characteristics of domestic firms in terms of their technology content, the sample is divided into two subcategories viz., low technology intensive firms and high technology intensive firms[22]; and the results with respect to each are

[22] Low technology and high technology firms are firms belonging to low technology and high technology industries respectively.

presented in column (ii) and (iii) of Table 3. In column (ii) we find that both coefficients of backward and forward FDI are statistically significant. The coefficient of backward FDI indicates that increase in share of output of foreign firms in downstream industries raises the TFP of domestic firms, where as the coefficient of forward FDI shows the opposite results. That is, the increase in share of output of foreign firms in upstream industries brings down TFP of domestic firms. Though, there is technology spillovers through backward linkages from FDI, there is higher loss to domestic firms from foreign firms in supplying industries. This may be due to the fact that domestic firms in low technology industries have less absorptive capacity to exploit knowledge embodied in intermediate goods produced by foreign firms.

In column (iii) both the coefficients of backward and forward FDI are statistically significant at 10 per cent and 5 per cent level respectively. As per the coefficient of backward FDI domestic firms benefit from the presence of foreign firms in downstream industries. Similar to the finding of low technology firms, the coefficient of forward FDI unravels that productivity of high technology firms deteriorates with the presence of foreign firms in upstream industries. This implies that even domestic firms in high technology industries are less competent to internalize the embodied technology in intermediate goods purchased from foreign firms in supplying industries or upstream industries and thereby incur loss. However, positive spillovers from foreign firms in downstream industries are higher than the negative spillovers from foreign firms in upstream industries.

It can be said that foreign firms in downstream industries are sourcing more inputs from suppliers in high technology industries compared to suppliers in low technology industries, and thus increases the productivity of domestic firms in high technology industries in term of knowledge transfers and training to employees. We can, therefore, conclude that firms in high technology industries have more capability to absorb spillovers from FDI in comparison to those in low technology industries.

(c) Structure of foreign ownership in affiliates & technology Spillovers from FDI

Table 4 depicts the results on the estimation of model 2 where we are examining how the characteristic of FDI, like, ownership of foreign firms affects the technology spillovers to domestic firms. Column (i) of the table shows the result obtained from the use of full sample on domestic firms. Columns (ii)-(iii) present the results from sub-samples where whole sample has been segregated to two parts on the basis of technology intensity of industries.

Table 4: Regression Results of Domestic Firms for period 2000-01 to 2007-08. Dependent Variable: LogTFP

Independent Variables	**All Firms (i)**	**Low Technology Firms (ii)**	**High Technology Firms (iii)**
MajBW	0.528*** (0.146)	0.569*** (0.138)	1.048* (0.579)
MinBW	0.542*** (0.184)	0.715*** (0.185)	-0.084 (0.621)
MajFW	0.096 (0.190)	-0.393** (0.191)	8.164*** (1.419)
MinFW	-0.048*** (0.014)	-0.041*** (0.014)	1.364 (1.430)
MajHZ	-0.114 (0.080)	-0.013 (0.119)	0.171* (0.100)
MinHZ	-0.007 (0.068)	0.021 (0.061)	0.147 (0.167)
HHI	0.080 (0.218)	-0.145 (0.256)	-0.350 (0.389)
RDS	-0.003 (0.003)	0.002 (0.001)	-0.460* (0.255)
XNS	0.033 (0.029)	0.037 (0.037)	0.001 (0.048)
TMS	-0.092 (0.068)	-0.165 (0.105)	-0.002 (0.035)
Constant	3.806*** (0.030)	3.811*** (0.032)	3.649*** (0.097)
Year Dummies	Yes	Yes	Yes
Firm Dummies	Yes	Yes	Yes
R^2	0.064	0.034	0.166
F - Statistics	18.08***	8.81***	21.13***
Observations	9840	5527	4313

Note: (1) Robust standard errors are in parentheses.
(2) *, **, and *** are significant at 10 per cent, 5 per cent, and 1 per cent level respectively

The column (i) reveals that the coefficients on MajBW and MinBW are statistically significant, suggesting that productivity of domestic firms is positively correlated with the presence both majority and minority owned foreign firms in downstream industries. However, it is seen that domestic firms are getting more benefit from minority-owned foreign firms than majority-owned foreign firms. This implies that the minority-owned foreign firms might be sourcing or buying more intermediates input than majority-owned foreign firms. This is because local partners with majority equity holdings in foreign affiliates have the tendency to buy more intermediate inputs and thereby disseminating technology to their suppliers at upstream industries. Further, there are negative and significant technology spillovers from minority-owned foreign firms in supplying industries**.** It may be the case that minority-owned foreign affiliates are selling low quality inputs (as there are older technology transfers from parent company to minority-owned foreign affiliates) which reduces the productivity of domestic firms. Thus, there are negative spillovers to domestic firms who source inputs from foreign firms with minor equity holdings.

Column (ii) of the table 4 provides the same evidence that minority owned foreign firms have more spillovers than majority owned foreign firms. It also shows negative spillovers via forward linkages both from minority and majority-owned foreign firms. The possible explanation for this could be that firms in low technology industries are incompetent to decode the technology embodied in the inputs sourced from foreign firms. However, the positive spillover effect from backward FDI outweighs this negative spillovers effect from forward FDI.

Column (iii) confirms the significant productivity gains from majority-owned foreign firms and there is no significant spillover from minority-owned foreign firms. This implies domestic firms in high technology industries gain both from vertical and horizontal technology spillovers from majority-owned foreign firms. The possible explanation for this is as follows. There are two essential conditions underlying the transfer of technologies from MNE parent to subsidiaries in host developing countries. First, MNE should have full or majority ownership in affiliates in order to avoid the technological leakages to host country (Mansfield and Romeo, 1980); second, characteristics of host firms, e.g., technological capabilities of firms which reduces cost of transferring technology to host countries (Behrman and Wallander, 1976, Dahlman et al., 1987; Kokko, 1994). Therefore, majority-owned foreign firms benefit only firms in high technology industries. Domestic firms in high technology industries are being more productive via vertical linkages with majority-owned foreign firms. As we know, high technology intensive firms have more capability to go in for reverse engineering of the products displayed by majority-owned foreign firms, which upgrades their technology and thereby increases productivity.

5. Concluding Observations

This chapter has examined the productivity effect of FDI spillovers in the Indian manufacturing industries. Departing from earlier studies, we have added the understanding of technology spillovers by the following ways. We have explained how the technology spillovers from FDI vary across industries by technology. Furthermore, the study also unravels how the degree of foreign ownership in affiliates mediates the technology spillovers in the host country.

Supporting the earlier studies carried out by Schoors van der Tol (2002), Javorcik (2004), and Blalock and Gertler (2005), we have also found the existence of spillovers from FDI via backward linkages. This implies that there may be some sort of technology transfers or knowledge assistance from foreign firms to suppliers of intermediates in upstream industries in host country. Besides this finding, we get that supplying firms in high technology industries gains more from the presence of foreign firms compared to same in low technology industries which is completely in line with our stated hypothesis. Domestic firms belonging to high technology industries benefit from technology spillovers from foreign firms in downstream industries since they can be able to meet the stringent quality and time schedule set by MNEs on the delivery of products.

Further, taking into account the ownership structure of foreign firms, it is seen that domestic firms in supplying industries benefit more from minority-owned foreign affiliates compared to majority-owned foreign affiliates. This also supports our hypothesis, i.e., vertical technology spillovers are more associated with affiliates with minority foreign ownership compared to affiliates with majority foreign ownership. This asserts that firms with minority foreign equity holding source or buy more domestically produced inputs compared to firms with majority foreign share-holdings.

Nevertheless, it is noticed that domestic firms in high technology industries can get more spillover benefits from majority-owned foreign firms in the host country. Two things such as majority foreign equity in affiliates and technology capability of firms in host developing country induces the transfer of technology form parent company to foreign affiliates in the host country. Therefore, domestic firms in high technology industries gain from technology spillovers from the presence of majority-owned firms.

From the above findings we can conclude that technology spillovers from FDI are conditional upon the characteristics of domestic as well as foreign firms. That means there is conditional technology spillover from FDI.

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APPENDIX

Table A. 1: Country wise break up for FDI Inflows received from 1991 to 2008

Country	1991-99	2000	2001	2002	2003	2004	2005	2006	2007	2008	2000-08
Mauritius	**30.64**	**35.39**	**47.80**	**45.23**	**27.64**	**31.77**	**51.04**	**47.33**	**53.68**	**50.00**	**48.01**
Singapore	3.05	4.97	1.02	1.40	1.80	1.97	7.69	6.08	9.80	13.18	8.77
U.S.A.	20.53	17.85	10.54	8.43	20.35	20.51	11.23	7.07	6.11	6.30	8.46
U.K.	5.48	2.79	8.18	10.55	9.22	4.53	5.20	16.67	3.31	5.85	7.26
Germany	5.78	3.68	3.81	4.12	3.87	5.01	2.00	2.98	2.38	2.78	2.98
Netherlands	5.34	5.42	6.57	4.64	12.42	15.68	2.86	4.78	4.69	3.58	5.03
Sub Total	**70.81**	**70.11**	**77.92**	**74.37**	**75.31**	**79.46**	**80.01**	**84.90**	**79.97**	**81.69**	**80.51**
Cyprus	0.24	0.02	0.20	0.25	0.16	0.11	1.66	0.55	3.70	4.87	2.80
France	2.37	3.39	3.79	3.29	1.76	3.64	0.70	0.83	0.88	1.71	1.69
Japan	7.30	9.78	6.35	12.30	4.64	3.67	4.04	1.11	4.66	1.42	3.44
Italy	2.27	5.78	1.02	0.14	0.66	0.81	0.78	0.55	0.20	1.24	0.95
U.A.E.	0.09	0.03	0.66	0.37	0.88	0.93	1.14	2.34	1.49	1.04	1.23
Switzerland	1.95	1.86	1.13	1.56	4.59	2.16	2.00	0.67	1.52	0.52	1.15
Korea (South)	5.14	0.76	0.13	1.13	1.21	0.84	1.60	0.63	0.47	0.52	0.65
Sweden	1.22	2.52	2.86	0.54	2.25	2.37	0.75	0.06	0.58	0.33	0.73
Sub Total	**20.58**	**24.14**	**16.14**	**19.58**	**16.14**	**14.54**	**12.67**	**6.73**	**13.49**	**11.65**	**12.63**
Grand Total	**91.39**	**94.25**	**94.07**	**93.95**	**91.45**	**94.00**	**92.68**	**91.63**	**93.46**	**93.33**	**93.15**

Note: Value in 1991-99 & 2000-08 are the percentage of cumulative FDI from 1991 to 1999 & 2000 to 2008 respectively.
Moreover values are expressed as percentage of total FDI received from various countries.
Here year refers to calendar year (January to December).

Source: Own compilation using data from SIA NEWSLETTER, various issues

A. Methodology for Industry x Industry Coefficient Matrix

For our studies we need to construct an *industry* × *industry* coefficient matrix using the Input-output transaction Table of India of year 2003-04, published by the Central Statistical Organization (CSO). The Input-output transaction Table consists of two matrices: absorption matrix (commodity-industry) and make matrix (industry-commodity). The former records the values of purchases of commodities by industries and the later records the value of commodities produced by industries. There are two basic assumptions, which combine both information in the make and absorption matrices to estimate a 'pure' table of *industry* × *industry* or *commodity* × *commodity* (Input-Output Tables and Analysis, 1973). They are generally referred to as the commodity technology and industry technology assumptions. The former assumes that a commodity has the same input structure in whichever industry it is produced. The industry technology assumption, on the other hand, assumes that all commodities produced by an industry are produced with same input structure and thus commodities will have different input structures depending on the industry in which they are produced.

The following gives briefly the methodology in mathematical terms for constructing 'pure' tables. The basic data available from industry input and output tabulations satisfy the following relationships:

Input relations: $$q_j = \sum_K X_{jk} + f_j \quad (1)$$

Output relations: $$q_j = \sum_i M_{ij} \quad (2)$$

$$g_i = \sum_j M_{ij} \quad (3)$$

Where

q_j = total output of j-th commodity group

g_i = total output (of all products and by-products) of the i-th industry group

f_j = final demand of the j-th commodity

X_{jk} = output of j-th commodity used as input in the k-th sector (industry group)

M_{ij} = output of j-th commodity produced by the i-th industry group

The above symbols without subscript refer to the corresponding vectors.

We can put all the mathematical expression of the input-output relationships explained above into a simplified accounting framework (see following Table).

	Commodity	**Industries**	**Final Demand**	**Total**
Commodity		X	f	q
Industries	M			g
Primary inputs		y'		
Total	q'	g'		

Note: y denotes the column vector of y_j and y_j denotes the value of primary inputs (factor incomes) in the j-th industry. The superscript prime (′) is used to denote the transpose.

Source: Central Statistical Organization (CSO) Report/Publication, India

Given the industry technology assumption, *industry* × *industry* coefficient matrix can be constructed using the above accounting data. Symbolically, it is defined as follow.

$$E = DB$$

Where **E** is the *industry* × *industry* coefficient matrix**, D** is the Market share matrix, the columns of which show proportions in which various industries produce the total output of a particular commodity. Symbolically, it is as $\mathbf{D} = \mathbf{M}\ (\mathbf{q})^{-1}$, and B is the *commodity* × *industry* coefficient matrix, defined as $\mathbf{B} = \mathbf{X}\ (\mathbf{g})^{-1}$.[23] For constructing *industry* × *industry* coefficient matrix we first have to aggregate the input-output transaction table for manufacturing sector to two-digit level. Then we construct the *industry* × *industry* coefficient matrix using the make and absorption matrices.

Table A. 2: Production Function Estimation for TFP, Dependent variable: Output

Independent Variables	Observed Coefficients	Bootstrap Standard Error
Capital	0.050***	0.015
Labour	0.263***	0.011
Raw materials	0.628***	0.015
Energy	0.089***	0.011

Note: (i) Production Function estimated using Levinson-Petrin (2003) Methodology
(ii) *** denotes significant at 1 per cent level

[23] Here q is the diagonal matrix with diagonal elements as the elements of vector q and similarly g is the diagonal matrix with diagonal elements as the elements of vector g.

Table A. 3: Classification of Manufacturing Industries by Technology

NIC Code	Low Technology Industries
15	Food Product and Beverages
16	Tobacco Products
17	Textiles
18	Wearing Apparel; Dressing and Dyeing of Fur
19	Tanning and Dressing of Leather; Manufacture of Luggage, Handbags Saddlery, Harness and Footwear
20	Wood and of Products of Wood and Cork, Except Furniture; Manufacture of Articles of Straw and Plating Materials
21	Paper and Paper Products
22	Publishing, Printing and Reproduction of Recorded Media
23	Coke, Refined Petroleum Products and Nuclear Fuel
25	Rubber and Plastic Products
26	Other Non-Metallic Mineral Products
27	Basic Metals
28	Fabricated Metal Products, Except Machinery and Equipments
36	Furniture; Manufacturing N.E.C.
	High Technology Industries
24	Chemicals and Chemical, Products
29	Machinery and Equipment N.E.C.
31	Electrical Machinery and Apparatus N.E.C.
32	Manufacture of Radio, Television and Communication Equipment and Apparatus
33	Medical, Precision and Optical Instruments, Watches and Clocks
34	Motor Vehicles Travelers and Semi-Trailers
35	Other Transport Equipment

Table A. 4: Summary Statistics

	Full Sample		Domestic Firm	
Variables	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**
Log TFP	3.936	0.308	3.923	0.304
RDS	0.026	0.137	0.004	0.086
XNS	0.132	0.226	0.153	0.240
TMS	0.023	0.066	0.011	0.055
BW	0.108	0.102	0.110	0.103
FW	0.045	0.037	0.043	0.037
HZ	0.205	0.133	0.199	0.131
HHI	0.062	0.072	0.073	0.073
MajBW	0.053	0.050	0.054	0.051
MinBW	0.052	0.054	0.053	0.055
MajFW	0.022	0.022	0.022	0.022
MinFW	0.028	0.150	0.026	0.144
MajHZ	0.127	0.109	0.122	0.107
MinHZ	0.077	0.074	0.076	0.072
Observations	11506		9840	

Source: Own calculations

Table A. 5: Correlation Matrix of Variables in Model 2

	Log TFP	MaJBW	MinBW	MajFW	MinFW	MajHZ	MinHZ	HHI	RDS	XNS	TMS
Log TFP	1										
MaJBW	0.09*	1									
MinBW	0.08*	0.86*	1								
MajFW	-0.02	-0.32*	-0.30*	1							
MinFW	0.03*	-0.09*	-0.07*	0.01	1						
MajHZ	0.07*	-0.05*	-0.02	-0.07*	-0.03*	1					
MinHZ	0.03*	-0.06*	-0.04*	-0.00	0.06*	0.01	1				
HHI	0.00	-0.23*	-0.14*	0.17*	0.02	-0.05*	0.30*	1			
RDS	0.00	-0.00	-0.00	-0.01	-0.00	0.01	-0.00	-0.01	1		
XNS	-0.01	0.01	-0.02	-0.01	-0.03*	0.01	-0.09*	-0.00	0.04*	1	
TMS	0.02	-0.04*	-0.04*	0.04*	0.00	-0.03*	-0.00	0.00	0.00	0.08*	1
Note: * stands for 1 per cent level of significance											

Source: Constructed using Data from PROWESS, CMIE

Table A. 6: Correlation Matrix of Variables in Model 1

	Log TFP	BW	FW	HZ	HHI	RDS	XNS	TMS
Log TFP	1							
BW	0.1141*	1						
FW	0.0810*	-0.2123*	1					
HZ	0.0771*	0.0002	0.2621*	1				
HHI	0.0079	-0.1953*	0.1143*	0.1238*	1			
RDS	0.0064	-0.0041	-0.0041	0.0103	-0.0104	1		
XNS	-0.0183	-0.0135	-0.0363*	-0.0437*	-0.0056	0.0456*	1	
TMS	0.0244	-0.0480*	0.0198	-0.0351	0.0006	0.0016	0.0834*	1
Note: * stands for 1 per cent level of significance								

Source: Constructed using Data from PROWESS, CMIE

Table A. 7: Industrial Classification

NIC CODE	Industry Classification	IOTT Sector No. (2003-04)
15	Food Product and Beverages	38-44
16	Tobacco Products	45
17	Textiles	46-51
18	Wearing Apparel; Dressing and Dyeing of Fur	52-54
19	Tanning and Dressing of Leather; Manufacture of Luggage, Handbags Saddlery, Harness and Footwear	59-60
20	Wood and of Products of Wood and Cork, Except Furniture; Manufacture of Articles of Straw and Plating Materials	56
21	Paper and Paper Products	57
22	Publishing, Printing and Reproduction of Recorded Media	58
23	Coke, Refined Petroleum Products and Nuclear Fuel	63-64
24	Chemicals and Chemical, Products	65-73
25	Rubber and Plastic Products	61-62
26	Other Non-Metallic Mineral Products	74-76
27	Basic Metals	77-80
28	Fabricated Metal Products, Except Machinery and Equipments	81-82
29	Machinery and Equipment N.E.C.	83-87
31	Electrical Machinery and Apparatus N.E.C.	88-91, 93
32	Manufacture of Radio, Television and Communication Equipment and Apparatus	92, 94
33	Medical, Precision and Optical Instruments, Watches and Clocks	101-102
34	Motor Vehicles Travelers and Semi-Trailers	97
35	Other Transport Equipment	95-96, 98-100, 104
36	Furniture; Manufacturing N.E.C.	55, 103, 105