Foreign Direct Investment and Innovation Activities in Indian Manufacturing Industries

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Sanjaya Kumar Malik*

[***Abstract***: *This paper revisits the technology effect of foreign direct investment (FDI) in Indian manufacturing sector. Estimating the equation representing the relationship between FDI and technological change in first difference as well as in longer time-differences through firm-level fixed effect estimator, the study shows technological improvements in domestic firms due to the presence of foreign firms within the same industry. However, the inter-industrial presence of FDI is not found to have improved the technological change in domestic firms in the manufacturing sector. Further controlling for the technology differences across industries, the horizontal nature of FDI is found to have improved the technological change in low-tech domestic firms, not in high-tech domestic firms in the manufacturing sector. The paper concludes that the feasibility of technology effect of FDI is conditional upon the nature of FDI and the industry characteristics in the host developing country.*]

Keywords: *FDI, Transnational enterprises, technology effect, manufacturing industries, fixed effect models.*

JEL Classification: *C23, F21, F23, L6*

I. Introduction

The policy-makers, particularly in developing countries, are continuously simplifying their internal administrative structures and offering several fiscal and financial incentives to transnational enterprises (TNEs) to attract foreign direct investment (FDI) (WIR, 2017 and 2018). Technology transfer or spillover from FDI is the foremost justification for these alluring investment incentives offered by host developing countries. Further, in this regard, some developing countries are modifying their incentive packages towards more innovation-intensive FDI—FDI in more technology-intensive industries.[1]

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[1] The Republic of Korea has redesigned its tax incentives for foreign companies engaged in high-tech businesses; and Thailand has devised a new Investment Promotion Act to offer more incentives for advanced technology, innovation activities and research and development (R&D) (WIR, 2018: 83). In the same spirit, Israel launched Innovation Visas, a new incentive programme, to attract innovative foreign entrepreneurs; to attract more innovation-intensive FDI, Turkey introduced an extensive support package for R&D and innovation related activities (WIR, 2017: 101).

TNEs produce and control most of world's technologies, and account for a sizable chunk of global business expenditures on research and development (R&D) efforts (Caves, 1982; UNCTAD, 2005). These technologies—because of their non-rival characteristics—tend to spill over in host countries and thus foster local innovation activities in these countries. These technology effects of FDI are classified into horizontal technology effects—i.e. technology spillovers from foreign firms to domestic firms in the same industry—and vertical technology effects—i.e. technology spillovers from foreign firms to domestic firms in upstream and downstream industries in the host country.[2] The empirical studies in host developing countries have not reached at any consensus with respect to the existence of horizontal technology spillovers from FDI. The early studies on firm-level panel analysis in developing countries undertaken by Haddad and Harrison (1993), Aitken and Harrison (1999) and Kinoshita (1999), among others, were not affirmative about the occurrence of technology spillovers from the horizontal presence of foreign firms in these countries. Nevertheless, the studies during the 2000s in developing countries, Kathuria (2002), Siddhartha and Lal (2004), Blalock and Gertler (2009), among others, established the existence of horizontal technology spillovers from FDI when they control for absorptive capacity of the firms in India. Similarly, Marin and Sasidharan (2010) reported a positive and significance technology spillovers from FDI in domestic manufacturing industries, and these spillovers are nevertheless dependent upon foreign firms that are oriented to technologically creative activities in India. In recent studies, Khachoo and Sharma (2016) and Khachoo, Sharma and Dhanora (2018) have reported unconditional technology spillovers from the horizontal presence of foreign firms in Indian manufacturing industries.

With respect to vertical technology effects of FDI, the studies in developing countries are unequivocal. As argued, foreign firms have the tendency to protect spillovers through demonstration effect and employment turnover, they are nevertheless incentivised to transfers technological assistances to their suppliers and users in upstream and downstream industries respectively in host developing countries and consequently help building their technological capability to produce or innovate (Javorcik, 2004; Blalock and Gertler, 2008). The empirical studies by Javorcik (2004) and Blalock and Gertler (2008) for Lithuania and Indonesia respectively confirms the occurrence of technology spillovers via backward linkages only and they do not find any significant horizontal technology spillovers from the presence of foreign firms in these countries. Some recent studies in developing countries also reaffirm the technology effect of foreign firms on domestic firms in upstream industries in India (Malik, 2015 and Khachoo *et al*., 2018).

Most of the aforementioned studies are based on panel of short time period, which is not enough to assess the potential spillover-effects of FDI in host developing countries, like India. In addition, the early firm-level analyses set up in the early phase of economic

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[2] Technology spillovers from FDI and technology effect of FDI are used interchangeable in this study.

liberalisation are too early to disentangle the technology effect of FDI in host developing countries. The present study employs a large firm-level data covering a longer time period of eighteen years spanning from 2000 to 2018 and revisits the technology effects of FDI in India's manufacturing industries.

Since the outset of 1990s, several internal as well as external reforms have been being undertaken in India to liberalise the economy and thus to make it a business friendly atmosphere to draw FDI. These reforms have led to substantial FDI inflows from US$ 97 million in 1990-91 to US$ 39 billion in 2017-18 (Reserve Bank of India, 2018). Of the FDI inflows over the last three decades, a large chunk (i.e. around 45 percent) has come to the manufacturing industries and in the manufacturing industries, the high-tech manufacturing industries has had a sizable proportion of FDI inflows. The substantial FDI inflow in the manufacturing industries and the high-tech manufacturing industries in particular is purported to affect the innovation and technological change in these industries in India. The focus of the paper is to examine the technology effect of FDI in the local high-tech manufacturing industries in India. It also deals with how the linkages from FDI—backward and forward linkages from FDI—affect technological change in these industries in India.

The remainder of the paper is organised as follows. The next section discusses the theoretical literature related to FDI spillovers in host countries. Section 3 presents empirical framework of the study that includes discussions on estimation strategy, data description and descriptive statistics. Empirical results on technology effects of FDI in Indian manufacturing industries are documented in section 4. The last section concludes the discussion of the study.

II. Theoretical underpinnings

II.1 Channels for Technology Effect of FDI

Technology effect of FDI occurs through the following channels. First, domestic firms may improve or upgrade their existing technologies or products, when they emulate advanced technologies and products displayed by foreign firms in the host country (Das, 1987). Second, when the employees trained in foreign firms leave them and join the domestic firms they can leak out the technologies, expertise and other tacit knowledge that they have accumulated while working with the foreign multinational firms (Fusfuri *et al*, 2001). These employment turnovers bring about technological gain to the domestic firms in the host country. Third, stiff competition owing to the presence foreign firms may induce domestic firms to utilise their existing resources judiciously or efficiently or to source new or advanced technologies to compete with the former, which may upgrade their innovation activities or technologies (Glass and Saggi, 2002).

The aforementioned channels is likely to upgrade the innovation activities of domestic firms due to the presence foreign firms in the same industry where both foreign

firms as well as domestic firms are located. As argued by the studies of host developing countries, this horizontal technology effect of FDI is not likely to occur because foreign firms tend to prevent technological leakages to domestic firms in the host country. Technology leakages from MNEs can be controlled through the following. Institution of stringent intellectual property rights (IPR) in host countries may restrict technological leakages from foreign firms to domestic firms; this is why TNEs are sensitive to the strength of IPR protection in host countries (Javorcik, 2004). In addition, the TNEs offer higher wages to prevent the employment turnover from foreign to domestic firms in the host countries, as argued by studies, for example, Aitken et al. (1996) states that foreign firms pay more wages relative to domestic firms, inducing a *brain drain* by luring the most capable managers away from domestic firms. These considerations have made researchers less optimistic about the occurrence of horizontal technology effect of FDI in host developing countries. However, some recent studies of host developing countries show a positive externality to domestic firms due to the presence of foreign firms in the identical industry in Indian manufacturing sector (Khachoo and Sharma, 2016; Khachoo, Sharma and Dhanora, 2018).

Apart from benefitting domestic firms in the identical industry, foreign firms are more likely to benefit domestic firms in upstream industries as well as in downstream industries in the host country. As discussed in the previous paragraph, foreign firms may prevent technology spillovers to domestic firms in the similar industry in which they are located, they are however incentivised to transfer technology to their suppliers as well as to their users in upstream and downstream industries respectively (Javorcik, 2004; Blalock and Gertler 2008). Foreign firms' presence in downstream industries may benefit innovation activities of domestic suppliers through the following ways. Firstly, foreign firms tend to transfer technologies or other tacit knowledge to the upstream suppliers to avail the better quality intermediate inputs that suits to their requirements. Secondly, the better product quality requirements and on-time delivery mode set by multinationals compel domestic suppliers to bring about improvements in their technologies and production management skills. Finally, increased demand for intermediate inputs because of the advent of multinationals enables the local suppliers to reap the advantages of scale economies. Similarly, forward technology effects of FDI comprise all the downstream relationship of foreign firms with its users in the host country. When upstream foreign firms supply better quality intermediates products to downstream users, they are likely to facilitate technological benefits to the domestic firms in the host countries (Blomstrom and Kokko, 1998). It is however possible that the technological backwardness of domestic firms may hinder technological leakage from foreign firms to domestic firms as the domestic users fail to decode the sophisticated technology embodied in products supplied by foreign firms. While summing up the above discussion, it can be hypothesised that foreign firms in downstream industries have more spillover potential compared to those in upstream as well as in the same industry.

II.2 Technology differences across Industries and Technology Effect of FDI

Technology effects of FDI never take place spontaneously in host developing countries. There are some country-specific factors (e.g. characteristics of firms and industries) in the host country that can mediate technology spillovers from foreign firms to domestic firms.[3] The technology content of firms varies across industries and results in varied absorptive capacities to absorb technology spillovers from foreign firms (Malik, 2015). Technological advantages of domestic firms in high-technology industries (or high-tech industries) enable them to decode the technologies or knowledge embodied in products displayed by foreign firms, hence they can emulate these products or technology more comfortably than those firms in low-technology industries (or low-tech industries). Further, technological differences across industries may influence vertical technology effect of FDI in the host country. Upstream suppliers in high-tech industries are likely to receive more technological gains from FDI than those in low-tech industries in the host country (Malik, 2015). The suppliers from high-tech industries are capable of meeting the stringent quality requirements and delivery schedules of foreign firms and thus can become the preferred partners to benefit from technology spillovers. In addition, the downstream users in high-tech industries are likely to benefit more from FDI as they could decode the embodied knowledge in products supplied by upstream foreign firms in the host country. From the above discussion, I can therefore hypothesise that technology-difference across industries influence technology effects of FDI in Indian manufacturing industries.

II.3 Nature of FDI and Technology Effect of FDI

Technology effects of FDI are not merely dependent upon the characteristics of host country but also conditional upon the characteristics of FDI. Studies on FDI spillovers assume that all FDI are homogenous and equally important for host countries, and an increase in FDI irrespective of quality leads to technology spillovers in host countries, they nevertheless fail to account for how the spillovers occurs with the presence of heterogeneous FDI. Different quality attributed to FDI has different effects on the local firms in host countries (Pradhan, 2006; Smeets, 2008). The heterogeneous nature of FDI such as horizontal, vertical, export-platform, and so on may influence the technology effect of FDI in the host country.

Horizontal FDI is always market seeking in nature and it has less spillover potential compared to other forms of FDI.[4] In the short run, it may drive away domestic

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[3] The absence or presence of these factors may certainly affect the observed technology effect of FDI and the study, which fails to consider these factors, are likely to find biased estimates of technology effect of FDI (Smeets, 2008).

[4] Horizontal FDI is the foreign investment undertaken by a TNE in different countries. The moto of this kind of FDI is to conduct the similar business operations of the TNE in other countries. When Coco-cola (an American Soft drink MNE) starts a subsidiary outside USA, it is called horizontal FDI.

investment through its firm-specific advantage; nonetheless, it intensifies competition that brings about spillovers in the long run. Vertical FDI is the efficiency- or resource-seeking in nature that tends to generate spillovers in host countries through its backward and forward linkages.[5] Export-platform FDI is motivated by a desire to find an efficient location from where the output or products could be exported easily and profitably to other countries. With the desire to utilise the locational advantages (e.g. cheap labour, raw materials, other intermediate inputs and so on) offered by the host country, the export-oriented FDI has the tendency to develop strong links with local suppliers and users in upstream and downstream industries and thereby enhancing the chances of knowledge diffusion and spillovers in the host country (Pradhan, 2006). Given the nature of FDI, it can be hypothesised that the technological spillovers from vertical FDI are more likely compared to those from horizontal FDI in the host country.

III. Empirical Framework

III.1 Estimation Strategy

To investigate the technology effect of FDI in domestic manufacturing firms in India, a variable measuring technological change or innovation activities is regressed upon variables measuring foreign presence in manufacturing industries along with other firm- and industry-specific variables. Broadly, there are three methods to measuring technological change or innovation of a firm—the input method (e.g. R&D expenditures), output method (e.g. patent grants) and total factor productivity (TPF) change. This study however applies the third approach to measure innovations or technological change of firms in manufacturing industries. The regression equation that captures the relationship between FDI and technological change is presented below.

$$lnTFP_{ijt} = \delta_0 + \delta_1 lnHZ_{jt} + \delta_2 lnBW_{jt} + \delta_3 lnFW_{jt} + \delta_4 lnHHI_{jt} + \delta_5 lnSize_{ijt} + \delta_6 lnAge_{ijt} + \lambda_i + \mu_j + \nu_t + \varepsilon_{ijt} \text{ ---------- } (1)$$

where, i, j, and t denote firm, industry and time respectively; and *lnTFP, lnHZ, lnBW, lnFW, lnHHI, lnSize, lnAge* are logarithmic transformation of TFP, horizontal-FDI, backward-FDI, forward-FDI, Herfindahl-index, size, age, respectively; and ϵ is the measurement error, respectively (see Section 3.2 for detail of these variables). Besides, λ_i, μ_j and ν_t are firm-fixed effect, industry-fixed effect and time-fixed effect, respectively (the so-called unobservable heterogeneities).

Several econometric problems need to be taken care while estimating technology effect of FDI. There are hosts of time-variant and time-invariant unobservable variables

[5] Vertical FDI occurs when the transnational fragments the production process internationally, and locate each stage or part of production in the country where it can be manufactured at the least cost.

(viz. time-fixed effect, firm-specific effect, industry-fixed effect and region-fixed effect). It is not plausible on the part of the econometrician to experience or know these unobservable variables. The time-variant unobservable can be captured through the inclusion of time-dummies, nevertheless the presence of time-invariant effects render the series non-stationary in nature. Non-stationary data-series thus invalidate classical econometric assumptions. In short-panels, the question of non-stationarity or unit root is less problematic, the longer time-dimensions in the present panel accentuates presence of unit-root problem.

Following Javorcik (2004) and Haskel, Pereira and Slaughter (2007), the panel has been time-differenced to get rid of the unit-root problem. Time differencing drives away the time-invariant fixed effects such as firm, industry, region, and so on. Accordingly, the Equation (1) becomes:

$$\Delta lnTFP_{ijt} = \delta_1 \Delta lnHZ_{jt} + \delta_2 \Delta lnBW_{jt} + \delta_3 \Delta lnFW_{jt} + \delta_4 \Delta lnHHI_{jt} + \delta_5 \Delta lnSize_{ijt} + \delta_6 \Delta lnAge_{ijt} + \nu_t + \epsilon_{ijt} \text{ ---------- } (2)$$

The above model is estimated in first, second, third, fourth, fifth and sixth differences; and for robustness check, the model is estimated at higher-order time-differences (i.e. seventh to tenth). As argued by Javorcik (2004), the investigation of longer differences provide relatively more weightage to more persistent changes in the variables of interest and thus reduces the effect of noise. The disadvantage of longer time differences is that it leads to reduction in sample size, since the panel of the study has a big sample, the study can go for longer time differences for the persistent results of the estimated technology effect of FDI.

The study employs the fixed effect estimator to estimate the Eq. (2), since the Hausman test on preliminary regressions has apparently rejected the random effect estimation in favour of fixed effect estimation. In fixed effect of estimation, heteroscedasticity is a potential problem, as found in the preliminary regression of the study; and the presence of heteroscedasticity leads to inefficient estimate of the model. To address this problem, the study applies the cluster sampling method (Wooldridge, 2003) which is the generalisation of robust co-variance matrices, developed by White (1990). The robust variance matrix estimator is robust in the presence of heteroscedasticity and serial correlation in the model.

III.2 Data Description

The study employs panel data on manufacturing firms extracted from the Centre for Monitoring Indian Economy's (CMIE) firm-level database PROWESSIQ.[6] The database

[6] The rational for selecting manufacturing industries is that the manufacturing industries has attracted around 40 percent of the total consolidated FDI inflows in India during the study period (Department of Industrial Policy and Promotion, 2018).

provide information at firm level (or five-digit level) in which firms are categorised into various industries according to the national industrial classification (NIC) 2008. The panel is a balanced panel of 1179 firms over a period of 18 years spanning from 2000-2001 to 2017-2018. The sample of the study consists of 21,222 observations which have been arrived after filtering out a few observations having zero, negative and missing values for sales, gross fixed asset (GFA), wages and salaries, raw material and energy.[7] Since the objective of the study is to estimate the technology effect of foreign firms on domestic firms only, a sample of 17,010 observations on 945 domestic firms is selected for the analysis. In addition, after the first differencing of the model, the total number of domestic firms has reduced to 932, because some variables (say *lnAge*) have zero values (log transformation of 'one' becomes 'zero').

The other datasets employed in the analysis are the industry-level database from Annual Survey of Industries (ASI) for the calculation of labour variables; the World Input-Output Database (WIOD) for Input-Output Tables; the Office of the Economic Advisor for price indices.

All the variables specified in Equation (1) are in logarithmic form. The specific detail on the construction of each variables is as follows:

Total Factor Productivity (TFP)

TFP is the residual estimated at firm-level production function. There are plethora of estimators to estimate production function, nonetheless, the semi-parametric method of Levinsohn and Petrin (2003) is applied here to estimate the production function and TFP. Before understanding the estimation of TFP, it is wise to understand the problems akin to the estimation of production function. As well-acknowledged, the ordinary least squares (OLS) estimation of production function results in inconsistent and biased estimates of explanatory variables. There are likely to be a host of firm, industry, time, and region-specific effects; and these effects are unobservable to the econometrician but are unknown to the firm. These unobservable effects might influence the usage of production inputs, making them endogenously determined. The OLS technique assumes production inputs are orthogonal to the omitted unobservable variables, hence it fails to correct the endogeneity issue, giving inconsistent and biased estimates of the production function. Marschak and Andrews (1944) and Griliches and Mairesse (1995), *inter alia*, explored the potential correlation between input levels and firm-specific productivity shocks while estimating the production function. The Levinsohn-Petrin approach suggests the usage of intermediate input as a proxy to control the correlation between input levels and unobserved firm-specific productivity shocks in the estimation of the production function.[8]

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[7] Since the database does not provide information related to FDI prior to 2000-2001, the analysis is limited to the period from 2000-2001 to 2017-18.

[8] The Levinsohn-Petrin approach estimates the following Cobb-Douglas production function:

$$lnY_{ijt} = \beta_0 + \beta_k lnK_{ijt} + \beta_l lnL_{ijt} + \beta_m lnM_{ijt} + \beta_e lnE_{ijt} + \omega_{ijt} + \eta_{ijt}$$

This study employs raw materials to take care the endogeneity issue while estimating the production function.

Horizontal FDI (HZ)

It measures the presence of foreign firms in the same industry in which both domestic firms and foreign firms are located. It is defined as the share of sales of foreign firms in the total sales of the industry.[9] Symbolically, it is as follows:

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

where, Y_{it} is the sale of *i-th* firm in year *t*, Y_{it}^{f} is the sales of foreign firms *i* in the same year, n denotes total number of firms in an industry, comprising both foreign and domestic firms, and m is the number of foreign firms in the industry. This variable is expected to have positive effect on innovation activities of firms in India; that is increase in share of foreign firms in the intra-industry will lead to increase in innovation activities in domestic firms in the host country.

Moreover, in order to take into account how the vertical linkages (backward and forward linkages) of foreign firms are affecting the innovation activities of domestic firms, variables measuring vertical linkages of foreign firms (backward FDI and forward FDI) are included in the model. The calculation of these variables is based on the formula developed by Javorcik (2004) and Blalock & Gertler (2008), and this is the widely used method to calculate backward and forward linkages from FDI.

Backward FDI (BW)

BW is the share of output of an upstream industry supplied to foreign firms in downstream industries in the host country. Technology spillovers (or effects) from foreign firms in downstream industries *k* to their domestic supplying industries *j* are calculated as follows:

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

where, α_{jkt} is the proportion of industry *j*'s output supplied to industry *k* during the time period *t*, which is taken from the World input-output tables of India, provided by WIOD.[10] In this formula, the inputs supplied within the industry are not included, since

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where, Y, K, L, M, E, ω and η refers to output, capital stock, labour, raw material, energy, productivity, and measurement error in output, respectively to obtain the TFP. See Appendix for the detail discussion of output and input variables.

[9] Firm with foreign equity at least 10 percent of total equity are defined as foreign firms or foreign affiliates.

[10] Input-output table of 56 sectors classified according to the International Standard Industrial Classification revision 4 (ISIC Rev. 4) for 43 countries are compiled and provided by WIOD, and the tables are in tune with the 2008 version of the System of National Accounts (SNA).

the horizontal FDI controls this effect. This variable is assumed to have positive effect on technological changes in domestic firms, i.e. the higher presence of foreign firms in downstream industries bring about more backward linkages to domestic firms in the upstream industries in the host country.

Forward FDI (FW)

It is the forward linkages from foreign firms to domestic firms in downstream industries, and the share of an industry's intermediate consumption supplied by foreign-owned firms captures the forward linkages from FDI. While measuring the share of foreign firms' output in upstream industries, the goods produced by firms for exports are excluded, since only intermediates sold in the domestic markets are relevant for the construction of forward FDI. The approximation for forward linkages of FDI is as:

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

where σ_{wjt} is the share of industry *j's* intermediate inputs that it purchases from industry *w* during the year *t;* X_{it} is the export of firm *i* in year *t, and* X_{it}^{f} *is* the export of foreign firms *i* in the same year. The second term on the right side of the equation computes the share of output of foreign firms in upstream industries that is sold in domestic market in the host country only. For the same reason as before, inputs usage within the industry are not included. A rise in share of foreign firms' output in upstream industry increases the value of the FW.

Herfindahl Index (HHI)

The Schumpeterian proposition is that a concentrated market structure (i.e. oligopolistic market structure) is conducive to innovation activities because a competitive firm will hardly have surplus to devote on risky activity such as R&D. Kumar (1987) in the study of Indian industries revealed that market concentration had adverse effect on innovation activities. The Schumpeterian expectation of positive effect of market concentration on innovation had been proved wrong by Subramanian (1971), Mansfield (1979), Acs and Audretsch (1987, 1988), among many others. In a recent study by Sasidharan and Kathuria (2011) found that market concentration had negative and insignificant effect on R&D activities of firms; nonetheless, the market concentration boosts the chance of R&D undertaken by domestic firms in India. Here, in this study, the Herfindahl index is employed to measure market concentration in an industry. It is computed as the sum of the squared market shares of all firms in the industry. Symbolically, it is as follows:

$$HHI_{jt} = \sum_{i} \left(\frac{S_{it}}{\sum S_{it}} \right)^{2}$$

where, S_{it} is the sale of firm *i in* t period; j denotes industry; and $S_{it}/\sum S_{it}$ is the relative size (i.e. market share) of firm *i* in year *t.*

Firm Size (Size)

Firm's size, as argued by Schumpeter (1942), plays a crucial role in its technological efforts (i.e. R&D efforts) and innovation. He states that compared to smaller firms, large firms are more innovative because of their scale economies, resources and market share or market power that help them hedge risk and uncertainty of undertaking variety of R&D (Sasidharan and Kathuria 2011). Empirical studies however examining the effect firm's size on R&D have shown a variety of pattern, some have found small and insignificant relationship or some other have found an U-shaped relationship between the two (Cohen, Levin and Mowery, 1987; Acs and Audretsch, 1988; Siddharthan, 1988; and Kumar and Agarwal, 2005). This paper follows Sasidharan and Kathuria (2011) to measure size of the firm as the firm's share in the median sales in the industry.

Age

As shown by studies, aging has two seemingly contradictory results for firm behaviour, especially with respect to innovation. First, as firm grows older it tends to accumulate knowledge and becomes innovative, which implies a positive relationship between age of the firm and its innovative activities (Sorensen and Stuart, 2000). Second one, the established practices and routine of older firms not only acts as resistance to the integration to the major external advances, but also generate inertia to innovations or technological changes (Freel, 2003) which indicates an inverse relationship between aging and innovation of the firms.

III.3 Descriptive Statistics

Table 1 reports the summary statistics of the dependent variable and independent variables. Mean value comparison of TFP between foreign firms and domestic firms is captured by Table 2, which shows that foreign firms are more productive compared to the domestic firms as the mean differences between foreign firms and domestic firms are positive and statistically significant for most of the years during the study period.[11] As argued in the literature, the foreign firms (i.e. TNEs) produce and control most of world technological innovation, they are therefore highly productive in comparison to other local firms in the host country. The additional summary statistics for dependent variables and variables measuring foreign presence or FDI presence in the host country India are presented in Tables (3 and 4).

There is significant variation across industries and time in the variables measuring foreign presence (Table 3 and 4). For example, the average value of HZ ranges from 55 percent in motor vehicle, trailers and semi-trailers and 42 percent in chemical and chemical products to around 4 percent in coke and refined petroleum products (see Table 3).[12]

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[11] Around 20 percent of the total firms of the study are foreign firms or foreign affiliates.

[12] The leather and related products and wood and wood products do not have any foreign presence in them

Table 1: Summary Statistics

Variables	*Observations*	*Mean*	*Std. Dev.*
Ln(TFP)	17010	3.174	0.388
HZ	17010	0.263	0.154
BW	17010	0.069	0.030
FW	17010	0.084	0.044
HHI	17010	0.084	0.076
Size	17010	4.965	15.145
Age	17010	33	20

Source: Author's calculation

Table 2: Mean Value Comparison of *lnTFP* between Foreign Firms and Domestic Firms

Year	*Foreign firms*	*Domestic firms*	*Mean Difference*
2000-2001	3.074 (0.026)	3.064 (0.015)	0.010 (0.033)
2001-2002	3.128 (0.024)	3.103 (0.012)	0.025 (0.027)
2002-2003	3.143 (0.025)	3.106 (0.012)	0.037* (0.028)
2003-2004	3.168 (0.025)	3.125 (0.013)	0.043* (0.029)
2004-2005	3.170 (0.025)	3.132 (0.013)	0.038* (0.029)
2005-2006	3.184 (0.025)	3.145 (0.012)	0.039** (0.027)
2006-2007	3.216 (0.029)	3.150 (0.013)	0.066** (0.029)
2007-2008	3.226 (0.027)	3.162 (0.012)	0.064** (0.028)
2008-2009	3.209 (0.025)	3.174 (0.012)	0.035 (0.028)
2009-2010	3.211 (0.024)	3.167 (0.013)	0.044* (0.028)
2010-2011	3.244 (0.025)	3.190 (0.013)	0.054** (0.029)
2011-2012	3.234 (0.023)	3.206 (0.012)	0.028 (0.027)
2012-2013	3.275 (0.023)	3.222 (0.012)	0.053** (0.026)
2013-2014	3.283 (0.023)	3.228 (0.012)	0.055** (0.026)
2014-2015	3.290 (0.023)	3.231 (0.012)	0.059** (0.026)
2015-2016	3.323 (0.024)	3.263 (0.012)	0.059** (0.027)
2016-2017	3.329 (0.025)	3.266 (0.012)	0.062** (0.028)
2017-2018	3.264 (0.031)	3.199 (0.012)	0.064** (0.029)
All	3.221 (0.006)	3.174 (0.003)	0.046*** (0.007)

Notes: Mean difference= Mean (*lnTFP* of foreign firms) – Mean (*lnTFP* of domestic firms); values in parentheses are Standard error; ***, ** and * are 1 percent, 5 percent and 10 percent level of significance respectively.

Table 3: Additional Summary Statistics for FDI Variables (value in percentage)

Industry (Two-digit)	*HZ*		*BW*		*FW*	
	Mean	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*
Food products	17.90	1.19	10.43	1.23	12.13	1.37
Beverages	53.75	4.39	5.40	0.53	6.30	0.52
Tobacco products	12.10	1.35	11.25	1.35	13.23	1.51
Textiles	11.99	1.11	4.42	1.28	8.84	1.54
Wearing apparel	16.72	7.25	3.54	0.43	7.14	0.33
Leather and related products	0.00	0.00	6.78	1.19	11.87	1.46
Wood and wood products	0.00	0.00	7.79	0.49	2.92	0.17
Paper and paper products	15.15	1.82	11.12	0.50	5.55	0.25
Coke and refined petroleum products	3.92	0.70	3.84	0.62	1.28	0.78
Chemical and chemical products	41.95	2.03	6.85	0.46	5.30	0.56
Pharmaceuticals	27.95	2.80	3.42	0.24	17.90	0.87
Rubber and plastics products	19.39	1.68	8.56	0.62	15.91	0.85
Other non-metallic mineral products	37.35	3.72	1.45	0.17	5.75	0.69
Basic metals	11.71	1.57	9.71	1.35	2.24	0.51
Fabricated metal products	9.02	3.83	10.09	0.83	7.94	0.37
Computer, electronic and optical products	15.90	2.30	4.35	0.37	9.66	0.79
Electrical equipment	46.71	1.52	7.55	0.99	7.71	0.42
Machinery and equipment n.e.c.	42.73	2.52	8.12	1.25	6.82	0.61
Motor vehicles, trailers and semi-trailers	54.90	4.70	2.06	0.36	9.16	0.45
Other transport equipment	31.06	6.12	2.73	0.59	7.84	1.48

Table 4: Additional Summary Statistics for FDI Variables (value in percentage)

Year	*HZ*		*BW*		*FW*	
	Mean	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*
2001-02	24.88	17.31	6.98	3.15	8.95	4.66
2001-02	24.40	17.38	6.47	3.05	8.43	4.21
2002-03	24.79	17.43	6.87	3.12	8.91	4.48
2003-04	24.00	16.94	6.74	3.03	8.58	4.28
2004-05	23.66	16.70	6.56	2.97	8.21	4.11
2005-06	23.53	16.77	6.20	2.82	8.16	4.21
2006-07	22.89	16.37	6.24	2.87	7.93	4.24
2007-08	22.60	16.50	6.15	2.97	8.09	4.32
2008-09	22.69	17.45	6.46	3.25	8.41	4.64
2009-10	22.80	17.42	6.44	3.28	8.22	4.32
2010-11	22.83	17.34	6.82	3.49	8.44	4.42
2011-12	22.50	17.50	6.76	3.75	8.68	4.76
2012-13	22.89	18.15	6.23	3.31	7.88	4.36
2013-14	23.16	18.24	6.21	3.29	7.95	4.30
2014-15	23.71	19.04	6.40	3.47	8.10	4.41
2015-16	23.65	18.63	6.31	3.37	8.10	4.42
2016-17	23.83	18.94	6.30	3.45	8.05	4.33
2017-18	24.40	19.18	6.35	3.53	7.84	4.23

Table 4 documents the annual average of foreign presence variables during the study period. It shows that the average horizontal presence of foreign firms ranges from 22 percent to around 25 percent during the period of study. Compared to horizontal presence, the foreign firms have smaller vertical presence in the local manufacturing industries in India, which is apparent from the smaller average value of BW and FW during the period of analysis. In addition, the average value of BW and FW are more or less stagnant around 6 percent and 8 percent respectively during the period under consideration. From the mean value of HZ, BW and FW, it is clear that FDI inflows in Indian manufacturing industries is horizontal in nature (see Table 1 and 4).

IV. Empirical Results

The technology effect of FDI on the domestic manufacturing industries has been estimated in Eq. (2). The equation has been estimated at first difference to sixth difference and the estimated results are reported in Table 5. Further, to check how the technology-content of domestic firms mediate the technology effect of FDI, the sub-sample of domestic firms has been divided into low-technology intensive firms (low-tech firms) and high-technology intensive firms (high-tech firms). The estimated results of how technology mediates technology effect on domestic firms are reported in Table 6 and 7. In what follows, we discuss the estimated results on technology effect of FDI in manufacturing industries in India.

IV.1 Horizontal and Vertical Technology Effect of FDI

Column (2) of Table 5 reports the estimation of Eq. (2) based on a full sample of domestic firms only as the objective of the study is to see the technology effect of foreign firms on domestic firms in India. The estimate of the coefficient of *lnHZ* is positive and significant at conventional level of significance, which indicates that one percent growth in share output of foreign firms brings about 5 percent growth of TFP in domestic firms in the same industry. The coefficient of *lnHZ* is positive and statistically significant across all the regressions (from first difference to sixth difference regression). This implies that the presence of foreign firms in the same industry improves technological changes or innovations in domestic firms in the manufacturing industries. When foreign firms display advanced products in host countries, the risk and uncertainty akin to these products go away, which in effect help domestic firms upgrade their innovation activities, and thus their existing products. This finding corroborates with the finding of Khachoo *et al.* (2018). The estimated coefficient of *lnBW* is not statistically significant across any of the estimated regression model, as shown in Table 5, which tells us that the presence of foreign firms in downstream industries does not influence the innovation activities of domestic firms in manufacturing industries. Likewise, the other vertical FDI variable, i.e. *lnFW* is not seen to have considerable effect on innovation activities of domestic firms, since the estimated coefficient of *lnFW* is not significant in all the estimated regression models, especially in longer differenced equations or models. Therefore, the presence of foreign firms in upstream industries does not bring about

technological change in domestic firms as the significance of estimated coefficient of *lnFW* is not consistent across all the regression models.

As for the other explanatory variables, the coefficient on *lnHHI* is positive and statistically significant, indicting positive relationship between the industrial concentration and firm-level productivity in manufacturing industries and the result is significant statistically in all the specification in Table 5. This finding implies that a concentrated market is conducive for innovation activities in manufacturing industries in India and this goes in line with the Schumpeterian proposition, i.e. a competitive market is hostile to innovation activities because a competitive firms hardly get surplus for risky R&D efforts. Similarly, size of the firm has positive relationship of the productivity of the firms, which is statistically significant in all the estimated regressions. This indicates that large firm size is conducive for innovation activities in manufacturing activities. This finding again goes along with the Schumpeterian proposition and a study by Sasidharan and Kathuria (2011) reported the similar result as well. However, the experience of the firms (captured by age) is not turned out to be statistically significant across all the specification, indicating the experienced firms or older firms do not seem to have any effect of technological change in the local manufacturing firms in India.

Table 5: Firm-level fixed effect estimation of technology effect of FDI, dependent variable: ln TFP and time period 2000-2001 to 2017-2018

Explanatory variables	*First Difference*	*Second Difference*	*Third Difference*	*Fourth Difference*	*Fifth Difference*	*Sixth Difference*
lnHZ	0.052* (0.020)	0.132*** (0.027)	0.170*** (0.031)	0.198*** (0.035)	0.221*** (0.038)	0.238*** (0.042)
lnBW	-0.020 (0.024)	0.018 (0.033)	0.038 (0.042)	0.035 (0.049)	0.021 (0.053)	0.006 (0.058)
lnFW	0.044** (0.011)	0.065** (0.024)	0.068** (0.025)	0.065* (0.029)	0.054 (0.033)	0.0456 (0.036)
lnHHI	0.059*** (0.014)	0.118*** (0.019)	0.152*** (0.023)	0.165*** (0.027)	0.169*** (0.030)	0.172*** (0.032)
lnSize	0.222*** (0.018)	0.239*** (0.021)	0.236*** (0.023)	0.234*** (0.024)	0.233*** (0.024)	0.233*** (0.026)
lnAge	0.027 (0.075)	-0.003 (0.224)	1.808 (1.27)	7.529 (4.264)	23.37* (11.55)	44.10* (21.93)
Time-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15,838	14,906	13,974	13,042	12,110	11,178
Number of firms	932	932	932	932	932	932
R-squared	0.114	0.118	0.116	0.116	0.117	0.118
F-statistic	14.68***	17.22***	17.16***	14.18***	13.07***	11.74***

Note: Robust Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

From the aforementioned discussion, it is apparent that presence of foreign firms in the identical industry in which domestic firms also exist improves the innovation activities of domestic firms in India. As argued in the literature that when FDI in the host country is more of horizontal in nature, not in vertical in nature, it will bring about horizontal technology spillovers in the host country. FDI inflows in the local manufacturing industries are less vertically linked with domestic firms, but more horizontally spread in the industries. The horizontal nature of FDI therefore explains the technology spillovers from the presence of foreign firms in the same industry in India.

IV.2 Technology differences across Industries and Technology Effect of FDI

To evaluate the influences of characteristics of domestic firms in terms of their technology content, the full sample of domestic firms are classified into two sub-samples—low-tech firms and high-tech firms, and estimated results with respect these sub-samples are documented in Table 6 and Table 7, respectively. Both the tables report the estimates the regressions in first difference as well as in longer time differences (second to sixth differences). As apparent from Table 6, the results of regression in first difference as well as in longer time difference assert positive and significant technological gains to low-tech firms because of the horizontal presence of foreign firms in manufacturing industries. The low-tech domestic firms, as shown in Table 6, are benefited from the intra-industrial presence of foreign firms, as they can emulate the technologies or products displayed by foreign firms in the domestic manufacturing industries. In contrast, the sub-sample of low-tech firms do not show any technological effect from the presence of foreign firms in downstream and upstream industries, as the coefficients on lnBW as well as on lnFW are not significant across all the estimated regressions. This indicates that the low-tech domestic firms are not benefited in terms of technology transfers or leakages from the inter-industrial presence of foreign firms.

Table 7 documents the estimates of technology effects of FDI in high-tech firms. As is evident, high-tech domestic firms do not benefit from the presence of foreign firms in the same industry, as the coefficients on *lnHZ* appear to be insignificant in half of the regressions. Similarly, the presence of presence of foreign firms in downstream and upstream industries do not bring about technological spillovers to domestic firms in high-tech manufacturing industries, which is apparent from the statistically insignificant coefficients of lnBW and lnFW across all the regressions. The absence of horizontal technology effect of FDI in high-tech firms indicates that the high-tech foreign firms (or TNEs) could protect the technological leakages to domestic firms in India, and this is possible through the introduction of strong IPRs in India. For instance, the introduction of drug product patent in India in 01 January 2005 has almost done away with the emulation process of domestic firms in pharmaceutical industry.[13] Moreover, the higher technological

[13] In 1 January 2005, India introduced the drug product patent to comply with requirements under the agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) of the World Trade Organisation (WTO).

sophistication of products displayed by foreign firms hinders the process of technological emulation by domestic firms in high-tech industries.

Table 6: Fixed estimation of technology effect of FDI in low-tech manufacturing firms; dependent variable: lnTFP and time period 2000-2001 to 2017-2018

Explanatory variables	*First Difference*	*Second Difference*	*Third Difference*	*Fourth Difference*	*Fifth Difference*	*Sixth Difference*
lnHZ	0.050*	0.106***	0.139***	0.165***	0.197***	0.232***
	(0.024)	(0.031)	(0.034)	(0.038)	(0.042)	(0.046)
lnBW	0.020	0.0826*	0.144**	0.179*	0.169*	0.140
	(0.030)	(0.042)	(0.055)	(0.069)	(0.081)	(0.089)
lnFW	0.024	0.046	0.043	0.035	0.031	0.032
	(0.022)	(0.027)	(0.033)	(0.039)	(0.045)	(0.050)
lnHHI	0.065***	0.128***	0.170***	0.190***	0.202***	0.214***
	(0.017)	(0.021)	(0.026)	(0.032)	(0.033)	(0.035)
lnSize	0.210***	0.236***	0.237***	0.234***	0.231***	0.227***
	(0.024)	(0.026)	(0.030)	(0.033)	(0.036)	(0.038)
lnAge	0.050	-0.593**	0.078	5.882	23.26	44.59
	(0.132)	(0.212)	(0.861)	(5.936)	(17.25)	(31.06)
Time-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,364	8,813	8,262	7711	7160	6609
Number of firms	551	551	551	551	551	551
R-squared	0.097	0.108	0.108	0.107	0.105	0.101
F-statistic	10.42***	13.36***	14.04***	12.28***	11.41***	10.73***

Note: Robust Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7: Fixed estimation of technology effect of FDI in high-tech manufacturing firms; dependent variable: lnTFP and time period 2000-2001 to 2017-2018

Explanatory variables	*First Difference*	*Second Difference*	*Third Difference*	*Fourth Difference*	*Fifth Difference*	*Sixth Difference*
lnHZ	0.061	0.152*	0.191*	0.211*	0.215	0.193
	(0.051)	(0.070)	(0.089)	(0.105)	(0.119)	(0.129)
lnBW	-0.089	-0.137	-0.154	-0.163	-0.159	-0.152
	(0.053)	(0.075)	(0.083)	(0.086)	(0.087)	(0.088)
lnFW	0.045	0.061	0.063	0.048	0.025	0.004
	(0.046)	(0.057)	(0.063)	(0.071)	(0.077)	(0.082)
lnHHI	0.013	-0.005	-0.016	-0.031	-0.047	-0.053
	(0.046)	(0.058)	(0.056)	(0.053)	(0.063)	(0.069)

Explanatory variables	*First Difference*	*Second Difference*	*Third Difference*	*Fourth Difference*	*Fifth Difference*	*Sixth Difference*
lnSize	0.243***	0.248***	0.241***	0.239***	0.240***	0.243***
	(0.029)	(0.034)	(0.036)	(0.035)	(0.034)	(0.035)
lnAge	-0.003	0.527*	3.237	8.647	22.62	41.43
	(0.069)	(0.214)	(2.031)	(5.949)	(15.28)	(29.59)
Time-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,474	6,093	5,712	5331	4950	4569
Number of firms	381	381	381	381	381	381
R-squared	0.150	0.140	0.137	0.141	0.148	0.156
F-statistic	11.12***	9.34***	7.87***	6.67***	6.80***	6.78***

Note: Robust Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

From the above estimations, it is understood that the technology effect of FDI is not spontaneous; the technological variations across industries tend to influence the technological effect of FDI in the domestic firms in India. An increase in share of output of foreign firms in high-tech industries do not facilitate technological transfers to high-tech domestic firms, because FDI in high-tech industries tends to protect or restrict transfers or leakages of intangible assets to domestic firms in high-tech industries. On the contrary, the FDI in low-tech firms do not have the tendency to protect their intangible assets, as a result they bring about technological gains to domestic firms in low-tech manufacturing industries.

IV.3 Robustness Check

The estimated results show that the presence of foreign firms in the same industry has positive and statistically significant effect on innovation activities in domestic manufacturing firms in India. Moreover, after controlling the technology content of domestic manufacturing firms, we have only found the horizontal technology spillovers of FDI in domestic firms in low-tech manufacturing industries, not in high-tech manufacturing industries. To check for robustness of the estimated result, the higher order differencing of the Equation (2) is adopted. The estimated results of the equation at higher order difference are as follows:

Table 8 reports the horizontal technology effect of FDI both in the full sample of domestic firms. This confirms that the presence of foreign firms in the same industries benefits domestic firms in manufacturing industries in India. This finding is in line of the findings obtained in Table 5. Table 9 and 10 report the robustness check for how the technology-content of domestic firms influences the technology effect of foreign firms in the domestic firms in the manufacturing industries. Here also, there is only horizontal technology effect of FDI experienced by the low-tech domestic firms, not the high-tech

domestic firms in manufacturing industries. This finding goes with results provided in Table 6 and 7.

Table 8: Fixed effect estimation of technology effect of FDI, dependent variable: lnTFP and time period 2000-2001 to 2017-2018

Explanatory variables	Seventh Difference	Eighth Difference	Ninth Difference	Tenth Difference
lnHZ	0.250*** (0.046)	0.254*** (0.050)	0.250*** (0.054)	0.239*** (0.059)
lnBW	-0.008 (0.060)	-0.021 (0.062)	-0.036 (0.064)	-0.049 (0.066)
lnFW	0.046 (0.038)	0.055 (0.039)	0.070 (0.041)	0.089* (0.042)
lnHHI	0.176*** (0.035)	0.178*** (0.038)	0.175*** (0.042)	0.160*** (0.048)
lnSize	0.234*** (0.028)	0.234*** (0.030)	0.235*** (0.034)	0.232*** (0.037)
lnAge	78.78* (37.08)	90.31 (68.47)	87.60 (145.8)	-29.70 (347.6)
Time-fixed effect	Yes	Yes	Yes	Yes
Observations	10246	9314	8382	7450
Number of firms	932	932	932	932
R-squared	0.117	0.116	0.115	0.110
F-statistic	10.43***	9.01***	8.44***	7.76***

Note: Robust Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9: Fixed Effect Estimation of Technology Effect of FDI in Low-tech Firms, Dependent Variable: *lnTFP* and Time Period: 2000-2001 to 2017-18

Explanatory variables	Seventh Difference	Eighth Difference	Ninth Difference	Tenth Difference
lnHZ	0.268*** (0.0504)	0.292*** (0.0544)	0.304*** (0.058)	0.303*** (0.061)
lnBW	0.106 (0.097)	0.076 (0.104)	0.047 (0.111)	0.029 (0.117)
lnFW	0.042 (0.053)	0.058 (0.055)	0.076 (0.056)	0.096 (0.059)
lnHHI	0.233*** (0.036)	0.248*** (0.039)	0.259*** (0.044)	0.251*** (0.051)
lnSize	0.226*** (0.041)	0.228*** (0.045)	0.232*** (0.049)	0.233*** (0.053)
lnAge	64.71 (33.04)	22.39 (39.64)	-107.8 (179.7)	-523.7 (575.7)
Time-fixed effect	Yes	Yes	Yes	Yes
Observations	6,058	5,507	4,956	4,405
Number of firms	551	551	551	551
R-squared	0.099	0.100	0.101	0.099
F-statistic	9.87***	8.26***	8.29***	7.31***

Note: Robust Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 10: Fixed estimation of technology effect of FDI in high-tech firms, dependent variable: *lnTFP* and time period 2000-2001 to 2017-2018

Explanatory variables	Seventh Difference	Eighth Difference	Ninth Difference	Tenth Difference
lnHZ	0.141 (0.141)	0.076 (0.156)	-0.013 (0.181)	-0.117 (0.209)
lnBW	-0.151 (0.088)	-0.157 (0.089)	-0.172 (0.091)	-0.192* (0.094)
lnFW	-0.009 (0.086)	-0.013 (0.089)	-0.015 (0.093)	-0.018 (0.097)
HHI	-0.059 (0.072)	-0.063 (0.077)	-0.069 (0.083)	-0.084 (0.090)
lnSize	0.244*** (0.038)	0.240*** (0.043)	0.235*** (0.048)	0.227*** (0.054)
lnAge	84.67 (59.43)	132.1 (114.0)	210.1 (208.5)	260.8 (383.4)
Constant	0.788* (0.387)	-1.407 (0.726)	2.426 (1.418)	-3.711 (2.801)
Time-fixed effect	Yes	Yes	Yes	Yes
Observations	4,188	3,807	3,426	3,045
Number of firms	381	381	381	381
R-squared	0.159	0.158	0.154	0.146
F-statistic	6.56***	6.05***	5.68***	5.54***

Note: Robust Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

V. Concluding Remarks

There is an undisputable assumption that FDI inflows lead to benefit the innovation activities of domestic firms in host developing countries. The studies on technology spillovers from FDI have largely trivialised the presence of spillovers from FDI in the same industry, as the foreign firms may protect or restrict the technology leakages to domestic firms in the host country. However, they are more optimistic with regard to the occurrence of FDI spillovers via backward linkages from foreign firms in host developing countries. Scholarly works on FDI spillovers in India also argue in the similar line. Using a large balanced panel of 945 domestic firms covering a long time of 18 years spanning over 2000-2001 to 2017-2018, this paper re-examined technology spillovers from FDI in India's manufacturing industries. It also examined how the technology differences across industries influences the technology spillovers from FDI in the manufacturing industries. The equation representing the relationship between FDI and TFP was estimated in first difference as well as in longer time-differences using the firm-level fixed effect estimator.

The findings of the study shows that there are technology spillovers from the horizontal presence of foreign firms in the local manufacturing industries. This implies that domestic firms are successful in emulating the products of foreign firms and thereby improving their existing technologies or innovation activities. The finding goes in line with the findings study by Khachoo et. al. (2018) which reported the presence of horizontal technology spillovers from FDI in Indian manufacturing industries. Further, controlling for technological differences across industries, the study has only discovered the presence

of horizontal technology spillovers from FDI in low-tech domestic manufacturing firms, not in high-tech one. It is clear that the presence of horizontal nature of FDI is benefiting low-tech domestic firms as they could emulates the products of foreign firms and thus upgrade their existing technology or innovation activities. The absence of significant technological spillovers from horizontal FDI in high-tech domestic firms can be attributed to the following. First, there is higher technological sophistications in products displayed by high-tech TNEs, which certainly hinders the emulation process of domestic firms in high-tech manufacturing industries. Secondly, the strong property rights protection in the host country help high-tech TNEs control the leakage of technology to the domestic firms in high-tech industries in India. For instance, the introduction of product patent in India since January 2005 has almost controlled the emulation process of domestic firms in pharmaceutical industry in India.

However, the empirical exercise of the study does not found any apparent vertical technology effect of FDI in Indian manufacturing industries, and even after controlling for technological differences across industries, it has failed to register any considerable technological spillovers from the presence of foreign firms in upstream and downstream industries in India. Smaller and stagnant linkages of FDI inflows can be attributed to the insignificant vertical technology spillovers from FDI in India.

It is thus understood from the analysis that nature of FDI mediates the technology effect of FDI in the host country, as in this case the horizontal nature of FDI inflows in India does not seem to have generated technology spillovers via backward and forward linkages in Indian manufacturing industries. Further, the technology-content of domestic firms also influences the technology spillovers from FDI, as seen in this study, the increase in FDI in high-tech industries does not bring about technology spillovers, instead FDI in low-tech industries leads to technology spillovers into low-tech firms in the local manufacturing industries. Therefore, technology effect of FDI is conditional in nature since it depends on the characteristics of FDI as well as on the characteristics of host country.

The nature of FDI in India, as observed from this study, is more of intra-industrial in nature and less of inter-industrial in nature. This is why the study fails to report vertical technology spillovers from FDI. Moreover, the FDI inflows, which are high technology intensive, do not bring about horizontal spillovers in the host developing countries because of the presence of strong IPRs in these countries. The only possibility through which one can expect technology transfers is the inter-industrial or vertical FDI that can develop high backward and forward linkages with domestic firms in host countries and thus facilitate technological leakages in these countries. The policymakers should therefore focus on devising policies to attract more inter-industrial FDI to upgrade the innovation activities of domestic firms in Indian manufacturing industries.

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Appendix

Table A1: Concordance between NIC-2008 and NIC-2004/1998

Serial Number	*NIC-1998/2004 Code*	*NIC-2008 Code*	*NIC-2008 Code*
1	1511	101	10
2	1512	102	10
3	1513	103	10
4	1514	104	10
5	152	105	10
6	1531+1532	106	10
7	154	107	10
8	1533	108	10
9	155	110	11
10	160	120	12
11	171	131	13
12	172	139	13
13	173	143	14
14	191	151	15
15	192	152	15
16	201	161	16
17	202	162	16
18	210	170	17
19	232	192	19
20	241+233	201	20
21	242-2423	202	20
22	243	203	20
23	2423	210	21
24	251	221	22
25	252	222	22
26	261	231	23
27	269	239	23
28	271	241	24
29	272	242	24
30	273	243	24
31	281-2812	251	25

Serial Number	*NIC-1998/2004 Code*	*NIC-2008 Code*	*NIC-2008 Code*
32	289	259	25
33	321	261	26
34	30007	262	26
35	322	263	26
36	323-32303	264	26
37	(331-3311) + 333	265	26
38	3311-33112	266	26
39	311	271	27
40	314	272	27
41	313+312	273	27
42	315	274	27
43	293	275	27
44	319	279	27
45	291+(300-30007)	281	28
46	292-2927	282	28
47	341	291	29
48	342	292	29
49	343	293	29
50	352	302	30
51	359	309	30

Source: EPW Research Foundation

Table A2: Production function estimation, dependent variable: output and time period: 2000-2001 to 2017-2018

Independent variables	LP estimation				OLS estimation			
	Coef.	Bootstrap Std. Err.	95% Conf. Interval		Coef.	Robust Std. Err.	95% Conf. Interval	
Capital	0.083***	0.013	0.057	0.109	0.234***	0.005	0.224	0.244
Labour	0.211***	0.012	0.188	0.235	0.057***	0.003	0.052	0.063
Raw materials	0.659***	0.014	0.632	0.686	0.714***	0.005	0.705	0.723
Energy	0.082***	0.010	0.063	0.100	0.074***	0.003	0.068	0.081
Observations	18,864							

*** denotes significance at 1 percent level.

Table A3: Correlation matrix of variables

Variables	lnTFP	lnHZ	lnBW	lnFW	lnHHI	lnSize	lnAge
lnTFP	1.0000						
lnHZ	0.0793	1.0000					
lnBW	-0.0525	-0.2888	1.0000				
lnFW	-0.1443	0.1989	-0.0984	1.0000			
lnHHI	0.0772	-0.0771	-0.1350	-0.1377	1.0000		
lnSize	0.0686	-0.0301	0.0118	-0.0014	0.0130	1.0000	
lnAge	0.0748	0.0184	-0.0447	-0.0832	-0.0091	0.1493	1.0000

A4: Description of variables used in the estimation of production function

Output: Output variable is the normalised value of sales of the firms obtained from ProwessIQ (CMIE). A more disaggregated level of industry price indices is employed here to normalise sales' value of the firms.

Capital stock: The database reports gross fixed assets (GFA) of the firm in historical cost.[14] Capital stock is constructed using the perpetual inventory method by taking 2000–2001 as the benchmark year. For this, we have converted the reported GVA of 2000-2001 into replacement cost based on a revaluation factor computed using the process provided in Srivastava (1996). I 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 firms.

Labour: The ProwessIQ provides information on wages and salaries of the firm, but provides no information on *number of employees*. This information is used to arrive at *number of employees* in each firm. The number of employees in a firm is arrived at by dividing the salaries and wages at the firm level by the average wage rate of the industry (three-digit industry) to which firm belongs. To arrive at the average wage rate, I make use of the ASI data on wages and salaries as well as number of employees for the relevant industry. At the time of this study, ASI data was available only up to 2015–2016. We have extrapolated the values for the remaining years in our study.

Raw materials: This is obtained by deflating the reported cost of raw materials consumed using raw material price indices. The raw material price index for each industry (two-digit industry) is constructed using weights obtained from the Input–Output Table of India provided by World Input-Output Database and suitable price indices collected from the Index Number of Wholesale Price in India (base: 2011-12=100).

Energy: This variable is constructed by deflating the reported energy cost, which comprises expenditures of firm on power and fuel, by energy price index. The energy price indices are constructed employing weights taken from Input–Output Table of India provided by World Input-Output Database and suitable price indices collected from the Index Number of Wholesale Price in India (base: 2011-12=100).

[14] GFA includes gross intangible assets, gross land and buildings, gross plant and machinery, gross computers, gross electrical installations and fittings, gross transport infrastructure, gross transport equipment and vehicles, gross communication equipment, gross furniture and fixtures, gross social amenities, and gross other assets.

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