Technology Spillovers and Determinants of Foreign Direct Investment: Evidence across Indian Manufacturing Industries

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Abstract

This paper attempts to analyze the spillover effect of Foreign Direct investment (FDI) and determinants of FDI across Indian manufacturing industries. By estimating Pedroni cointegration tests, the analysis tries to give a long-run relationship between endogenous variables and explanatory variables, which further leads to technology spillovers across Indian manufacturing industries. We find that technology spillovers become higher in industries like foods products, textiles, chemicals, drugs and pharmaceuticals and in non-metallic mineral products. Further, labor productivity over domestic firms of an industry and market size is the major determinants for the inflow of FDI into Indian manufacturing industries.

JEL classification: O41; F43; E23; C22; C23

Keywords: Foreign Direct Investment; Technology Spillover; Manufacturing; Panel Cointegration; Unit Root Tests

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Acknowledgements

We acknowledge Pami Dua, Prof B. N. Goldar and Arup Mitra for their valuable comments and insightful suggestions that have improved this paper considerably. We are thankful to conference participants at Indian Econometric Society, 2010; 1st Research Conference on Empirical Issues in International Trade and Finance, Kolkata, 2008; 2nd Research Conference on Empirical Issues in International Trade and Finance, New Delhi, 2010 for helpful comments.

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1. Introduction

Imports and FDI have been recognized as a channel for technology spillover. Importing technologically advanced intermediate inputs or commodities might trigger learning that enables the domestic producer to produce similar goods at lowest cost at home. FDI might be associated with the spillovers to domestic firms because the workers that embody the firm specific knowledge assets of the Multinational National Enterprises (MNEs) affiliates which can be absorbed by domestic firms (Fosuri, Motta, and Ronde, 2001). Because the MNEs have access to new specialized intermediate inputs, or domestic firms use local intermediate goods and its productivity can be raised through the technology know-how of the foreign firms. The technology diffusion of MNEs in the host country and its impact on domestic firms is the subject of current research for many empirical studies. These empirical studies have generally found that there exit significant cross-industry knowledge and technology spillovers in embodied and disembodied large and small size firms. The outcome of the technology spillover impact from FDI on host economies has two linked steps. The first step involves the MNCs parent to subsidiary international transfer of technology that is superior to the prevailing technology in the host country industry. The second step involves the subsequent spread of this technology to domestic firms–a technological spillover effect.

The most important aspect of the technology spillover is that these are indeed externalities. Technology spillover occurs when a firm receives economic benefit from another firm's R&D activity without sharing any cost. This is the most important and significant difference between technology spillover and transfer, i.e., whether the innovator can appropriate the welfare surplus from the transferred knowledge. R&D innovations and subsequent technological change and spillovers by intermediate factors of production, through foreign affiliation or acquisition are the most important factors for the economic development by increasing the productivity of domestic firms. The most important complementary role is the diffusion of technology by increasing the productivity growth of domestic firms and it has been widely recognized in the present context. A widely held view is that the international trade and the role played by MNCs in the diffusion of technology leads to faster economic growth and it gives higher rates of productivity growth in the host country industry in India (Veeramani and Goldar, 2005).

FDI is now widely recognized as an important source for industrial development in developing countries in view of the fact that it brings new intermediate goods, bundle of capitals, technology transfers and skills in the form of externalities and technology spillovers. Industry in the developing countries like India is now under pressure to speed up their production process in order to exist and face the competition in the global competitive market. The process of initiation has been started after economic reforms in India after the 1990s; in order to take an attempt to make for a systematic shift towards an open economy along with privatization of a large segment of the economy. The removals of quantitative barriers in a phased manner, applying the suitable tax policy, and land acquisition policy, etc., have opened up the Indian economy to international market forces which has led to the rapid emergence of a highly competitive environment; especially in the industrial sector. This has again emphasized the importance of continuous improvement in productivity, efficiency, and technology spillovers of the industrial sector in India.

Keeping these factors in mind, this study tries to empirically estimate the FDI and technology spillover and determinants of FDI across Indian manufacturing industries. For this empirical estimation the present analysis covers sixteen Indian manufacturing industries, out of which twelve are broad 2-digit level industries and four 3-digit level allied industries have been selected.[1] The study has been undertaken at the industry level analysis of sixteen selected manufacturing industries in India out of which 2,148 firms are considered as domestic firms and 231 are classified as foreign firms. So, the total number of firms in these selected industries is 2,379. By the implication of Pedroni (1999, 2000, 2004) panel cointegration tests, it estimates the long-run relationship between the labor productivity over domestic firms with respect to its relevant regressors as real gross capital stock, capital intensity, foreign presence, technological gap, interaction between market concentration and foreign presence, R&D intensity of the domestic and foreign firms and technology import intensity (TMI) of the domestic and foreign firms.

The rest of paper has been organized as follows. Section 2 discusses the empirical framework, i.e. it presents a theoretical model which is the background for the empirical

[1] See Appendix B, Table B.1, for the details of the selection.

estimation and analysis. Section 3 discusses the econometric approaches of panel unit root tests, Pedroni panel cointegration tests, fully modified OLS (FMOLS), group fully modified OLS (GFMOLS) and dynamic OLS (DOLS) techniques for the empirical models. Section 4 interprets the empirical results and, finally, section 5 summarizes the findings and some policy implications of this analysis.

2. Empirical Framework

In this section, we present a theoretical background for our empirical model and its estimation to assess whether the technology spillover in the form of foreign presence, R&D accumulation, and TMI can contribute to the domestic firms labor productivity and technology spillovers across industries. Following Romer's (1990) or Jones' (1998) (R&D) based endogenous growth models; we specify the output of an industry i at time t, denoted by Y_{it}, which is as follows:

$$Y_{it} = A_{it}\left(H_{it}L_{it}\right)^{\beta}\left[\int_{0}^{\bar{z}_{it}}\left(\chi_{it}(z)^{\rho}\right)dz\right]^{\alpha/\rho} \qquad \text{....................(1)}$$

Here H_{it} is human capital stock, L_{it} is the labor (working labor), A_{it} is considered as industry-specific factor of industry i at time t, with industry-specific constant trend, and $\chi_{it}(z)$ is the input of intermediate factors continuously distributed over the interval $\left[0, \bar{Z}_{it}\right]$, where $\bar{Z}_{it}$ is the varieties of intermediate factors for industry i at time t. We assume that $0 < \alpha < 1$ and $0 < \rho < 1$, that is, $\alpha \in (0,1)$ and $\rho \in (0,1)$. Thus, total output can be produced by quality adjusted effective labor and intermediate factors of production in a Cobb-Douglas function. Now the effective labor can be defined as the raw labor incorporated with human capital and a continuum of intermediate factors are incorporated in CES form.[2] In a symmetric equilibrium, where $\chi_{it}(z) = \chi_{it}$, for all $z \in \left[0, \bar{Z}it\right]$, all firms producing intermediate factors set the same price and sell the same quantity of each intermediate factors (Kwark and Shyn, 2006).[3] This implies that the capital stock of an ith industry can be defined as the stock of intermediate factors.

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[2] See Mankiw et al. (1992) and Hamilton & Monteagudo (1998) for empirical analysis of the determinants of the productivity and economic growth.

[3] Our theoretical intuition in this model are closely linked with the paper, 'International R&D Spillovers Revisited: Human Capital for Foreign Technology' by Kwark, Noh-Sun and Shyn, Yong-Sang (2006).

$$K_{it} = \int_0^{\bar{z}_{it}} \left(\chi_{it}(z)\right) dz = \bar{Z}_{it}\chi_{it} \qquad \text{..............(2)}$$

From this discussion we get the following form of the production function:

$$Y_{it} = A_{it}(H)_{it}^{\beta}(L)_{it}^{\beta}(\bar{Z})_{it}^{\sigma}(K)_{it}^{\alpha} \qquad \text{...........(3)}$$

This equation shows that final output of *i*th industry at time t is efficiently produced by industry-specific factor A_{it}, human capital H_{it}, labor L_{it} and intermediate factors are interpreted as capital, K_{it}, incorporated with R&D stocks and TMI stock, etc. We interpret $(\bar{Z})_{it}^{\sigma}$ is the varieties of intermediate inputs that is R&D intensity and TMI together (Coe & Helpman, 1995), which has been incorporated with the capital stock. However, in the present analysis we presume the factors of intermediate inputs which can affect the industrial labor productivity are TMI and R&D intensity at the firm or industry level.[4] From the above discussion, the final output of *i*th industry at time t can be efficiently produced by the industry-specific factor, foreign presence (FORP), one of the factors influencing A_{it}, human capital, labor, and intermediate factors which are incorporated with the capital stock K_{it} that is R&D intensity and TMI. The Eqn. 3 has been again written as follows:

$$Y_{it} = A_{it}(H)_{it}^{\beta}(L)_{it}^{\beta}(\bar{Z})_{it}^{\sigma}(K)_{it}^{\alpha}e_{it} \qquad \text{............(4)}$$

Here, e_{it} stands for the random disturbance terms.

Dividing Eqn. 4 by the labor L_{it} on both sides, we get:

$$Y_{it}/L_{it} = A_{it}(H)_{it}^{\beta}(\bar{Z})_{it}^{\sigma}\,(K)_{it}^{\alpha}/(L)_{it}^{1-\beta}\;e_{it}$$

$$= A_{it}(H)_{it}^{\beta}(\bar{Z})_{it}^{\sigma}(k_{it})^{1-\beta}(K_{it})^{\alpha+\beta-1}e_{it} \qquad \text{.......... (5)}$$

Taking natural logarithm in Eqn. 5

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[4] Coe & Helpman (1995) and Lichtenberg & Van Pottelsberghe de la Potterie (1998) pointed out how R&D spillovers embodied in intermediate factors on total factor productivity (TFP) so that technology spillovers become higher in the long-run.

$$\ln\left(\frac{Y_{it}}{L_{it}}\right) = \ln\left[A_{it}(H)_{it}^{\beta}(\bar{Z})_{it}^{\sigma}\right] + \beta_1 \ln k_{it} + \beta_2 \ln K_{it} + \varepsilon_{it} \quad ....(6)$$

$$LP_{it} = TFP_{it} + \beta_1 k_{it} + \beta_2 K_{it} + \varepsilon_{it} \;...........(7)$$

From Eqn. 6,[5] output per labor of an industry has been defined as the value-added per worker or labor productivity (LP) of a particular industry. However, in the present analysis to estimate the technology spillovers across Indian manufacturing industries, we are considering only the labor productivity over domestic firms of an industry (LPd) become the endogenous variable. So the Eqn. 7 can be specified as follows.

$$LPd_{it} = TFP_{it} + \beta_1 k_{it} + \beta_2 K_{it} + \varepsilon_{it} \;........(8)$$

From Eqn. 6 and 7, the total factor productivity (TFP) of an industry can be explained as follows:

$$TFP_{it} = Ln\, A_{it} + \beta \ln H_{it} + \sigma \ln \bar{Z}_{it} \;..............(9)$$

The level of technology which is represented by TFP is influenced by industry-specific factor like foreign presence, human capital, and varieties of intermediate factors taken together, like R&D intensity and TMI, etc.[6] However; the intermediate factors can be split into different factors, based upon the degree of effectiveness of R&D intensity and TMI.[7] Further, R&D intensity can be separated into R&D intensity of the domestic firms (RDID) and of foreign firms (RDIF) and, similarly, TMI can be separated into TMI of the domestic firms (TMID) and of foreign firms (TMIF) (Coe & Helpman, 1995). After including these factors, the Eqn. 9 can be written below.

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[5] After the logarithmic transformation of the Eqn. 5, in Eqn. 6 and 7; β_1 represents $1-\beta$ and β_2 represents $\alpha + \beta - 1$ and Eqn. 7 is in the log form but for convenience we are not writing the log signs in Eqn. 7 and k , K represents the capital intensity and capital stock in the model.

[6] See Borensztein et al. (1998) for a framework of incorporating the role of FDI by multinational firms as a determinant of economic growth and see Easterly (1993) for a model of technology adoption through international trade and human capital accumulation.

[7] Xu (2000) empirically estimate the host country productivity growth by total factor productivity (TFP) of the host country and as the TFP increases because of the technology diffusion of the MNEs.

$$TFP_{it} = \beta_{0i} + \beta_3 FORP_{it} + \beta_4 QL_{it} + \beta_5 RDID_{it} + \beta_6 RDIF_{it} + \beta_7 TMID_{it} + \beta_8 TMIF_{it} + \varepsilon_{it} \quad \text{..........} (10)$$

By substituting the TFP from Eqn. 10 in Eqn. 8 we can get the following equation.

$$LPd_{it} = \beta_{0i} + \beta_1 k_{it} + \beta_2 K_{it} + \beta_3 FORP_{it} + \beta_4 QL_{it} + \beta_5 RDID_{it} + \beta_6 RDIF_{it} + \beta_7 TMID_{it} + \beta_8 TMIF_{it} + \beta_9 X_{it} + \varepsilon_{it} \quad \text{.........} (11)$$

The specification in Eqn. 11 does not imply that all industries must have the same foreign presence, quality of labor (QL), capital stock, intermediate factors, and, specifically, same capital-labor ratio, that is, the identical technology. Rather we can draw separate inferences from each variable upon labor productivity across Indian manufacturing industries. Further, these industries must exhibit a significant level of variation in their different explanatory factors from each other. This functional form has been widely used in previous empirical studies using industry-level data (e.g., Blomstrom & Persson, 1983; Kokko, 1994).

From the Eqn. 9 human capital can be presented as the quality of labor QL_{it} of a particular firm/industry and can be proxied by the ratio of number of supervisory and management workers in a firm/industry to total employment of firm/industry (Kohpaiboon, 2006). Apart from the industry-specific factor like foreign presence in place of A_{it} we are including other industry-specific factors of an industry in Eqn. 11; X_{it} represents the set of other explanatory variables containing the industry-specific factors of the *i*th industry. The industry-specific factor like technological gap (TGAP) between foreign firms and local firms of an industry can be considered as another key determinant for inferences of industrial labor productivity and degree of technology spillovers across industries (Kokko, 1994). The market concentration (MCON) of an industry can be included in the set of explanatory variables as it acts as another determinant for labor productivity over domestic firms and technology spillovers across Indian manufacturing industries. In fact, two industries having same technical efficiency may show a different value-added per worker because of different domestic market concentration. In addition, as argued by Hall (1988), the impact of any possible exogenous factors on industrial labor productivity would be conditioned by the degree of market concentration. As market concentration is one of the control variable, and to capture the effect of market concentration an interaction variable of market concentration and foreign presence (MCON*FORP) is added into the model. Based on these discussions, the empirical model for estimation can be extended to a new model by including these discussed exogenous factors into the Model 11. Now the estimating equation has been specified as follows:

$$LPd_{it} = \beta_{0i} + \beta_1 k_{it} + \beta_2 K_{it} + \beta_3 FORP_{it} + \beta_4 QL_{it} + \beta_5 RDID_{it} + \beta_6 RDIF_{it}$$
$$+ \beta_7 TMID_{it} + \beta_8 TMIF_{it} + \beta_9 TGAP_{it} + \beta_{10} MCON * FORP_{it} + \varepsilon_{it} \quad ....(12)$$

Foreign presence

In order to find out the determinants of FDI at industry level, we develop another empirical model that is foreign presence is regressed to the corresponding regressors. Foreign presence is a function of the market size, technological gap of an industry, R&D intensity of an industry, TMI of an industry and LPd.

The size of the domestic market can be one of the relevant factors for MNEs when deciding modes of entry that is either producing at foreign location or exporting from the home country. If the size of the market is large then it can expand its product in the domestic market as well as in foreign market. Firms become more competitive in the international markets and it can face the competitive environments in a more dynamic way. FDI is more likely to set up its affiliation with the local firms if the domestic market size is large. In addition, the R&D intensity and TMI of an industry, technological gap of an industry can be another determinant for the level of foreign presence and these factors can be acting as a catalyst for the foreign investors to invest in host country industries in India.[8] Finally, the labor productivity of the domestic firms can be a significant factor for the foreign investors to attract more foreign capital into host country industries in India. However, these factors have been empirically estimated and analyzed in empirical

[8] In the second empirical model we club the R&D intensity of the domestic and foreign firms to the R&D intensity of an industry and technology import intensity of the domestic and foreign firms to the technology intensity of an industry. We club to one variable because here we want to analyze the FDI determinants at the industry level and our motivation is to find out the factor responsible for attracting the FDI to the individual manufacturing industry in India rather than of more explicit description regarding the technology spillover at the industry level. Moreover, the first model is trying to explore the FDI and technology spillover across Indian manufacturing industry. So the second model is restricted to the factor responsible for attraction of FDI to the individual industry level. Thus, we club these discussed two variables into single variable.

results. MNEs are interested to invest in host country when they get wide extents of markets, cheap accessing of skill labor in terms of remuneration, better quality of raw materials, and high labor productivity of the localized firms. Some of the foreign investors locate entrepreneurial activities across the countries when they get these types of facilities in the host country (Kophaiboon, 2006). Keeping these factors into consideration, the following empirical model has been developed, which is as follows:

$$FORP_{it} = \beta_{0i} + \beta_1 LPd_{it} + \beta_2 TGAP_{it} + \beta_3 RDI_{it} + \beta_4 TMI_{it} + \beta_5 MSIZE_{it} + \beta_6 QL_{it} + \varepsilon_{it} \quad (13)$$

3. Econometric Approaches

From an econometric point of view, the present analysis follows three familiar steps. The first step is to investigate the stochastic process of the variables involved by means of panel unit root tests. To test the presence of stochastic trends in our data sets, the present analysis employs a battery of panel unit root tests designed explicitly to address the assumption of cross-sectional dependence. The reason for applying several panel unit root tests is to check for the robustness of our results, as the testing strategies vary. Four different approaches of panel unit root test are proposed and used in the present analysis, namely Levin Lin and Chu (LLC); Breitung; Im, Pesaran, and Shin (IPS); and Hadri.

The second step consists of testing for cointegration in order to asses for the presence of a long-run relationship between the endogenous variables and exogenous variables in empirical models, which leads to the technology spillovers across Indian manufacturing industries in the long-run. This is done by applying the test developed by Pedroni (1999 and 2004) that arguably represent a significant advancement in addressing the lower power of conventional single equation tests for a single time series by exploiting both the cross-section and time series information. Further, due to the limitation of the data sets there is no exact information regarding the numbers of supervisory and management workers in the firm/industry level from our principal source of the data set, that is, Center for Monitoring Indian Economy (CMIE) based ‘Prowess’, the variable quality of labor QL_{it} has been excluded from the estimating Eqn. 12 and 13. Now, in order to conduct the Pedroni cointegration tests in a labor productivity context, the model which is discussed in the empirical section has been specified for the panel cointegration is given below:

$$LPd_{it} = \beta_{0i} + \beta_1 k_{it} + \beta_2 K_{it} + \beta_3 FORP_{it} + \beta_4 RDID_{it} + \beta_5 RDIF_{it} + \beta_6 TMID_{it} + \beta_7 TMIF_{it} + \beta_8 TGAP_{it} + \beta_9 MCON * FORP_{it} + \varepsilon_{it} \quad \text{...........(14)}$$

To check the FDI determinants at the industry level we develop another model (which is already discussed in the empirical section), that is foreign presence is a function of LPd, technological gap of an industry, R&D intensity of an industry, TMI of an industry, market size of an industry, etc.[9] Thus, the proposed empirical model has been specified for panel cointegration is given below.

$$FORP_{it} = \beta_{0i} + \beta_1 LPd_{it} + \beta_2 TGAP_{it} + \beta_3 RDI_{it} + \beta_4 TMI_{it} + \beta_5 MSIZE_{it} + \varepsilon_{it} \quad (15)$$

From Eqn. 14 and 15, $i = 1,2,...,16$ means it covers sixteen Indian manufacturing industries and the time series varies from $t = 1,2,....,18$ means it covers the time series data for relevant information from 1990 to 2007. Data sources and construction of the variables are explained in the Appendix A.

Then the third step is to obtain the consistent parameter of estimates from the panel cointegration models for which a number of econometric procedures need to be addressed. Most of these arises because of vary nature of the error term ε_{it} in the model. If the error terms are independently and identically distributed and uncorrelated with input choices, then the ordinary least squares (OLS) estimates can be consistent but inefficient for the non-stationary unit roots panel data. Using the standard OLS techniques on non-stationary panel data may leads to false inferences in the regression model. Thus, to avoid this kind of inconsistency with respect to the OLS method, the present analysis has used Pedroni (2000) FMOLS, GFMOLS, and Stock and Watson

[9] In this analysis the second empirical model has been developed in order to find out the determinants of FDI at the industry level. In fact, the foreign presence and labor productivity are inter-related to each other and one can be the cause and another might be the effect in another model. Its looks like a simultaneous problem in the models. But in fact, our analysis is to estimate the long-run relationship between the productivity and its relevant regressors and foreign presence and its determinants at the industry level. Thus, for the above concerned the analysis has implicated the model of panel cointegration, FMOLS, and DOLS to solve the problem of endogeneity and serial correlation problem which is lies in the model. This new dimension of this approach through applying this technique is to estimate the long-run relationship between endogenous variable and explanatory variables.

(1993) DOLS estimates for panel cointegration to estimate the long-run relationship between the cointegrated vectors (Kao and Chiang, 1998).

Pedroni (2000) FMOLS estimate can capture the heterogeneity across industries (slope and intercept heterogeneity) and permits short-run dynamics. According to his arguments, by applying FMOLS inferences can be made regarding common long-run relationships which are asymptotically invariant to the considerable degree of short-run heterogeneity (as theory suggests), that is, prevalent in the dynamics typically associated with panels that are composed of aggregate data. The technique, therefore, deals with the endogeneity of the regressors and corrects for serial correlations, which may lead to consistent estimate of β's parameters in a relatively small samples.

4. Estimation Results

The present analysis has been used panel unit root test of LLC, IPS, Breitung, and Hadri to check the robustness of the variables and to check for stationarity of the model. The null hypothesis in each case, except Hadri test, proposes that each series has a unit root and the alternative hypothesis proposes that it allows for some but not all of the individual series unit roots. Moreover, Hadri based Lagrange Multiplier (LM) test is based on the proposition that null hypothesis contains no unit root against the unit root in the alternative hypothesis of panel data. From the reported panel unit root tests (Table 1), it can be seen that most of the test fail to reject the unit root null for variables in level form (with the exception of the IPS and LLC in two case),[10] but the tests reject the null of a unit root in first difference form (Table 2).

However, the table also reports the widely used Hadri-Z test statistics which uses a null of no unit root. Again, the results of this test are consistent with LLC, IPS and Breitung, [11] because it rejects the null in favor of a unit root for the variables in first difference form (Ramirez, 2007). Thus, evidence proposes that the variable in the regression model go forward to non-stationary processes and the application of simple OLS to the stacked regression models in 14 and 15 lead to the result of biased and

[10] For the variable RDIF, and TMIF out of four unit root tests, three are non-stationary, that is, I (1), only one exceptional case in IPS, and in LLC it is stationary at level, that is, I (0), thus, this variable is considered as non-stationary variable in levels form (Ramirez, 2007).

[11] There are many studies even in the short panels have applied LLC, IPS and Hadri test to check the robustness and stationarity of the variables and, similarly, Pedroni (2000) panel cointegration test has been applied in the short panel to check cointegration among the non-stationary variables in the level form.

inconsistent estimates.[12] Thus, it is necessary turn to panel cointegration techniques in order to determine whether a long-run relationship exists between the non-stationary variables in level form. However, panel cointegration among the non-stationary variables avoids the spurious regression and inconsistency problem at the time of estimation. Pedroni (2004) panel cointegration procedure has been used here to check for cointegration which leads to the long-run relationship between endogenous variables and explanatory variables in our empirical models 14, and 15. The optimal lag length is chosen to be one in all cases based on the AIC.

Table 1: *Panel Unit Root Tests*

Variables (levels)	*LLC*	*Breitung*	*IPS*	*Hadri*
LPd_{it}	-3.058	-0.635	-1.286	3.651*
k_{it}	0.1681	-0.512	1.860	8.513*
K_{it}	-3.904	-7.510	-4.365	4.298*
$TGAP_{it}$	-3.853	-4.651	-4.281	0.608*
$FORP_{it}$	-4.384	0.965	-4.039	2.119*
$MCON*FORP_{it}$	-9.650	1.043	-7.314	4.322*
RDI_{it}	-0.649	-2.654	-2.602	9.080*
$RDID_{it}$	10.227	-2.509	-2.196	4.401*
$RDIF_{it}$	-4.993	-2.811	-4.128*	4.227*
TMI_{it}	-18.73	-4.175	-9.628	0.020
$TMID_{it}$	-16.72	-4.595	-8.875	0.747*
$TMIF_{it}$	-60.61*	-2.466	-21.33	4.841*
$MSIZE_{it}$	17.056	-8.2915	17.4501	10.1680*

Note: 1.Automatic selection of maximum lags. Automatic selection of maximum lags is based on SIC: 0 to 3.
2. Newey-West bandwidth selection using Bartlett and Kernel.
3. A * indicates the rejection of null hypothesis of non-stationary (LLC, Breitung, IPS) or stationary (Hadri) at the 5% level of significance.

[12] See. Ramirez (2007) study for detailed discussion of application of panel unit roots tests (LLC, IPS, Breitung, and Hadri) and Pedroni (2000, 2004) panel cointegration analysis to the short panel data of 1980-2001 in the context of Latin America.

Table 2

Panel Unit Root Tests

Variables (1st Differences)	*LLC*	*Breitung*	*IPS*	*Hadri*
LPd_{it}	-13.321*	-3.551*	-13.105*	-0.018
k_{it}	-13.969*	-7.809*	-12.318*	3.262
K_{it}	-14.135*	-15.888*	-16.629*	8.933
$TGAP_{it}$	-13.721*	-6.608*	-13.472*	7.957
$FORP_{it}$	-18.048*	-4.659*	-14.383*	8.844
$MCON*FORP_{it}$	-15.844*	-5.270*	-13.913*	7.542
RDI_{it}	-5.897*	-7.587*	-14.112*	5.361
$RDID_{it}$	-5.707*	-6.662*	-14.103*	4.361
$RDIF_{it}$	5.386*	-8.632*	17.067*	5.971
TMI_{it}	-10.693*	-9.015*	-13.361*	1.171
$TMID_{it}$	-9.695*	-9.216*	-12.956*	1.626
$TMIF_{it}$	1.625*	-9.417*	-12.572*	4.046
$MSIZE_{it}$	1.164*	-6.221*	1.012*	9.919

Note: 1. Automatic selection of maximum lags. Automatic selection of maximum lags is based on SIC: 0 to 3

2. Newey-West bandwidth selection using Bartlett and Kernel

3. A* indicates the rejection of null hypothesis of non-stationary (LLC, Breitung, IPS) or stationary (Hadri) at the 5% level of significance.

The results reported in Row 2 of Table 3, that is, the cointegrated model 14 shows that out of seven statistics only four statistics are rejecting the null of no-cointegration and the cointegrating vector supports the model given that the second element in the vector is found to be non-negative and statistical significant (Note: the null is determined by large positive values for panel variance statistics while for other six is determined by large negative values). The test where the null of no cointegration has been rejected is where there is a heterogeneous trend specification. Row 3 represents the cointegration between foreign presence and its relevant regressors which is discussed in the empirical model 15. From the results, it can be concluded that the cointegration still exists in our proposed hypothetical empirical model 15. Further, from the theory of panel cointegration; out of seven statistics four are rejecting the null of no-cointegration. Therefore, we can estimate a long-run relationship between LPd and its relevant regressors in empirical model 14 and foreign presence and its regressors in empirical model 15.

Table 3
Panel Cointegration Test

Model	*Panel statistics*		*Group panel statistics*	*Cointegrating vector*
Model 14	Panel V-Statistic	-3.139 (0.156)		1.000 0.068* [5.268]
	Panel Rho-Statistic	4.625 (0.135)	5.994 (0.148)	
	Panel PP-Statistic	-5.922 (0.013)	-5.121 (0.095)	
	Panel ADF-Statistic	-7.566 (0.003)	-4.503 (0.102)	
Model 15	Panel V-Statistic	-1.149 (0.163)		1.000 1.523* [3.265]
	Panel Rho-Statistic	1.856 (0.456)	3.299 (0.458)	
	Panel PP-Statistic	-3.701 (0.103)	-4.606 (0.086)	
	Panel ADF-Statistic	-3.081 (0.096)	-5.054 (0.054)	

Note: 1. An intercept but no trend was included in estimation. Numbers in round parenthesis are p-values. Figures in square brackets are t-statistics. * indicates 1% level significance.
2. Row 2 represents panel cointegration of endogenous variable LPd_{it} with respect to the regressors in the empirical model 14.
3. Row 3 represents panel cointegration of endogenous variable $FORP_{it}$ with respect to the regressors in the empirical model 15.

Table 4 gives panel OLS, GFMOLS and DOLS estimates after estimating the empirical model 14.[13] The results reported in Table 4 suggest that foreign presence

[13]The FMOLS estimator directly estimates the long-run relationship by correcting the simple OLS estimator for serial correlation and endogeneity problem in the model. To do the robustness check in model the DOLS procedure has been added in the empirical estimation including one leads and one lags for the differenced regressors and regressing I (1) variables on the I (1) variables, the I (0) variables leads and lags of the first difference of the I (1) variables, and constant. The DOLS procedures corrects for potential endogeneity problems and small sample bias, and provide estimates of the cointegrating vectors which are asymptotically efficient.

coefficients are positive and significant at GFMOLS and DOLS estimates, which suggest that domestic firms are getting benefit from their foreign counterparts and show the existence of technology spillovers across Indian manufacturing industries. The scale variables, capital intensity and real gross capital stock, make sense for the technology spillovers because these variables are economically and statistically significant and have correct signs with respect to our empirical model. The coefficients for interaction variable of market concentration and foreign presence are found to be statistically and economically significant at OLS and DOLS estimates. This finding suggests that interaction variable has played a significant role in lifting the technology spillovers to the domestic firms of Indian manufacturing industries.

Table 4
Panel OLS, GFMOLS and DOLS Results
Dependent variable LPd_{it}

	OLS	*GFMOLS*	*DOLS*
k_{it}	0.22* (6.82)	1.15* (4.44)	0.24 (0.12)
K_{it}	0.02 (0.65)	2.74* (6.41)	0.009 (0.13)
$FORP_{it}$	0.02 (0.15)	6.23* (1.75)	1.25* (2.87)
$MCON^* FORP_{it}$	0.39** (0.139)	-3.30 (-0.52)	0.959* (6.19)
$TGAP_{it}$	-0.57* (-3.86)	-1.31** (-1.65)	-1.08 (0.76)
$RDID_{it}$	0.28 (0.77)	5.27* (1.85)	2.42* (6.22)
$RDIF_{it}$	-2.49 (-0.45)	7.74 (-0.12)	1.75* (2.43)
$TMID_{it}$	-2.96 (-0.84)	3.54* (2.36)	3.52* (2.83)
$TMIF_{it}$	-0.08 (-0.32)	3.14 (0.49)	2.05* (2.17)

Note: 1. The DOLS regressions include one lead and one lag for the differenced regressors. AR Lags in Computing is S (0) 1.
2. A * denotes statistical significance at least at the 5% level, while ** represents at the 10% level.
3. Absolute t-statistics are in the parenthesis. NT=288.

The coefficients for technological gap are found to be non-positive and statistically significant at OLS, GFMOLS, and DOLS estimates corresponding to our model 14. This suggests that technological gap has played a negative role in lifting of the technology spillovers across Indian manufacturing industries. Further, this line of reasoning suggests that higher the technological gap between foreign and local firms lower the absorptive capacity of the domestic firms and lower the technology spillovers to the domestic firms. It is evident from this empirical exercise that with few exceptions, R&D intensity of the domestic firms and TMI of domestic firms are found to be economically and statistically significant with correct positive signs. From the R&D intensity of the foreign firms and TMI of foreign firms in some of the estimates these coefficients are non-positive and statistically insignificant. This line of reasoning suggests that the positive effect of TFP leads to the higher technology spillovers across Indian manufacturing industries and it depends on its own R&D intensity from the domestic firms and R&D intensity of the foreign firms, TMI of the domestic firms and foreign firms cumulative imported technology embodied in imported intermediate inputs and, therefore, technology has been transmitted via import intensity and import-weighted stock of knowledge.

Table 5 reports the individual FMOLS results for the empirical model 14 over the period 1990-2007 across sixteen Indian manufacturing industries. The coefficients of real gross capital stock and capital intensity are found to be non-negative and statistically or economically significant in most of the industries. In chemical and consumer electronics industries the coefficients of capital intensity are found to be statistically significant but giving negative signs. This finding suggests that in both industries capital intensity cannot lift their productivity spillovers. The coefficients of capital stock achieves robust economic and statistical significance in most of the industries and has correct positive sign except in few industries like leather products, chemicals, and rubber products. This finding suggests that except few industries, capital stock has played a favorable role in increasing labor productivity and technology spillovers across Indian manufacturing industries.

The next key inference for technology spillovers across Indian manufacturing industries is foreign presence. It is found from this empirical exercise that the coefficients of foreign presence are statistically and economically significant in most of the industries with expected positive signs. This suggests that higher the foreign presence higher would be the TFP and, finally, it can lift more technology spillovers to the domestic firms of Indian manufacturing industries.

Table 5

FMOLS Regressions over the Period 1990-2007 in Sixteen Industries of Indian Manufacturing (Individual FMOLS Results)

Dependent variable LPd_{it}

Variables Industries	k_{it}	K_{it}	$FORP_{it}$	$MCON*FORP_{it}$	$TGAP_{it}$	$RDID_{it}$	$RDIF_{it}$	$TMID_{it}$	$TMIF_{it}$
Food Products	-0.93 (-0.56)	3.75* (3.67)	2.78* (2.40)	-3.85 (-1.02)	-0.02 (-0.23)	-0.62 (-0.52)	1.25* (2.58)	3.95* (2.15)	-2.82 (-0.51)
Beverages and Tobacco	7.23* (5.76)	6.28* (4.63)	0.52* (2.42)	-0.33 (-0.32)	-0.04* (-4.97)	2.42* (2.76)	-0.34 (-0.32)	0.60* (1.74)	-1.51 (0.60)
Cotton Textiles	0.24 (-1.17)	4.17* (2.80)	0.43** (1.32)	-3.47 (-0.72)	0.01 (0.01)	-6.13 (-1.00)	-3.14* (-1.68)	3.28 (1.24)	-0.57** (-1.62)
Textiles	0.38* (2.59)	1.96* (2.76)	6.03** (1.53)	4.50 (0.16)	-0.22* (-2.03)	-1.14 (-0.30)	-0.81 (-1.23)	-1.27 (-0.83)	0.66 (0.64)
Woods Products	-0.83 (-0.74)	2.43** (1.34)	0.14* (3.69)	5.55 (0.85)	0.09 (0.49)	5.28* (2.65)	-0.96* (-2.09)	2.82* (2.40)	-1.25 (-0.96)
Paper and Paper Products	0.64** (1.63)	2.65* (4.92)	0.22 (0.55)	1.88* (2.78)	-0.96* (-3.48)	2.92* (2.02)	1.08 (0.06)	2.20* 3.01)	2.12* (4.40)
Leather Products	0.32** (1.44)	-0.35 (-1.05)	0.10 (0.31)	0.93* (3.95)	-2.40* (-3.98)	3.31* (1.96)	3.88* (2.84)	1.68* (3.02)	-1.58 (-1.02)
Chemicals	-1.44** (-1.53)	-2.26 (-1.06)	2.41* (1.81)	3.72* (1.82)	-2.16* (-3.40)	1.69 (0.93)	3.17 (0.87)	2.16 (0.70)	1.48* (1.94)
Drugs and Pharmaceutical s	0.90* (6.05)	3.66* (5.82)	3.69* (4.48)	2.28 (0.94)	-1.96* 2.67)	1.01* (2.95)	2.70* (4.28)	-0.62 (-1.04)	3.18* (7.28)
Rubber and Rubber Products	-0.25 (-0.31)	-5.79 (-0.09)	0.17* (3.27)	2.29* (1.78)	-0.37 (-1.25)	-8.08 (-0.59)	2.85* (1.80)	-2.32 (-0.78)	0.04 (0.42)
Non-metallic Mineral Products	0.68* (2.47)	6.43** (1.28)	6.16* (1.35)	-2.04* (-2.58)	-4.18* (-5..90)	2.79* (5.96)	-2.96 (-1.26)	-0.32 (-0.06)	4.03* (6.69)
Metal Products	2.81* (5.06)	2.80* (6.03)	2.07 (3.45)	4.91* (4.37)	0.10 (0.71)	2.58** (1.35)	-2.16 (-1.06)	1.92 (0.82)	3.92* (2.11)
Non-Electrical Machinery	1.17* (2.82)	1.60* (2.14)	-0.64 (-0.16)	5.41 (0.79)	-1.74* (-7.36)	0.11 (0.00)	-0.36* (-2.38)	3.24** (1.54)	-1.45 (-0.69)
Electrical Machinery	1.31* (3.57)	6.73 (0.91)	0.24 (0.18)	5.73** (1.43)	-0.91* (-2.40)	-3.25 (-0.15)	3.01* (3.96)	0.61* (2.44)	2.20* (3.17)
Consumer Electronics	-0.79** (-1.40)	5.41* (1.94)	1.62 (0.97)	1.98* (3.34)	-0.40* (-5.53)	6.64 (1.00)	6.03* (3.26)	5.58 (1.17)	2.50* (2.25)
Automobiles	0.82* (6.58)	0.62* (3.39)	0.47* (3.77)	8.21* (4.07)	0.22** (1.42)	-2.97 (-0.86)	3.39** (1.44)	6.74* (2.11)	7.41* (3.96)

Note: 1. Coefficients are long run estimates of LPd_{it} with respect to the regressors in empirical model 14.
2. An * denotes statistical significance at least at the 5% level, while an ** represents at the 10% level.
3. Absolute t-statistics are in the parenthesis. NT=288.

However, the technology spillover becomes higher in industries like food products, textiles, chemicals, drugs and pharmaceuticals and in non-metallic mineral products. However, there are still other manufacturing industries which show existence of the technology spillovers effect form FDI. The coefficients of the interaction variables for the market concentration and foreign presence are found to be non-negative and statistically significant in almost all industries, with few exceptions like non-metallic mineral products industries, foods products, beverages and tobacco, and in cotton textiles industry, where the coefficients are found to be negative.

Industries with expected non-negative coefficients of the interaction variable leads to the higher productivity of the domestic firms and can bring more technology and knowledge spillovers to the industries. The coefficients for technological gap are found to be negative and statistically and economically significant in all most all sixteen Indian manufacturing industries. Thus, the inferences can be drawn from this empirical exercise that higher the technological gap between foreign and local firms, lower would be the labor productivity and technology spillovers. This suggests that higher technological gap broadens the imitation problems and minimizes the absorptive capacity of the localized firms in an industry, and finally, lower would be the labor productivity to the domestic firms of Indian manufacturing industries.

Knowledge and technology spillovers can be transmitted via the quality and variety of intermediated inputs are predominantly explained by R&D intensity of domestic firms and foreign firms, TMI of domestic and foreign firms. It is evident that the coefficients of R&D intensity of domestic firms are found to be positive and statistically significant in most of the manufacturing industries. This line of reasoning investigates that higher the R&D intensity higher would be the labor productivity and technology spillovers across Indian industries. The coefficients of R&D intensity of the foreign firms are found to be non-negative for some industries and in some industries it is found to be negative with statistically significant. Thus, it is evident that coefficients with non-negative signs have played a significant role for the labor productivity over the domestic firms and it can increase the technology spillovers of the Indian manufacturing industries. This is the positive externality which can lift up the knowledge and technology spillovers to the domestic firms, if foreign firms are increasing their R&D expenditure then domestic firms has to automatically increase their R&D expenditure in order to face the competition on the one hand and sustain in the market on the other hand. Similar inferences can be drawn with respect to the TMI of the foreign firms.

The results reported in Table 5 suggest that the coefficients for TMI of the domestic firms are found to be non-negative and economically and statistically significant in most of the industries. This evidence suggests that higher the TMI of the domestic firms higher would be the TFP. Further, it can facilitate the assimilation of knowledge embodied in imported technology and, thereby, raise the absorptive capacity of the domestic firms and can lift up higher technology spillover to the Indian manufacturing industries over the long-run. Finally, in some Indian manufacturing industries, the coefficients of TMI of foreign firms are found to be non-negative and statistically significant. This suggests that the productivity and spillovers becomes higher over domestic firms if foreign firms in an industry are increasing their technology up-gradation by importing worldwide leading edge technology then the domestic firms has to automatically increase technology up-gradation in order to improve their product quality at cheapest cost.

From the second empirical model 15, if market size of an industry increases then inflow of FDI is increased into the host country industry. So it's hypothesized that its expected sign would be positive. From the individual FMOLS results in Table 7, it suggests that most of the industries are in favor of the market size is the key factor for the inflow of FDI into the Indian manufacturing industries. In addition, in most of the cases, it has non-negative coefficients with statistically and economically significant. Further, this individual FMOLS estimates result has been again supported by the group FMOLS results, because large size in the domestic market is likely to attract more FDI into the Indian manufacturing industries (Table 6).

The variable like LPd is a significant factor to attract more foreign capital into the host country industries in India. From the reported results in Table 7, domestic firms' labor productivity is the significant factor for the determination of foreign presence in most of the industries. Therefore, foreign investors are interested to invest in the host country industry like India when they can access cheap labor with higher capacity to produce more output. Because, FDI is likely gravitates to the highly productive domestic sectors in the host country. Moreover, the elasticity of the foreign presence with respect to labor productivity is quite high and statistical and economically significant across most of the Indian manufacturing industries. Thus, low cost of labor with highly productive in the domestic sectors can attract more FDI into the Indian manufacturing industries especially from the USA and East Asian countries to transplant and use the country as their export base from the late 1990s onward.

Table 6

Panel OLS, GFMOLS, DOLS Results

Dependent variable: Foreign Presence $FORP_{it}$

Variables	*OLS*	*GFMOLS*	*DOLS*
$MSIZE_{it}$	0.011* (1.92)	0.04* (3.85)	-0.013 (0.016)
LPd_{it}	0.009 (1.28)	0.12** (1.68)	0.004 (0.018)
$TGAP_{it}$	-.013** (-1.61)	-1.71* (-2.73)	-0.022 (0.062)
RDI_{it}	1.94** (1.58)	0.089* (2.86)	3.93* (4.16)
TMI_{it}	0.35 (0.68)	1.42* (2.77)	0.59* (1.96)

Note: 1. The DOLS regressions include one lead and one lag for the differenced regressors. AR Lags in Computing is S (0) 1.

2. Coefficients are long run estimates of foreign presence (FORP) of an industry with respect to the regressors in the empirical model 15.

3. A * denotes statistical significance at least at the 5% level, while ** represents at the 10% level.

4. Absolute t-statistics are in the parenthesis.

The coefficients of technological gap are found to be non-positive, economically and statistically significant in individual FMOLS estimates and in group estimates of OLS, GFMOLS, DOLS results, which suggests that higher technological gap, can be a problem for the foreign investors to invest more capital into Indian industries. From this line of reasoning it suggests that if the technological gap becomes higher then domestic firms cannot absorb the foreign technology from their foreign counterparts and so, cannot improve their labor productivity. The R&D expenditure of an industry are providing adequate infrastructure for foreign investors to invest foreign capital into the host country industries and these intensity are creating direct as well as indirect benefit and demand push profit in the global market.

Table 7

FMOLS Regressions over the Period 1990-2007 in Sixteen Industries of Indian Manufacturing (Individual FMOLS Results)

Dependent Variable: $FORP_{it}$

	$MSIZE_{it}$	LPd_{it}	$TGAP_{it}$	RDI_{it}	TMI_{it}
Food Products	0.02 (1.09)	0.03** (1.67)	-0.00 (-0.75)	0.12 (0.24)	2.15 (0.31)
Beverages and Tobacco	0.02* (4.32)	0.03** (1.89)	-0.02 (-0.17)	4.86* (2.59)	2.82* (2.61)
Cotton Textiles	0.00 (0.25)	0.01 (0.34)	-0.02** (1.92)	4.16* (3.98)	0.17** (1.63)
Textiles	-0.01** (-1.42)	0.09* (3.23)	0.07* (7.68)	0.16 (0.17)	0.42* (2.44)
Woods Products	0.001* (2.73)	0.00 (0.95)	-0.00 (-0.06)	0.19* (3.40)	0.02** (1.48)
Paper and Paper Products	0.11* (3.85)	0.11 (1.05)	-0.09 (-0.51)	-3.84 (-0.45)	1.40* (2.11)
Leather Products	0.25* (8.16)	-0.15 (-0.88)	-0.06 (-0.07)	9.12 (0.53)	-0.20 (-0.54)
Chemicals	0.02* (2.89)	0.01* (2.49)	0.09** (1.61)	0.58 (0.12)	1.06 (1.23)
Drugs and Pharmaceuticals	0.15* (2.59)	0.10* (4.84)	-0.30* (-4.11)	3.63* (4.97)	2.53** (1.39)
Rubber and Rubber Products	0.05 (0.95)	0.18* (2.93)	-0.07* (-2.60)	-0.76 (-0.88)	-0.90 (-1.00)
Non-metallic Mineral Products	0.03* (4.56)	0.02* (2.15)	0.01 (0.27)	-1.19 (-1.06)	1.29* (3.37)
Metal Products	0.0.9* (8.72)	0.03** (1.58)	-0.01 (-1.39)	2.51* (2.90)	1.04* (3.71)
Non-Electrical Machinery	0.03* (2.28)	0.01 (0.55)	0.02 (0.66)	7.42* (3.84)	-0.26 (-0.24)
Electrical Machinery	0.08* 5.02)	0.17* (4.83)	-0.15* (-1.98)	4.67** (1.45)	0.24 (0.59)
Consumer Electronics	0.02* (1.93)	0.06* (2.47)	0.07* (6.83)	4.09* (2.19)	-1.55 (-1.04)
Automobiles	0.05 (1.39)	0.05 (0.85)	0.23* (6.25)	-7.62 (-1.19)	2.41* (2.08)

Note: 1. Coefficients are long run estimates of FORP of an industry with respect to the regressors in empirical model 17.
2. An * denotes statistical significance at least at the 5% level, while an ** represents at the 10% level.
3. Absolute t-statistics are in the parenthesis.

The empirical results are in favor of the long-run relationship between R&D intensity of an industry and foreign presence. This suggests that more R&D expenditure of an industry leads to the attraction of higher FDI into that industry in India. The tendency of importing more technology from its foreign counterparts leads to the advantage of bringing more profit into that industry. In most of the industries, the coefficients of TMI are non-negative and statically and economically significant. Therefore, foreign investors are investing more funds in those industries that are using more advance technology for the improvement or up-gradation of their existing technology. Thus, in the long-run dynamics, we can estimate the long-run relationship between TMI and foreign presence, which is clearly analyzed from this GFMOLS and individual FMOLS estimates across Indian manufacturing industries.

5. Concluding Remarks

The present study empirically examined the FDI and technology spillovers and the determinants of FDI across Indian manufacturing industries. The study examined the panel cointegration tests with respect to our different empirical models to find out the long-run relationship between endogenous and explanatory variables. Employing Pedroni (2000, 2004) cointegration tests, the empirical evidence shows a significant long-run relationship between labor productivity over domestic firms and its determinants in the empirical model 14. After documenting these cointegration results, based on the panel data from 1990 to 2007 across sixteen Indian manufacturing industries suggests that foreign presence played a significant role in lifting technology spillovers to the domestic firms. Particularly, in most of the manufacturing industries there exists a long-run relationship between foreign presence and labor productivity over the domestic firms. In fact, foreign presence has been positively associated with labor productivity, knowledge and technology spillovers. Therefore, foreign presence by way of FDI brings new channels of knowledge and technology to the domestic firms and, further, it can facilitate higher productivity and technology spillovers.

The empirical results provide evidence of support that TFP is a positive function of R&D intensity of domestic and foreign firms and TMI of both domestic and foreign firms. Technology spillovers can be transmitted via different types of intermediate factors and from this result a rise in the TMI gained momentum for the improvement of labor productivity over domestic firms and technology spillovers across Indian manufacturing industries. Both R&D intensity and TMI can facilitate in raising the knowledge and technology spillovers through the channel of imports. Thus, we can interpret that there is a positive association between R&D intensity and TMI with respect to the labor productivity and technology spillovers. The results also highlight the important role of TMI of the foreign firms in order to increase the labor productivity over the domestic firms. Our findings indicate that higher the TMI of the foreign firms the higher would be the TMI of the domestic firms in order to compete in the market. Thus, TMI of the foreign firms can be an indirect way to generate positive externality for the domestic firms to improve their labor productivity. Our findings also suggests that except a few exceptional manufacturing industries the capital stock, capital intensity, and the interaction variable has played an important role to facilitate the improvement of labor productivity and technology spillovers over domestic firms. Technological gap between foreign firms and local firms has played a negative role to raise the productivity over domestic firms, and our findings suggest that higher the technological gap, higher the imitation problem and lower the absorptive capacity of the domestic firms, and lower the technology spillovers.

From other aspects of the study, labor productivity over the domestic firms of an industry and market size are the major determinants for the inflow of FDI into Indian manufacturing industries. In addition, the variables like R&D intensity and TMI of an industry can create good environment for the foreign investors by creating direct and indirect benefit to the foreign firms in the host country industries in India. Thus, foreign investors are likely to gravitate to the localized firms in India those who are using more funds for the R&D expenditure and more funds for the technology up-gradation.

Appendix A

Data

The data in this paper mainly comes from the Center for Monitoring Indian Economy (CMIE) based corporate data base 'Prowess', Annual Survey of Industries (ASI), and National Accounts of Statistics (NAS).

Variables

Labor productivity

LPd_{it}: The labor productivity at the firm level has been constructed by dividing the gross value added to the number of man-days (labor) of firm of an industry. The analytical estimation has been based on the industry level, so the labor productivity has been constructed to the industry-specific variable. To make labor productivity as an industry-specific variable and to get the spillover effect across Indian manufacturing industry we simply take the average of the labor productivity over domestic firms in an industry for a specific period of time.

Capital K_{it}**:** For the present study, to construct the capital variable from the Prowess data sets we are closely followed the methodology, derived by Srivastava (1996) and Balakrishnan (2000) et al. They use the perpetual inventory method, which involves the capital at its historic cost. Thus, the direct interpretation of the perpetual inventory method is not an easy task. So the capital stock has to be converted into an asset value at replacement cost. The capital stock is measured at its replacement cost for the base year 1993-94. Then, we followed the methodology of Balakrishnan (2000) et al. to arrive at a revaluation factor. The revaluation factors R^G and R^N for initial year's gross and net capital stock, respectively, has been obtained as follows:

The balance sheet value of the assets in an initial year has been scaled by the revaluation factors to obtain an estimate of the value of capital assets at replacement cost.[14] However, the replacement cost of capital $= R^i$ *(value of capital stock at historic cost), where, i stands for either gross (G) or net (N) value. The formula for the revaluation factor for the gross fixed asset R^G and value of the capital stock at its historic cost $(GFA)_t^h$ is given below:

$$(GFA)_t^h = P_t I_t \left[(1+g)(1+\pi) \big/ (1+g)(1+\pi)-1 \right]$$

Where, P_t = Price of the capital stock and I_t = Investment at the time period t (t =1993); I_t = the difference between the gross fixed assets across two years, that is, $I_t = GFA_t - GFA_{t-1}$. Where, g stands for the growth rate of investment, that is, $g = I_t \big/ I_{t-1} - 1$ and $\pi = P_t \big/ P_{t-1} - 1$

[14]See Srivastava (1996) study for the detailed discussion of perpetual inventory method to compile the real gross capital stock from the CMIE based Prowess data sets.

The revaluation factor for the gross fixed asset is $R^G = {(l+g)(l+\pi)-1}\big/{g(1+\pi)}$. Here, l stands for the Life of the machinery and equipment. Thus, the revaluation factor has been constructed by assuming that the life of machinery and equipment is 20 years and the growth of the investment is constant throughout the period. We assume that the price of the capital stock has been changed at a constant rate from the date of incorporation of the firm to the later period, i.e., up to 2007. The revaluation factor which has been obtained is used to convert the capital in the base year into the capital at replacement cost, at the current prices. We then deflate these values to arrive at the values of the capital sock at constant prices for the base year. The deflator used for this purpose is obtained by constructing capital formation price indices from the series for gross capital formation from the NAS. Then, subsequent year's capital stock is arrived at by taking the sum of investments, using the perpetual inventory method.

Labor: For the present study, our principal source of the data base is Prowess. Our analysis is based on the Prowess data set. However, the Prowess data base does not provide the exact information regarding labor per firm. Thus, we need to use this information on man-days per firm. Man-days at the firm level are obtained by dividing the salaries and wages of the firm to the average wage rate of an industry to which the firm belongs.[15] Thus, the man-days per firm are as given below.

Number of man-days per firm = salaries and wages/average wage rate

To get the average wage rate, we used the information from ASI data. ASI contains information on total emoluments and total man-days for the relevant industry groups. The average wage rate can be obtained by dividing the total emoluments to the total man-days for relevant industry groups.

Average wage rate = total emoluments/ total man-days

Capital Intensity k_{it}: Capital intensity at the firm level can be obtained by dividing the real gross capital to the labor of that firm. To get capital intensity as an industry-specific effect, we simply divide the summation over all firms' capital stock to the summation over all firms' labor of an industry.

[15]For the present analysis when we compile the labor variable from CMIE based Prowess data sets and from ASI sources, then information's for total man-days and total emoluments in ASI data were available up to 2004-05. Thus, from ASI data we extrapolating the data range from 2004-05 to 2007 to get the average wage rate of an industry.

Foreign Presence $FORP_{it}$**:** Foreign presence is measured by the output share of foreign firms to the total industry output. However, in some previous empirical studies, employment or capital shares have been used to measure the foreign presence. Taking foreign presence as an employment share tends to underestimate the actual role of foreign affiliates because MNEs affiliates tend to be more capital intensive than local non-affiliated firms. On the other hand, the capital share can be easily distorted by the presence of foreign ownership restrictions. Hence, output share is the preferred proxy (Kohpaiboon, 2006).

Technological Gap $TGAP_{it}$**:** Technological gap between foreign firms and local firms is proxied by the ratio of average value added per workers of the foreign firms to that of local firms.

Interaction variable $MCON*FORP_{it}$**:** To measure the market concentration, we are taking widely used proxies of Herfindahl-Hirschman index of concentration (HHI). The HHI of market concentration formula is given below:

$$HHI = \sum_i \left(s_{ij} \big/ \sum s_{ij} \right)^2 .$$

Where, s_{ij} is a total sale of the *i*th firm in the *j*th industry. To calculate the interaction variable, we multiply the HHI market concentration to the foreign presence of an industry.

R&D Intensity

RDI_{it}: The R&D intensity is measured by the share of R&D expenditure to the total sales. To make R&D intensity as an industry-specific effect, we measure the total R&D expenditure by taking the summation over R&D expenditure of firms of an industry for a specified period divided to the total sales of that industry by again summing the sales of each firms during that period of time.

$RDID_{it}$**:** The R&D intensity at the firm level is measured by the share of R&D expenditure to total sales. To make the R&D expenditure over the domestic firms (RDID) as an industry-specific variable, we measured the total R&D expenditure over the domestic firms by summing R&D expenditure over all the domestic firms in an industry, and divide by the total sales of all firms by again summing the sales of each domestic firm of that industry, for that specified period.

$RDIF_{it}$: To calculate the R&D expenditure of foreign firms (RDIF) as an industry-specific variable, we divide the sum of R&D expenditure of all foreign firms in a specific industry to the sum of the total sales of all foreign firms in that industry.

Technology Import Intensity (TMI)

TMI_{it}: The technology imports can be broadly classified into two categories as embodied technology consisting of imported capital goods and disembodied technology consisting of blue prints and license fees as it is considered to be remittances on royalty and license fees. Hence, the technology imports intensity can be obtained by summing the embodied and disembodied technology divided by the total sales of the firm. To make the TMI as an industry-specific effect, we can calculate by summing the total disembodied and embodied technology across the firms of an industry in specified period divided by the total sales of that industry which is again obtained by summing the sales of each firms during that period of time.

$TMID_{it}$: To calculate the TMI of domestic firms (TMID) as an industry-specific variable, we divide the sum of the total disembodied and embodied technology over all domestic firms in an industry to the total sales of that industry by again summing the sales of all domestic firms for a specified time period.

$TMIF_{it}$: To calculate the TMI of foreign firms (TMIF) as an industry-specific variable, we divide the sum of the total disembodied and embodied technology over all foreign firms in an industry to the total sales of that industry by again summing the sales of all foreign firms for a specified time period.

Market Size $MSIZE_{it}$:

The size of the domestic market is measured by the sum of gross output and import at the industry level in Indian manufacturing.

Appendix B

Table B.1

Classification of firms across Indian manufacturing industries in 2007

NIC 1987 CODE	*Industry Classification*	*Domestic Firms*	*Foreign Firms*	*Total Firms*
20-21	Food Products	146	12	158
22	Beverages and Tobacco	85	4	89
23	Cotton Textiles	307	4	311
26	Textiles	245	13	258
27	Woods Products	20	1	21
28	Paper and Paper Products	40	5	45
29	Leather Products	14	1	15
30	Chemicals	410	77	487
304(30)	Drugs and Pharmaceuticals	117	21	138
312(31)	Rubber and Rubber Products	12	2	14
32	Non-metallic Mineral Products	96	14	110
34	Metal Products	176	24	200
35	Non-Electrical Machinery	229	26	255
36	Electrical Machinery	226	21	247
365(36)	Consumer Electronics	6	2	8
375(37)	Automobiles	19	4	23

Source: Based on own calculations from the CMIE data set Prowess.

Note: 1. FDI firms (foreign firms) are those firms with foreign equity of 10 percentages or more than of 10 percentages.

2. According to National Industrial of Classification (NIC) the four 3-digit level industries are drugs and pharmaceuticals (304) coming under chemicals (30), rubber and rubber products (312) coming under rubber and plastic products (31), consumer electronics (365) coming under electrical machinery (36), and automobiles (375) coming under the transportation industry (37).

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