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Technology Spillover and Determinants of Foreign Direct Investment: An Analysis of Indian Manufacturing Industries

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Abstract

This paper examines the spillover effect of foreign direct investment (FDI) and determinant of FDI across Indian manufacturing industries. The result, based on two-equation model that allows for the two-way link between labour productivity of locally owned industries and foreign presence provide evidence that foreign presence brings new channels of knowledge and technology spillover to domestic industrial firms. We find that intermediate factors like R&D intensity and technology import intensity can impact positively the productivity of domestic firms. Furthermore, we find that bigger market size and highly productive domestic sectors are likely to attract more foreign capital into Indian industries.

Keywords: Foreign Direct Investment; Technology Spillover; Manufacturing; Panel Cointegration; Unit Root Tests.
JEL classification: O41; F43; E23; C22; C23

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1. Introduction

Imports and foreign direct investment (FDI) have been recognized as channels for technology spillover. Importing technologically advanced intermediate inputs or commodities might trigger learning that enables the domestic producer to produce similar goods at lower 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 can be absorbed by domestic firms (Fosuri *et al*., 2001). Because the MNEs have access to new specialized intermediate inputs, whereas domestic firms use local intermediate goods, the productivity of the latter 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 has been the subject of research of many empirical studies (Helpman, 1997). These empirical studies have generally found that there exist significant cross-industry knowledge and technology spillovers in embodied and disembodied forms among large and small size firms. The outcome of the technology spillover impact of 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.

An 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 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 important factors for economic development by increasing the productivity of domestic firms. The complementary role of MNCs 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 international trade and the role played by MNCs in the diffusion of technology leads to faster economic growth and helps to achieve higher rates of productivity growth in the host country industry (Ambos *et al.*, 2006).

FDI is now widely recognized as a catalyst for industrial development in developing countries in the view of the fact that it brings new intermediate goods, additional capital for industrial projects, technology transfers and skills in the form of externalities and technology spillovers. The industrial sector in developing countries like India is now under pressure to speed up modernization of its production process in order to survive and face the competition in the global competitive market. The process of economic reforms in India which started in the 1990s, was directed at 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, the lowering of tariff on imports, and the application of 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.[1] This has again emphasized the importance of continuous improvement in productivity, efficiency, and technology spillovers of the industrial sector in India.

[1] For a recent literature survey, see Athreye and Kapur (2006); Ang (2009) and Madsen, Saxena and Ang, 2010.

Keeping these factors in mind, this study empirically examines the FDI and technology spillover and further examines the determinants of FDI across Indian manufacturing industries. For empirical estimation, 16 manufacturing industries have been selected, out of which 12 are broad 2-digit level industries and four 3-digit level allied industries which are part of chemicals, transportation industry, electronics, rubber and plastic products.[2] The study has been undertaken at the industry level analysis of 16 manufacturing industries in India out of which 2148 firms are considered as domestic firms and 231 are classified as foreign firms. So, the total number of firms in these selected industries is 2379.

The rest of paper has been organized as follows. Section 2 discusses the foreign presence in Indian manufacturing industries. Section 3 discusses the empirical framework, i.e. it presents a theoretical model which is the background for the empirical estimation and analysis. Section 4 discusses the econometric approaches of simultaneous equation models, polled ordinary least squares (OLS) and 2 stage least squares (2SLS) techniques for the empirical models. Section 5 interprets the empirical results and, finally, section 6 summarizes the findings and some policy implications of this analysis.

2. Foreign Presence and Technological Gap in Indian manufacturing

The relevant information to compile the key factors like foreign presence, market concentration and technological gap of Indian manufacturing industries are obtained from the Centre for Monitoring Indian Economy based data set 'Prowess' and, presented in Table 1. If market concentration of an industry is high then it is expected to affect the labour productivity of that industry in a positive way. However, in the present study, the market concentration variable is compiled by widely used proxies of Herfindahl-

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

Hirschman (HHI) index of market concentration. The output share of foreign firms in respect of an industry is considered as foreign presence, and the ratio of the average labour productivity of foreign firms to the local firms is considered as technological gap of an industry. Detailed discussion of definitions and construction of the variables is given in the Appendix A.

Table 1: *Foreign Presence (%), Market Concentration (%) and Technological Gap in Sample Industries in 2000 and 2007*

NIC (1987) CODE	*Industry Group*	*Foreign Presence (%)*		*Market Concentration (%)*		*Technological gap*	
		2000	*2007*	*2000*	*2007*	*2000*	*2007*
20-21	Food Products	18.83	17.54	2.948	5.004	0.72	3.95
22	Beverages and Tobacco	8.61	10.38	24.54	30.28	0.72	0.47
23	Cotton Textiles	2.99	4.70	1.74	2.51	0.45	0.36
26	Textiles	5.03	7.81	0.97	1.42	0.40	0.49
27	Woods Products	0.21	0.14	11.58	17.54	0.33	1.20
28	Paper and Paper Products	33.25	12.62	9.35	8.63	0.65	0.75
29	Leather Products	55.11	32.70	35.23	18.18	0.17	0.17
30	Chemicals	10.55	9.04	14.41	14.50	0.76	0.82
304 (30)	Drugs and Pharmaceuticals	23.62	23.88	3.46	3.71	0.59	0.56
312 (31)	Rubber and Rubber Products	8.99	5.54	9.86	8.84	0.81	0.32
32	Non-metallic Mineral Products	6.28	13.43	6.22	4.96	0.12	0.20
34	Metal Products	7.29	19.90	11.97	6.780	0.73	0.90
35	Non-Electrical Machinery	15.43	13.11	8.68	10.75	0.68	1.06
36	Electrical Machinery	38.32	39.79	2.52	3.78	0.70	0.49
365 (36)	Consumer Electronics	18.76	9.15	20.35	34.09	1.14	1.09
375	Automobiles	21.24	36.66	14.63	16.52	1.26	1.75

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

From this study and the data presented in Table 1 pertaining to the three significant inferences are analyzed to corroborate the FDI and technology spillover across Indian manufacturing industries. The first one, foreign presence is relatively high in leather products and in electrical machinery industry where foreign output share accounts for more than 30% of total industry output. In addition, in other sectors like food products, metal products and drugs and pharmaceuticals, foreign outputs constitute more than 15% of the industry output. In sectors like beverages and tobacco, textiles, cotton textiles, non-metallic minerals products, woods products, chemicals, rubber and rubber products, non-electrical machinery and consumer electronics, foreign output shares are less than 15 percentage of the industry output.

The second important inference that can be drawn in this study is the market concentration index. From Table 1, it is seen that the market concentration is high in consumer electronics and beverages and tobacco industry which is more than 30 percentages. The concentration ratio is relatively low in drugs and pharmaceuticals, rubber and rubber products, paper and paper products, textiles, cotton textiles, food products, non-metallic mineral products, metal products and in electrical machinery industries. However, in automobiles, leather products, chemicals and in woods products industry there is relatively higher degree of market concentrations and its ratios are about or more than 15 percentages in each industry. The third inference which is another significant explanatory factor for the estimation of industrial labour productivity is the technological gap of an industry. From this compilation report in Table 1, the technological differences is quite high in food products, non-electrical machinery, consumer electronics, woods products and in automobiles industry. However, in other remaining sample industries the technological gap is relatively low.

3. Empirical Framework

In this section, we present a theoretical background for the empirical model and its estimation to assess whether the technology spillover arising from foreign presence, R&D accumulation, and technology imports can contribute to the domestic firms' labour productivity and technology spillovers across industries. Following Romer's (1990) or Jones' (1998) R&D based endogenous growth models, we specify the production function for output of an industry *i* at time *t*, denoted by Y_{it} as being subject to the following functional relationship:

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

Here H_{it} is human capital stock, L_{it} is labour (working labour), A_{it} is considered as industry-specific factor of industry i at time *t*, with industry-specific constant trend, and $\chi_{it}(z)$ is intermediate factors continuously distributed over the interval $(0, \bar{Z}_{it})$, 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 produced is determined by quality adjusted effective labour and intermediate factors of production in a Cobb-Douglas function.[3] Now the effective labour can be defined as the raw labour incorporated with human capital and a continuum of intermediate factors are incorporated

[3] We follow Kwark and Shyn (2006) in specifying our model.

in CES form.[4] In a symmetric equilibrium, where $\chi_{it}(z) = \chi_{it}$, for all $z \in (0, \bar{Z}_{it})$, all firms producing intermediate factors set the same price and sell the same quantity of each intermediate factors (Kwark and Shyn, 2006).[5] This implies that the capital stock of an *i*th industry can be defined as the aggregate stock of intermediate factors:

$$K_{it} = \int_0^{\bar{z}_{it}} (\chi_{it}(z))dz = \bar{Z}_{it} \chi_{it} \tag{2}$$

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

$$Y_{it} = A_{it} H_{it}^{\beta} L_{it}^{\beta} \bar{Z}_{it}^{\sigma} K_{it}^{\alpha} \tag{3}$$

From Equation (3), the final output of *i*th industry at time t is efficiently produced by industry-specific factor (*A*), human capital (*H*), labour (*L*) and intermediate factors are interpreted as capital (*K*), incorporated with R&D stocks and technology import intensity (TMI) stock, etc. We interpret $\bar{Z}$ as the varieties of intermediate factors that is R&D intensity and TMI together (Coe and Helpman, 1995), which has been incorporated with the capital stock. However, in the present analysis we assume that the elements of intermediate inputs which can affect industrial labour productivity are TMI and R&D intensity at the firm or industry level.[6] From the above discussion, the final output of *i*th industry at time t can be efficiently produced by the industry-specific factor, human capital,

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

[5] Our theoretical intuition in this model is closely linked with the paper by Kwark and Shyn (2006).

[6] Coe and Helpman (1995) and Lichtenberg and Van Pottelsberghe de la Potterie B. (1998) pointed out how R&D spillovers embodied in intermediate factors impacts on total factor productivity (TFP) so that technology spillovers become higher in the long-run. Amiti and Konings (2007) estimate the effects of trade liberalization on plant productivity in Indonesia.

labour, and intermediate factors which are incorporated with the capital stock (*K*) that represent R&D intensity and TMI. Equation (3) has been again written as follows:

$$Y_{it} = A_{it} H_{it}^{\beta} L_{it}^{\beta} \bar{Z}_{it}^{\sigma} K_{it}^{\alpha} e_{it} \tag{4}$$

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

Dividing Equation (4) by labour (L_{it}) on both sides, we get:

$$\begin{aligned} Y_{it}/L_{it} &= A_{it}\ H_{it}^{\beta}\ \bar{Z}_{it}^{\sigma} \left(K_{it}^{\alpha}/L_{it}^{1-\beta}\right) e_{it} \\ &= A_{it} H_{it}^{\beta}\ \bar{Z}_{it}^{\sigma} (K_{it}/L_{it})^{1-\beta}\ K_{it}^{\alpha+\beta-1}\ e_{it} \end{aligned} \tag{5}$$

Taking natural logarithm in Equation (5)

$$\ln(Y_{it}/L_{it}) = \ln\left(A_{it} H_{it}^{\beta} \bar{Z}_{it}^{\sigma}\right) + \beta_1 \ln(K_{it}/L_{it}) + \beta_2 \ln K_{it} + \varepsilon_{it} \tag{6}$$

To estimate the technology spillovers across Indian manufacturing industries, we are considering only the labour productivity of domestic firms of an industry (*LPd*) as the endogenous variable. Thus, Equation (6) can be specified as follows:

$$LPd_{it} = TFP_{it} + \beta_1 (k_{it}/l_{it}) + \beta_2 k_{it} + \varepsilon_{it} \tag{7}$$

In this equation LPd_{it} is $\ln(Y_{it}/L_{it})$, and total factor productivity (TFP) represents $\ln\left(A_{it} H_{it}^{\beta} \bar{Z}_{it}^{\sigma}\right)$.[7] The small letter symbol represents the natural log form. That is, (k_{it}/l_{it}) and k_{it} stands for $\ln(K_{it}/L_{it})$ and $\ln K_{it}$, respectively. Furthermore, in place of TFP *A*, *H*, and $\bar{Z}$, we may use proxies such as industry-specific factor like foreign presence (*FORP*), quality of labour (*QL*), R&D intensity, and technology import intensity

[7] 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.

(TMI).[8] The quality of labour (*QL*) of a particular firm/industry 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). In addition, as guided by theory and previous empirical works on the determinants of industrial labour productivity and technology spillovers across industries, two additional explanatory variables are used. Firstly, the study takes into account the role of industry-specific factor like technological gap (*TGAP*) between foreign firms and local firms of an industry and it can be considered as another key determinant for inferences of industrial labour productivity and degree of technology spillovers across industries (Kokko, 1994). Secondly, market concentration (*MCON*) of an industry can be included in the set of explanatory variables as it acts as another determinant for labour productivity over domestic firms and technology spillovers across Indian manufacturing industries. In fact, two industries having the same technical efficiency may show 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 labour productivity would be conditioned by the degree of market concentration. As market concentration is one of the control variable, 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 in Equation (7). Now the estimating equation has been specified as follows:

$$\begin{aligned} LPd_{it} &= \beta_{0i} + \beta_1 (k_{it}/l_{it}) + \beta_2 k_{it} + \beta_3 FORP_{it} + \beta_4 QL_{it} + \beta_5 RDI_{it} + \beta_6 TMI_{it} \\ &+ \beta_7 TGAP_{it} + \beta_8 MCON*FORP_{it} + \varepsilon_{it} \end{aligned} \qquad (8)$$

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

Foreign presence

In order to redress the problem of simultaneity involved in the relationship between *FORP* and *LPd*, Eqn. (8) is estimated together with a separate equation to explain the FDI determinants at industry level. The specification of the second equation is discussed below before presenting the two equation model. In addition, to a simultaneous relationship with *LPd*, *FORP* is a function of market size, technological gap of an industry, R&D intensity of an industry, TMI of an industry, quality of labour, and *LPd*.

The size of the domestic market is one of the explanatory factors for MNEs when deciding modes of entry that is either producing at foreign location or exporting from the home country. The size of the domestic market (*MSIZE*) is measured by the sum of gross output and import at the industry level of Indian manufacturing industries. If the size of the market is large then it is supposed to expand its product in domestic and in the foreign market. Large size firms supposed to be more competitive in the international market 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, higher R&D intensity and more technologically upgraded firms can be other influential factors for inflow of foreign capital towards Indian industries.

Technological gap of an industry can be another determinant for the level of foreign presence and it is supposed that higher technological difference between foreign and local firms can blockage the learning ability with absorptive capacity over local firms. Therefore, the standard hypothesis is that lager technological gap reduces the inflow of foreign capital towards Indian industries. Finally, the labour 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, we can arrive at a certain conclusion after the empirical estimation and analysis of results in the next section. MNEs are interested to invest in host country when they get wide extents of markets, cheap accessing of skill labour in terms of remuneration, better quality of raw materials, and highly productive localized firms. Some foreign investors locate entrepreneurial activities across countries in order to access cheaper with better quality raw materials and labour to enhance the productivity (Kophaiboon, 2006). Based on these discussions, the second estimate equation has been specified as follows:

$$FORP_{it} = \beta_{0i} + \beta_1 LPd_{it} + \beta_2 TGAP_{it} + \beta_3 RDI_{it} + \beta_4 TMI_{it} + \beta_5 MSIZE_{it} + \beta_6 QL_{it} + \varepsilon_{it} \quad (9)$$

where $i = 1,2,...,16$ 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 Appendix A. Furthermore, due to the unavailability of proper data on the numbers of supervisory and management workers in the firm/industry level obtainable from our principal source of the data set, that is, Centre for Monitoring Indian Economy (CMIE) based 'Prowess', the variable quality of labour (*QL*) has been excluded from the estimating Equations (8) and (9).

4. Econometric Procedure

Initially we follow the ordinary least squares (OLS) method to estimate Eqns. (8) and (9). The estimation strategy requires that the parameters β in both equations are estimated consistently. Because of the simultaneous nature of the two equations, OLS cannot provide a consistent estimate of the parameters β in Eqns. (8) and (9). Unbiasedness and consistency of OLS estimates rest on the assumption that the explanatory variables are uncorrelated with the stochastic disturbance terms. This assumption becomes invalid for any individual equation in a system of equations whenever at least one of the explanatory variables of that equation is jointly determined and makes the use of the OLS inappropriate. The alternative estimators devised to be used in this situation fall into two main categories: systems methods and single-equation methods. The system methods, of which three-stage least squares (3SLS) and full-information maximum likelihood (FIML) are best known, are superior to single-equation methods in terms of efficiency of the estimates. However, in using 3SLS or FIML, all equations in the system must be properly specified. Since these methods utilize information on the interconnection among all the equations in the system, what is happening elsewhere in the system will be transmitted throughout the whole system, causing biases and distortions.

Based on a Monte Carlo experiment of a finite sample, two-stage least squares (2SLS) has emerged as a good promising choice among available alternatives. 2SLS provides a very useful information procedure for obtaining the values of structural parameters in over-identified equations. 2SLS estimation uses the information available from the specification of an equation system to obtain a unique estimate for each structural parameter. 2SLS generally performs well in terms of both bias and mean-squared error, shows a relatively higher degree of stability, and is not greatly affected by specification (Intriligator *et al.*, 1996). Moreover, 2SLS and 3SLS estimates are asymptotically equivalent if each equation is just identified, 2SLS equation by equation is algebraically identical to 3SLS. Furthermore, regardless of the degree of over-identification, 2SLS equation by equation and 3SLS are algebraically identical if $\hat{\Omega}$ (variance-covariance matrix) is identical (Wooldridge, 2002).

2SLS involves applying OLS in two stages. Intuitively, the first stage of 2SLS involves the creation of an instrument, while the second stage involves a variant of instrumental-variables estimation (Pindyck and Rubinfeld, 1998, p.349). Furthermore, the first stage involves regressing each of the explanatory endogenous variables on all the pre-determined variables. In the second stage, the fitted values of the explanatory endogenous variables, obtained from the first regression, are used in place of their observed values to estimate the structural form coefficients. This two-stage procedure avoids the simple one-stage least square bias and inconsistency in the estimates by eliminating from the explanatory endogenous variables whose part of the variation is due to the disturbance. However, before going to interpret the estimation results of the simultaneous equation models, the statistical summary and correlation matrix of the variables are given in Tables 2 and 3.

Table 2: *A Statistical Summary of the Key Variables*

Variables	*Mean*	*SD*	*Min*	*Max*
LPd	8.895	1.616	6.138	18.777
k/l	11.1145	4.111	1.51	17.927
k	12.808	3.861	1.934	20.742
FORP	0.261	1.420	0	0.962
RDI	0.003	0.007	0	0.062
TMI	0.017	0.019	0	0.166
TGAP	0.705	0.564	0	1.875
*MCON*FORP*	0.044	0.202	0	2.935
MSIZE	9.073	1.892	2.549	13.892

Note: Mean = simple average; SD = standard deviation; Min = minimum; and Max = maximum.
Estimates of *LPd*, *k/l*, *k* and *MSIZE* are logarithmic transformation of their value. The other variables are converted into logarithmic form as ln(1+x) where x is the variable. No. of observations, NT=288.

Table 3: *Correlation Matrix of the Variables*

	LPd	*k/l*	*k*	*FORP*	*MCON* FORP*	*TGAP*	*RDI*	*TMI*	*MSIZE*
LPd	1								
k/l	0.480	1							
k	0.342	0.783	1						
FORP	-0.128	-0.375	-0.496	1					
MCON FORP*	0.011	-0.132	-0.211	0.363	1				
TGAP	-0.110	0.181	0.201	0.018	-0.056	1			
RDI	0.022	-0.004	-0.010	0.081	-0.042	0.000	1		
TMI	0.042	0.130	0.070	-0.058	-0.033	0.049	-0.062	1	
MSIZE	0.485	0.371	0.637	-0.122	-0.081	0.043	0.195	-0.023	1

Source: Author's computations are based on data sources described in the Appendix. No. of observations, NT=288.

5. Estimation Results

The regression results relating to determinants of productivity and technology spillover are reported in Table 4. We start by examining if there are positive spillovers from FDI in Indian manufacturing industries. Followed by examining the spillovers from FDI, we examine the determinants of foreign presence across Indian manufacturing industries. Going through the results, the scale variables as capital intensity and capital are significantly different from 0. This suggests that size and scale variables have significant impact to the value addition of productivity and technology spillover across Indian manufacturing industries. The key significant variable to measure the spillover from foreign direct investment across host industry experience is foreign presence. It is generally presume that local participation with multinationals revel the MNCs proprietary knowledge and in that way facilities technology spillover to the host country local firms. Furthermore, the competitive pressure from FDI is likely to gravitate to the domestic firms in order to exist in the global market. Higher foreign establishments in an industry may increase competition and force domestic firms to become more efficient. Therefore, foreign presence with large extent is an important indicator of labour productivity and productivity spillover across Indian manufacturing industries. The three estimations of Eqn. (8) give different results for coefficients of foreign presence which has been reported in columns 2, 3, 4, and, 5 of Table 4.

From the first estimation results the coefficient of foreign presence is negative with statistically insignificant. This would be due to the presence of the multicollinearity problem between foreign presence and interaction term of foreign presence with market concentration. In the absence of a strong theoretical reason in favor of dropping one variable over the other, two alternative functional forms are estimated. On the other hand, the interaction term is dropped from Eqn. (8) and the equation re-estimated is reported in column 3 of Table 4. The coefficients of foreign presence are significantly different from 0 at the 5 and 10% level with the theoretically expected (positive) sign at OLS and 2SLS estimates. This suggests that there are positive effects, spillovers, on domestic establishments from foreign presence within the industry. Thus, we conclude that industries with foreign presence experience intra-industry spillovers from FDI.

For the impact of competition, the coefficient of market concentration reaches a positive sign and is statistically different from 0. This suggests that a highly concentrated market structure significantly impact on the value added per worker. Furthermore, the coefficients of interaction terms are theoretically expected positive sign. Large foreign share in a combination with market concentration are found to augment the productivity and spillovers in Indian manufacturing industries. In addition, empirical result further suggests that competition has an impact on the degree of spillover from FDI. One explanation could be that the higher the competition between local and foreign firms the more technology has to be brought into make them competitive and larger is the scope for spillovers.

Table 4: *Determinants of labour productivity in locally owned industries of Indian manufacturing* (*Dependent variable: LPd)*

(1)	(2) OLS	(3) OLS	(4) 2SLS	(5) 2SLS
Intercept	1.803* (0.060)	1.813* (0.067)	1.813* (0.067)	2.804*** (1.513)
k/l	0.128* (0.018)	0.128* (0.018)	4.391*** (5.174)	-1.066 (1.154)
k	0.039*** (0.029)	0.033*** (0.028)	8.827 (1.025)	-3.574 (3.483)
FORP	-0.007 (0.014)	0.009** (0.005)	1.034*** (2.824)	7.645 (2.164)
*MCON*FORP*	0.132 (0.107)		6.424*** (1.033)	1.186*** (1.144)
MCON		0.063 (0.078)		
TGAP	-0.047* (0.014)	-0.048* (0.014)	-5.205 (2.234)	
*TGAP*FORP*				-7.264 (2.992)
RDI	0.452*** (1.025)	0.505** (1.037)	4.241*** (3.153)	-3.043 (2.832)
TMI	0.138*** (0.394)	0.159** (0.395)	4.043*** (6.391)	2.856** (4.114)
Adj. R^2	0.569	0.567	0.542	0.553
F-statistics	16.13*	15.95*	16.0*	16.32*
Observations	288	288	288	288

Notes: Numbers in parenthesis are standard errors and *, **, and *** indicate the level of statistical significance at 1%, 5%, and 10%, respectively. The instrument variables are *FORP, MCON*FORP, TGAP, RDI, TMI*.

We continue our analysis in Table 4 by examine the effect of technological gap on spillovers from FDI. According to Findlay (1978) we would expect domestic establishments in industries lagging far behind foreign technologies to benefit relatively much from FDI. Furthermore, a small technological gap seems to spur spillovers from FDI. In addition, some technological difference is required for spillovers to take place, and at an initial stage the degree of spillover may rise with size of technological gap. However, beyond a certain level, the gap may be so large that it will be difficult for the domestic firms to absorb foreign technology with their existing experience, educational level and technological knowledge (Sjoholm, 1999). From this exercise, the coefficients of technological gap are statistically significant with theoretically expected (negative) sign. This suggests that given the level of foreign presence and TFP, a locally owned industry that exhibits laggard technological capability relative to a foreign firm tends to exhibit lower technology spillover and lower labour productivity across Indian industries.

Kokko (1994) made an interaction term with the degree of foreign presence and various proxies on technological gap. Large foreign share in combination with a high technological gap prevent technology spillovers and labour productivity. We conducted a similar estimation with an interaction of foreign presence and technology gap, but found no clear results. Though, the coefficient is negative but statistically insignificant. Apart from this estimated results, it further suggests that larger technological gap with foreign presence can prevent the productivity and spillover in Indian industries.

Knowledge and technology spillover can be transmitted via the quality and variety of intermediate inputs, predominantly explained by R&D intensity and technology import intensity. It is argued that firms' absorptive capacity is crucial for realizing technology spillovers (Girma, 2005). R&D is often represented as an important indicator of local firms' absorptive capacity. The coefficients of R&D intensity and technology import intensity are found to be positive and significant. This suggests that both R&D expenditure and technology up-gradation are crucial conduit for productivity spillover in Indian industries. R&D expenditure and technology intensity are increasingly viewed as a key determinants of total factor productivity and, hence, of technology spillover. Thus, it is evident that industries with higher R&D expenditure and more technology up-gradation experience higher productivity and technology spillover. Furthermore, higher technology import intensity of an industry facilitate the assimilation of knowledge embodied in imported technology and, thereby, raise the absorptive of localized firms and can boost higher technology spillover across Indian manufacturing industries.

Table 5 presents the regression results relating to determinants of foreign presence in Indian manufacturing industries. Due to the presence of endogeneity problem between labour productivity and foreign presence and simultaneity bias in the model, the single equation 2SLS estimate has been preferable. It is presume that higher the size of the domestic market larger is the scope of foreign investment from abroad. The coefficients of market size are found to be positive and significantly different from 0. This suggests that in a large open economy especially the country like India can be able to attract more foreign capital into Indian manufacturing industries. Furthermore, bigger economy with wide extent of consumer market can attract huge foreign investment into the host country like India.

Table 5: *Determinants of foreign presence in Indian manufacturing Industries*
(*Dependent Variable: FORP*)

(1)	(2) OLS	(3) 2SLS
Intercept	1.685*** (1.224)	1.676*** (3.671)
LPd	0.856*** (0.612)	6.437* (1.331)
TGAP	-0.001 (0.037)	-2.712 (8.149)
RDI	4.130** (11.284)	1.91*** (2.456)
TMI	2.909 (4.240)	1.737*** (9.201)
MSIZE	0.07*** (0 .396)	7.397* (8.591)
Adj, R^2	0.11	0.12
F-statistics	1.62***	1.56**
Observations	288	288

Notes: Numbers in parenthesis are standard errors and *, **, and *** indicate the level of statistical significance at 1%, 5%, and 10%, respectively. The instrument variables are *MSIZE, LPd, TGAP, RDI, TMI*.

We further continue by examining whether foreign presence is affected by the size of the technological difference between local and foreign firms. Going through the results, the coefficients of technological gap are found to be negative but insignificant. Due to this statistically insignificant result we do not come to a clear conclusion. Although the coefficients of technological gap are negative at OLS and 2SLS estimates but statistically not significant. Moreover, we can say that higher the technological difference between local and foreign firms, then lower would be the technology spillover. If the gap becomes higher then local firms cannot learn the frontier technology from the leader firms. Furthermore, if the local firms do not come under a threshold level of existing technology, then in that case foreign investors are not interested to invest in the host country industries.

The coefficient associated with labour productivity is positive and significantly different from zero. This suggests that high productive domestic sectors can attract more foreign capital. It is hypothesized that FDI is likely gravitates to the highly productive domestic sectors with cheapest labour. Furthermore, low cost of labour 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. It is evident from this empirical exercise that higher R&D investment with large extent of technology upgrading firms can attract more foreign capital into that industry. In addition, R&D intensity of host country industries are providing adequate infrastructure for foreign investors to invest large extent of foreign capital into the industries. Moreover, R&D investment and technology upgrading firms can crate direct as well as indirect benefit to the foreign investors and demand push profit in the global market. Ultimately, more rivalry, more innovating, and more technology up-grading firms can create conducive atmosphere for foreign investors. Therefore, FDI is likely to gravitate to the host industry where local firms are busy in innovation and technology up-gradation.

6. Concluding Remarks

This paper has examined the FDI and its technology spillovers effect and the determinants of foreign direct investment (FDI) across Indian manufacturing industries. The primary objective has been to find out the technology spillover of FDI and the determinants of FDI across Indian manufacturing industries. In order to allow for the simultaneity between industrial labour productivity and the foreign presence, this study uses a system of two equations (productivity/technology determinants and FDI determinants) to find out the technology spillover in Indian manufacturing industries. After documenting the two equation models, the regression results suggests that foreign presence played a significant role in lifting the technology spillovers in Indian industries. Furthermore, foreign presence has been positively linked with labour productivity, knowledge and technology spillovers. We confirmed that foreign presence through MNCs can impact positively the productivity of local firms. In sum, the results suggest that foreign presence by way of FDI brings new channels of knowledge and technology diffusion to local firms and, further, it can facilitate higher productivity through technology spillovers.

We also find evidence that total factor productivity (TFP) is a positive function of the R&D intensity and technology import intensity (TMI). Technology spillovers has been transmitted via different types of intermediate factors and the regression result suggests that a rise in the TMI gained momentum for improvement of the labour productivity of domestic firms and technology spillovers across Indian manufacturing industries. Furthermore, R&D intensity and TMI can facilitate in raising the knowledge and technology diffusion in Indian industries through the channel of imports. We also show that size and scale factor like capital stock and capital intensity stimulate the value addition of labour in Indian industries. In addition, the interaction term has played an important role to facilitate the enhancement of labour productivity and technology spillovers of domestic firms. We further find that larger technological difference between foreign firms and local firms prevents the technology spillover and productivity in Indian industries.

From other aspects of the study, we show that highly productive domestic sectors able to attract large extent of foreign capital into that sectors. We find evidence that bigger market size and large consumer growing market especially the country like India can attract huge foreign investment into the manufacturing sectors. Furthermore, we find that high potential to invest in R&D and innovation and more technology up-grading firms can attract huge amount of foreign fund from abroad. Thus, foreign investors are interested to gravitate to the host country industry in India those who are using more funds in R&D and technology up-gradation.

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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

Labour productivity

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

Capital (*k*)**:** For the present study, to construct the capital variable from the Prowess data set we followed the methodology, derived by Srivastava (1996) and Balakrishnan *et* al. (2000). They used the perpetual inventory method, which involves capital at its historic cost. Thus, the direct interpretation of the perpetual inventory method is not an easy task. Therefore, 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 *et* al. (2000) to arrive at a revaluation factor. The revaluation factors R^G and R^N for initial year's gross and net capital stock, respectively, have been obtained as follows:

The balance sheet values of the assets in an initial year have been scaled by the revaluation factors to obtain an estimate of the value of capital assets at replacement cost.[9] 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:

$$GFA_t^h = P_t I_t * ((1+g)(1+\pi)/(1+g)(1+\pi)-1)$$

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

[9]See Srivastava (1996, 2000) for detailed discussion of the perpetual inventory method to compile the real gross capital stock from the CMIE based Prowess data set.

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.

Labour (*l*)**:** 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 labour 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.[10] 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/l*): Capital intensity at the firm level can be obtained by dividing the real gross capital to the labour 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' labour of an industry.

[10]For the present analysis when we compiled the labour variable from CMIE based Prowess data set 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***):** 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***):** Technological gap between foreign firms and local firms is proxied by the ratio of average value added per worker of the foreign firms to that of local firms.

Interaction variable **(***MCON*FORP***):** For the present study to measure the market concentration, we take 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***:** 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 as an industry-specific variable, we measured the total R&D expenditure over the firms by summing R&D expenditure over all firms in an industry, and divide by the total sales of all firms by again summing the sales of each firm of that industry, for that specified period.

Technology Import Intensity (TMI)

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 this is considered as remittances on royalty and license fees. Hence, the TMI at the firm level can be obtained by dividing the summation over embodied and disembodied technology to the total sales of the firm. To calculate the technology import intensity as an industry-specific variable, we divide the sum of the total disembodied and embodied technology over all firms in an industry to the total sales of that industry by again summing the sales of all firms for a specified time period.

Market Size *(MSIZE)*:

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

Serial No.	*NIC (1987) CODE*	*Industry Group*	*Domestic Firms*	*Foreign Firms*	*Total Firms*	*% of foreign firms*
1	20-21	Food Products	146	12	158	7.59
2	22	Beverages and Tobacco	85	4	89	4.49
3	23	Cotton Textiles	307	4	311	1.28
4	26	Textiles	245	13	258	5.03
5	27	Woods Products	20	1	21	4.76
6	28	Paper and Paper Products	40	5	45	11.11
7	29	Leather Products	14	1	15	6.66
8	30	Chemicals	410	77	487	15.81
9	304(30)	Drugs and Pharmaceuticals	117	21	138	15.21
10	312(31)	Rubber and Rubber Products	12	2	14	14.28
11	32	Non-metallic Mineral Products	96	14	110	12.72
12	34	Metal Products	176	24	200	12
13	35	Non-Electrical Machinery	229	26	255	10.19
14	36	Electrical Machinery	226	21	247	8.50
15	365(36)	Consumer Electronics	6	2	8	25
16	375	Automobiles	19	4	23	17.39
		Total	2148	231	2379	9.70

Source: *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).

References

Ambos, T. C., B. Ambos, and B. B. Schlegelmilch (2006). Learning from Foreign Subsidiaries: An Empirical Investigation of Headquarters Benefits from Reverse Knowledge Transfers. *International Business Review*, 15, 294-312.

Amiti, M. and Konings, J. (2007). Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia. *American Economic Review*, 97, 1611-1638.

Ang, J. (2009). Do Financial Sector Policies Promote Innovative Activity in Developing Countries? Evidence from India, MPRA Paper No. 14495, http://www.mpra.ub.uni-muenchen.de/14995/

Athreye, S. and Kapur, S. (2006). Industrial Concentration in a Liberalizing Economy: A Study of Indian Manufacturing. *Journal of Development Studies*, 42, 981-999.

Balakrishnan, P., Pushpangandan, K. and M. S. Babu (2000). Trade Liberalization and Productivity Growth in Indian Manufacturing: Evidence from Firm Level Panel Data. *Economic and Political Weekly*, 35, 3679-82.

Borensztein, E., De Gregorio, J., and Lee, J. W. (1998). How Does Foreign Direct Investment Affect Economic Growth? *Journal of International Economics*, 45, 115–135.

Coe, D.T. and Helpman, E. (1995). International R&D Spillovers. *European Economic Review*, 39 (5), 859-897.

Easterly, W. (1993). How much do Distortions affect Growth? *Journal of Monetary Economics*, 32, 187–212

Findlay, R. (1978). Relative Backwardness, direct foreign investment, and the transfer of technology: a simple dynamic model. *Quarterly Journal of Economics*, 92(1), 1-16.

Fosuri, A., Motta, M., and Ronde, T. (2001). Foreign Direct Investment and Spillovers through Workers' Mobility. *Journal of International Economics*, 53, 205-222.

Girma, S (2005). Absorptive capacity and Productivity Spillover from FDI: A threshold regression Analysis. *Oxford Bulletin of Economics and Statistics*, 67(3), 281-306.

Hall, R. E. (1988). The Relation between Price and Marginal Cost in US Industry. *Journal of Political Economy*, 96, 921-947.

Hamilton, J. D., and Monteagudo, J. (1998). The Augmented Solow Model and the Productivity Slowdown", *Journal of Monetary Economics*, 42, 495-509.

Helpman, E (1997). R&D and productivity: the international connection. NBER Working Paper No. 6101, Cambridge, MA.

Intriligator, M., Bodkin, R., & Hsiao, C. (1996). *Econometric models, techniques and applications* (2nd ed.). New York: Prentice Hall.

Jones, C. I. (1998). *Introduction to Economic Growth*. New York, Norton.

Kokko, A. (1994). Technology, Market Characteristics, and Spillovers. *Journal of Development Economics*, 43, 279-293.

Kophaiboon, A. (2006). Foreign Direct Investment and Technology Spillover: A Cross-Industry Analysis of Thai Manufacturing. *World Development*, 34, 541-2006.

Kwark, N.S., and Shyn, Y.S. (2006). International R&D Spillovers Revisited: Human Capital as an Absorptive Capacity for Foreign Technology. *International Economic Journal*, 20, 179-196.

Lichtenberg, F., and Van Pottelsberghe de la Potterie, B. (1998). International R&D Spillovers: A Comment. *European Economic Review*, 42, 1483-1491.

Madsen, JB., Saxena, S., and Ang, JB. (2010). The Indian growth miracle and endogenous growth. *Journal of Development Economics*, 93(1), 37-48.

Mankiw, G., Romer, D., and Weil, D. N. (1992). A Contribution to the Empirics of Economic Growth. *Quarterly Journal of Economics*, 107, 407–437.

Pindyck, R. S., and Rubinfeld, D.L. (1998). *Econometric models and economic forecasts* (Fourth Ed.). Irwin McGraw-Hill.

Romer, P. M. (1990). Endogenous Technological Change. *Journal of Political Economy*, 98, S71 - S102.

Sjoholm, F. (1999). Technology gap, Competition and Spillovers from Direct Foreign Investment: Evidence from Establishment Data. *The Journal of Development Studies*, 36, 53-73.

Srivastava, V. (1996). *Liberalization, Productivity and Competition: A Panel Study of Indian Manufacturing*, Oxford University Press, New Delhi.

Srivastava, V. (2000). The Impact of India's Economic Reforms on Industrial Productivity, Efficiency and Competitiveness, Report of a project sponsored by the Industrial Development Bank of India, New Delhi, National Council of Applied Economic Research.

Wooldridge, J. M. (2002). *Econometric analysis of cross section and panel data*. Massachusetts: MIT Press.

Xu, B. (2000). Multinational Enterprises, Technology Diffusion and Host Country Productivity Growth. *Journal of Development Economics*, 62, 477-493.