

SPIILLOVER EFFECTS OF TECHNOLOGY
TRANSFER TO INDIA: An Econometric Study

(Some Preliminary Results)

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SPIILLOVER EFFECTS OF TECHNOLOGY TRANSFER : An Econometric
study for India^{*}
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Abstract:- Using detailed (unpublished) firm-level data from Indian manufacturing industry, this paper examines the relationship between foreign investment in a sector and productivity of domestic firms in the same sector. The results suggest that the dispersion (average deviation from the most efficient firm) of productivity is smaller in sectors with more foreign firms. However, the spillovers are positive only for the firms belonging to low-technology sectors (where the technology-gap between domestic and foreign firms is not high).

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1.0 Introduction

Teece (1977), argued that the economic growth of every nation is inextricably linked to the successful international transfer of knowledge. Substantial resources are required to make a new process or product feasible (Mansfield, 1968). This resource requirement enhances the role of technology transfer in the economic growth of developing countries who are generally financially starved and scarce in human capital (the two basic inputs required for the inventive process). Developing countries need not reinvent-the-wheel but adopt the technology as most of the technologies are available off-the-shelf. The adoption of technology also involves substantial costs to the recipient (Tuma, 1987). This high cost of the technology adoption is because of the tacitness or disembodied form of the technology. However, the cost of technology transfer can be brought significantly down if the externalities associated with it are effectively harnessed.

The externalities or spillovers of technology transfer may influence both the structure of the industry and the conduct and performance of domestically-owned firms. Based on their influence on industry, spillovers can be broadly classified into two categories - intra-industry and inter-industry spillovers.

a In the present paper, the terms FDI (foreign direct investment) and MNCs (Multinational Corporations) have been used interchangeably.

One of the most important channels through which intra-industry spillovers may occur is competition induced increase in productivity of the domestic firms. The newer and advanced technology requires investment in physical and human capital by the receiver in order to effectively use the technology. However, this forces the other players in the market to invest or to use their resources efficiently in order to stay in the competition. Dunning (1993) argues that this is the most widely acknowledged spillover benefit of technology transfer. The other benefits within an industry are faster diffusion of newer technology because of demonstration effect, and the availability of skilled labour to the economy as a whole. However, inter-industry spillovers are overall improvement in the productivity and better quality standards because of forward- and backward- linkages created by the use of newer and advanced technology. An important spillover of FDI (foreign direct investment) is that because of the multi-market presence of foreign firms, they may act as a natural conduit for information about foreign markets, thereby, spurring the local export activity. Rhee and Belot (1990) in their study of a number of low income countries found that the presence of a single multinational company proved to be catalytic in spurring local export activity. Lastly the improved managerial practices - JIT (just-in-time), QA (Quality Assurance), QC (Quality Circles), etc., which are pre-requisites for effective and efficient use of the newer technology, may spill over to the rest of the industry.

Various empirical and case studies have confirmed the "direct" gains of technology transfer to the recipient firm. However the evidences on "indirect" benefits of technology transfer are fairly mixed. Beginning with Caves (1974)- for Australia, Globerman (1979)-

for Canada, Blomstrom and Persson (1983)- for Mexico, Wolff & Blomstrom (1989)- for Mexico, Blomstrom & Kokko (1992)- for Mexico, all have found weak but positive spillover impact of foreign presence on the productivity of local firms. On the other hand, Caves (1974)- for Canada, Blomstrom (1986)- for Mexico, Haddad & Harrison (1993)- for Morocco and Aitken & Harrison (1994)- for Venezuela have found either negative or no spillovers from FDI. The major drawbacks with most of these studies is that they captured only the spillover associated with foreign direct investment (FDI). Since licensing (arm's length of technology transfer) was more widely practiced channel of technology transfer for the developing countries till late 80's, the results of previous studies might be under-stating the true spillover benefits. Further, with the exception of two (Haddad & Harrison - for Morocco and Aitken & Harrison - for Venezuela), rest of the studies used cross-section data and tested for spillover hypothesis on labour productivity only, which can at the best be viewed as a partial measure.

Against this backdrop, the aim of the present study is to find out how the firms in the Indian industry have benefited indirectly from either of the means of technology transfer (i.e., FDI or arm's length transaction). The study has an added relevance in the present global context as not only India but other developing countries also have recently "opened their doors" to the multinationals who are supposed to bring in new and advanced technology in an unprecedented large scale. The emphasis on selectivity in allowing FDI in the past has given way to increasing the magnitude of FDI. The study covers a time span of 5 years from 1984-85 to 1988-89 covering 388 firms belonging to 8 different sectors. The results to be obtained can have significant implications for further policy changes. If spillovers are found significantly positive then an open-door industrial and trade policies similar to the one adopted by Singapore is worth pursuing. A negative spillover, on the other hand, makes the case stronger for a judicious mix of open as well as closed-door policies as pursued by South Korea on her road to industrialisation.

The structure of the paper is as follows: Section 2 discusses briefly about the model(s) to be estimated to test spillover hypothesis. Construction of variables and the data used in the study is discussed in section 3. Section 4 compares the relative performance of local and foreign owned firms followed by statistical results of the models in section 5. The paper ends by drawing some conclusions and policy implications of the study in section 6.

2.0 Models Specifications

2.1 Technology Spillover

Dunning (1993) argues that "perhaps the most widely acknowledged spillover effects of MNE activity are its impact on the competitive position of the industry (or strategic group) of which it is part and on the performance of individual firms".

This implies that increased competition caused by the entry of MNCs, forces the local inefficient firms either to be more productive by investing in physical or human capital, or to leave the industry. The logical fallout of this is reduced dispersion (fall in productivity

deviation between most efficient firm and rest of the firms) of overall productivity in the industry.

In this paper an attempt has been made to test the following hypothesis - the influence of foreign presence on the dispersion of productivity levels of domestic firms.

2.2 Influence of Foreign Direct Investment/Technology Transfer on the Dispersion of Productivity

Using panel data, Schmidt and Sickles (1984) have suggested a way to estimate the firm-specific productivity. If Y (valued added) is a function of two inputs, say labour (L) and capital (K), then

$$(1) \quad Y_{ijt} = A_{ij} F(L_{ijt}, K_{ijt}).$$

Where A_{ij} is a level of productivity which is assumed to vary across firms as each firm is a distinct identity, behaving differently even in similar conditions because of their routines and past behaviour.

For each sector, the model becomes:

$$y_{it} = a_i + b'x_{it} + e_{it} \quad (i= 1,2,\dots,N \text{ and } t = 1,2,\dots,T).$$

Where N is the total number of firms and t is the time period. y_{it} is the log of value added for ith firm at time t, x_{it} is a matrix of log of inputs, b' is a vector of constant parameters to be estimated and a_i is a vector of intercepts separate for each firm and is invariant over time. Without imposing the assumption of uncorrelatedness of a_i with the regressors, Schmidt and Sickles (1984) specified a simple method called as "Dummy variables" or "within estimator" where a_i for each firm i is obtained by including dummy variables which takes the value 1 for the corresponding i and 0, otherwise.

The level of multi-factor productivity can be examined relative to the level as achieved by the most efficient firm in each sector j. For N firms, there would be N estimated productivity measure within each sector j, given by $a_{1j}, a_{2j}, a_{3j}, \dots, a_{Nj}$. Defining $a_j = \max(a_{ij})$, as the productivity of most efficient firm in the industry then relative efficiency for a firm i is given by

$$(2) \quad z_{ij} = a_{ij} - a_j \quad (i = 1,2,\dots, N).$$

A high value of z_{ij} in absolute terms implies that firm i is very inefficient relative to the most efficient firm in the sector j. Further, u_{ij} is defined as deviation of firm- level productivity from the sector's best practice frontier, where $u_{ij} = z_{ij}/a_j$, $i = 1,2,\dots,N$.

To test the spillover hypothesis of technology transfer on the dispersion of productivity following equation is used:

$$(3) \quad u_{ij} = f(\text{FDI_firm}_{ij}, \text{ALT}_{ij}, \text{FDI_sector}_j).$$

Where FDI_firm and FDI_sector are the variables accounting for the foreign presence in the firm and the industry respectively. ALT is the variable explaining technology transfer through channels other than FDI (eg., licensing, technical assistance etc.) However, a large size firm is expected to show less deviation from the most efficient

firm because of its ability to reap the economies of scale. The above equation need to be modified to control for the size of the firm. The revised equation becomes:

$$(4) \quad u_{ij} = f(\text{FDI_firm}_{ij}, \text{ALT}_{ij}, \text{FDI_sector}_{j}, \text{SIZE}_{ij}).$$

For firms having no foreign equity participation (Non-FDI firms), the equation to be estimated would be:

$$(5) \quad u_{ij} = f(\text{FDI_sector}_{j}, \text{SIZE}_{ij}).$$

In the present study, a significantly positive value of coefficient of FDI_sector has been taken as an indication of existence of positive spillovers.

The estimation of all the above equations has been done by the Ordinary Least Squares (OLS) technique. The construction of the variables and the data used in estimation has been explained in the next section.

3.0 Data and Variables

The study uses the Reserve Bank of India (RBI) data tapes on the finances of large public limited companies with paid-up capital of Rs. 10 million or more. The data has been provided by Institute for Studies in Industrial Development (ISID), Delhi. The data is for the years 1984-85 to 1988-89 and covers nearly 90% of the large companies of India. However, the present analysis uses data for only 388 companies belonging to 8 major industries. The distribution of companies analyzed among the eight sectors is as follows: textiles - 69, automobiles and transport equipment - 32, electrical machinery - 44, non-electrical machinery and machine tools -62, metal products - 45, chemicals - 97, cement - 21, and paper & paper products - 18. Though at the start of the analysis around 432 companies were considered, but to have greater homogeneity in the data set some companies, which had exceptionally high growth rate of value added (75% or more) or exceptionally high negative growth rate (-25% or less), were excluded from the analysis. Some companies were left out as they had negative value added for a particular year.

In order to have realistic estimates, price corrections have been made to get the output and input data at constant prices. Gross value added has been taken as a measure of output. Wholesale price indices (WPI) for respective 3 digit industry classification has been used to bring the output at fixed 1984-85 prices. A measure of labour input has been derived first by forming a composite wage rate index of skilled (using growth rate of wage and salaries) and unskilled workers (using consumer price index, CPI for industrial workers) separately for each firm. This composite wage index has been used further to derive a measure of labour input from the data on labour income. Due to change in the definition of skilled or high income employees from 1988-89 onwards (Rs 3000/ p.m. to Rs 6000/p.m.), the study has used data till 1987-88 for constructing the composite wage index.

Gross fixed capital stock is taken as a measure of capital input. Investment in each year is deflated to bring it to 1984-85 prices and then summed to find the total investment in the period of analysis. The gross fixed assets for 1984-85, which were at their purchase

prices, are adjusted to bring them to 1984-85 prices. In absence of the knowledge of exact age distribution of the capital assets for a particular firm as on 1984-85, a simple average of the price index of machinery from 1971-72 to 1984-85 has been computed and is used to inflate the reported capital stock figure (for 1984-85) to bring it to 1984-85 prices. The limitation of this methodology might tend to over-estimate the capital stock in 1984-85 and thus underestimate the growth rate in capital input.

In the absence of data on foreign equity participation of the firm, the share of dividends declared in foreign currency to total dividends paid has been used as a measure of foreign equity participation. A firm having this ratio greater than 25 % for at least 3 years during 5 years of the study period is considered as a foreign owned firm. Table 1 gives the definitions and measures employed to construct the variables used in estimations.

Table - 1

Description of the variables used in the estimations

Variable	Description
FDI_firm	F_dm = 1, if share of dividends declared in foreign currency to total dividends declared for at least 3 years is $\geq 25\%$ and 0, otherwise.
FDI_sector	Ratio of industry sales of firms having F_dm = 1 to the total sales of the industry for a particular year.
ALT	Arm's length technology import intensity, Expenditure on royalty, technical fee, licensing fee, and lumpsum payments as a ratio of sales turnover.
RD	R&D intensity, Research and development expenditure as a ratio of sales turnover.
CGI	Capital goods import intensity, Ratio of capital goods imports to fixed investment.
SIZE	Size of the firm, Ratio of firm sales to the sales of the largest firm in the industry.

4.0 Comparative Performance/Behaviour of Domestic and Foreign Firms

Table 2, compares the relative performance of two group of firms. The indicators used to compare the relative performance are - export intensity (exports as a percentage of total sales), extent of vertical integration (ratio of gross value added to total sales), employee compensation behaviour (share of salaries and wages of high income employees to total salaries and wages), deviation of multifactor productivity (MFP) from the most efficient frontier, and total factor productivity (TFP) growth. Table 2 reports the performance indicators as a ratio of foreign- firm performance to domestic-firm performance. Results for only seven sectors have been tabulated as in textiles sector there is no foreign firm. Based on first set of figures, it seems that foreign firms are more vertically integrated, and are more productive than their local counterparts as in 5 out of 7 sectors the ratio of z_{ij} is less than one. Column 3 shows that foreign firms pay relatively higher salaries as in 6 out of 7 sectors, the ratio is greater than one. This superior behaviour of foreign firms in respect of employee's compensation may be either because of their pay policies or the qualitative differences in the skill composition of their employees. However, data limitation restrained the study from exploring this aspect further. In terms of export

intensity nothing can be said conclusively as domestic firms are export oriented in as many sectors as foreign firms.

Table - 2
Comparison of Behaviour/Performance of Two Group of Firms

INDUSTRY	Export/ Sales ^a (1)	GVA/ Sales ^a (2)	HIE ^{ca} (3) (3)	TFP deviation ^b (4)	TFPG _f - TFPG _d (5)
Automobiles	0.92 (1.30)	1.04 (1.46)	1.02 (1.44)	0.99 (0.70)	2.08
Electrical Machinery	0.89 (0.45)	1.13 (0.57)	2.82 (1.41)	1.02 (2.04)	-7.68
Non-electrical Machinery	1.05 (1.24)	1.12 (1.32)	2.93 (3.46)	0.87 (0.74)	-12.61
Metal Products	0.25 (0.28)	1.66 (1.86)	2.12 (2.38)	1.15 (1.03)	4.81
Chemicals	3.12 (2.61)	1.05 (0.88)	2.10 (1.76)	0.71 (0.84)	-4.10
Cement	0.21 (0.57)	1.37 (3.72)	0.78 (2.11)	0.18 (0.06)	-4.77
Paper	3.61 (5.40)	1.32 (1.98)	1.79 (2.68)	0.97 (0.65)	6.58

- a Ratio of performance for foreign owned to domestic owned firms.
- b Ratio of average deviation of foreign firms productivity from best-practice frontier to average deviation of domestic firm productivity. A value of less than one indicates foreign firms deviate less from the best-practice frontier.
- c Ratio of average share of salary and wages of high income employees (HIE) in total salary of two group of firms.

The shortcoming with the first set of results is that they are unweighted averages. The superior performance of a particular group of firms in a sector may be due to their size. In order to correct for the size differences, the indicators were re-calculated to produce weighted means - with weights given by total sales. The figures given in parentheses in table 2 are the weighted means of the various performance indicators. Except for vertical integration, rest of the results remain the same. Results show that after controlling for firm's size domestic firms appear to be more vertically integrated in electrical machinery and chemicals sectors. Using both weighted and unweighted means, it appears that, on average foreign firms pay higher salaries and have achieved a higher level of productivity.

If foreign firms have achieved higher level of productivity, then their growth of productivity is likely to be lower. This is because in order to stay in competition domestic firms would try to catch up with their foreign counterparts. Result shown in 5th column substantiates this. The growth rate of productivity of foreign firms is lower in the sectors where there level of productivity is higher than that of domestic firms.

In summary, table 2 suggests that there are some differences in behaviour and

performance between domestically-owned and foreign-owned firms. Foreign firms are more productive, relatively more vertically integrated and pay higher salaries, even after controlling for size of the firm.

5.0 Statistical Results

Impact of Foreign Direct Investment/Technology Transfer on the Dispersion of Productivity

The results of the equation (4) to estimate the impact of foreign investment on the dispersion of productivity are reported in table 3. The positive and statistically significant coefficient of foreign dummy implies that joint ventures or firms having foreign equity participation exhibit less deviation from most-efficient productivity levels than the domestic firms. Even the firms engaged in technology transfer through arm's length transaction seem to have benefited (positive and significant coefficient of ALT). The positive and highly significant coefficient of sector level investment variable suggests that sectors having large foreign presence have smaller deviation from maximum productivity levels. One plausible explanation, similar to the one given by Dunning (1993) is that foreign firms induce greater competition, thereby forcing inefficient firms either to improve their productivity or to exit. A coefficient of .0043 on the sectoral foreign share variable suggests that if foreign share is increased by 10%, firms would be 7 % closer to best practice frontier. Surprisingly, the coefficient of size came out to be negative but statistically insignificant. The negative sign can be due to the fact that till 1991, the prevailing license or quota system prevented companies to expand and reap the economies of scale. The large size might be due to the large scale diversification strategy pursued by these companies.

The explanatory power of the model and the significance level of the coefficient remains same even after introducing firm specific characteristics like R&D intensity (RD) and capital goods import intensity (CGI).

To check for spillover hypothesis, the model (equation 5) was run separately for non-fdi firms (firms having no foreign equity participation). Column 4 to 6, of the table 3 reports result for non-fdi firms. Highly significant and positive sign of the sector fdi variable implies that firms in the sectors having large foreign investment exhibit smaller dispersion in the productivity levels, thereby, indicating presence of positive spillovers. However, firm specific characteristics again do not seem to have any significant impact on the productivity level (column 6).

Table - 3

**Impact of foreign ownership on the level of firm
productivity, defined as the deviation from sector level
best practice performance (dependent variable: u_{ij})**

	All Firms ^a			Non-FDI		
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	-0.72011 (0.017477)	-0.71344 (0.016886)	-0.72226 (0.016830)	-0.72123 (0.018896)	-0.72120 (0.017747)	-0.72319 (0.017872)
F_dm	0.055363 (0.024121)		0.055096 (0.024091)			
FDI_sector	0.0043423 (0.000544)	0.0050416 (0.0005077)	0.0042304 (0.000548)	0.0047613 (0.000589)	0.0047615 (0.000587)	0.0046132 (0.000604)
ALT	0.087492 (0.035018)		0.081268 (0.035198)			
Size	-0.599E-6 (0.00051)			0.3476E-05 (0.000613)		
RD			0.049721 (0.039173)			0.052347 (0.053754)
CGI			0.00014855 (0.0002846)			0.00012346 (0.000296)
N	388	388	388	288	288	288
R-square	0.2302	0.2035	0.2341	0.1869	0.1869	0.1901

a Standard errors in ().

In order to gain some insights that whether the lower dispersion of productivity in sectors with a high foreign presence is due to increased competition or the more rapid diffusion of new technology or both, the sample was divided in two sectors 'high' technology sector and 'low' technology sector. The classification of the sectors is based on OECD (1986) 3-digit classification of industries. The results, given in table 4, show that the influence of foreign investment in reducing the dispersion of productivity was more in the low technology sector. In other words, spillover seem to have occurred in the sector where the productivity gap between domestic and foreign firms is (was) not too big. This is in line with the argument as given by Lapan and Bardhan (1973) that spillovers are negatively related to the size of the technology gap. This suggests that competition proved important in pushing firms towards the most efficient frontier than the transfer of advanced technology. Cantwell (1989) for European countries and Kokko (1994) for Mexico, also

concluded that spillover occurs only in those industries where local technological capability is already strong. One thing to be noted from the results is that in high technology sector coefficient of size is negative though statistically insignificant. This supports the earlier argument that a firm of larger size is mainly because of its being diversified rather than reaping economies of scale in that area.

Table - 4

Impact of foreign presence on the level of productivity of domestic firms in high and low technology sectors (dependent variable: uij)

	Non-FDI Firms ^a High Technology Sector		Non-FDI Firms ^a Low Technology Sector			
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	-0.53922 (0.076442)	-0.52463 (0.073453)	-0.54420 (0.077395)	-0.75573 (0.024667)	-0.75506 (0.023382)	-0.75210 (0.024150)
FDI-sector	0.00046479 (0.0017702)	0.0001016 (0.001739)	0.00022823 (0.001784)	0.0113690 (0.001784)	0.011960 (0.003566)	0.011940 (0.003631)
ALT	0.043961 (0.042996)		0.044670 (0.043135)	-0.11463 (0.12863)		-0.084641 (0.11861)
Size	-0.000593 (0.000755)			0.00063219 (0.001066)		
RD			0.066071 (0.052296)			-0.0051083 (0.13238)
CGI			-0.000156 (0.000554)			0.00014912 (0.00037)
N	144	144	144	144	144	144
R-square	0.0116	0.00	0.019	0.079	0.0734	0.0778

a Standard errors in ().

The results remain same even after introducing firms specific characteristics (column 3 and column 6).

6.0 Conclusion

Comparison of performance between domestic and foreign owned firms reveal that, on average, foreign firms are more vertically integrated, pay higher salaries to high income employees or the skill content of their high income employees is more, and exhibit higher level of overall multifactor productivity. However, the rate of growth of productivity is higher for wholly owned domestic firms and both groups of firms are export oriented in equal number of sectors. Results also show that not only foreign owned firms, but firms engaged in licensing or any other form of arm's length technology transfer seem to exhibit higher productivity.

One of the reasons often cited to invite MNCs is that they induce competition, thereby forcing local firms to improve their productivity levels. Using a production function

technique, a spillover hypothesis that "foreign presence is associated with increased productivity in wholly domestically owned firms" was tested statistically. Results show that the sectors having high foreign presence have lower dispersion of productivity. But it is only in the low technology sectors like paper, metal products etc. where presence of foreign firms induces domestic firms to move near the most efficient frontier. This implies that for spillovers to occur the technology gap between domestic and foreign firms should not be too high.

Based on these preliminary results, it can be concluded that benefits do exist from foreign investment, but to mainly those firms which have foreign equity participation (direct gains of technology transfer). The indirect gains or spillovers to the domestic firms in the form of lower dispersion in productivity occur only in the low-technology sectors. However, the short duration of the period of study (5 years only) and limited data coverage (only large joint sector companies) restrains to conclude the same definitely. A study covering longer time period, besides sector specific case studies could shed more light as whether spillovers actually exist or not.

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