FDI and Technology Spillover: An Evaluation across Different Clusters in India

Smruti Ranjan Behera*

Abstract:
The present analysis tries to explore the impact of FDI particularly its technology spillover effect within or between selected industries of Indian manufacturing in different select clusters across four regions in India. To measure the spillover effect of a particular cluster this analysis develops an innovative production function which allows for measuring the inter-cluster technology spillover across different clusters in India. The specification of the production function is to measure the technology spillover across different clusters in India and its inter-cluster spillover analysis with respect to some basic parameter in the model. It accounts for the role of investment climate to measure the spillover effect of a particular cluster in India. The empirical findings reveal that some clusters benefit more from the foreign counterparts due to more technological stock in cluster/region and cluster-specific effect and other intermediate factors. Furthermore, technology spillover intensity in some clusters seems to be strongly affected by geographical location and the better investment climate of these regions.

JEL classification: O41, O1, L6, R12
Keywords: Foreign Direct Investment, Technology Spillover, Clusters, Firms location

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1. Introduction: One of the aims in attracting FDI by developing countries is improvement of regional development. Having firms locate in undeveloped and developed regions provides a direct impact in terms of employment and capital creation given the underutilization of resources prior to the entry, and a potential indirect effect via spillovers to local firms. Multinational firms operating in emerging markets transfer technology to local suppliers to increase their productivity and this transfer generates

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* Address for correspondence: Ph.D. Research Scholar, Department of Economics, Delhi School of Economics, University of Delhi, Delhi-110007, India, Tel-91-11-27666703 , Fax- 91-11- 27667159.
E-mail address: smrutibehera2003@gmail.com

greater competition and lower prices that benefit the entire economy. The primary motivation of the multinationals to transfer technology to suppliers is to enable higher quality inputs at lower prices. Multinationals could diffuse the technology widely–either by direct transfer to additional firms or by encouraging spillover from the original [2]recipient. Wide diffusion of technology would then encourage entry into the supplier market, thereby increasing competition and lowering prices. In fact, the multinational cannot prevent the upstream supplier's firms also selling to others in the downstream markets. The lower input prices and cheap accessing of labor in developing economies may induce entry and therefore more competition in downstream markets, which lower input prices and therefore more output. Pack and Saggi (2001) show theoretically that, as long as there is not too much entry, profits will rise in both downstream and upstream markets. If so, the new surplus generated from increased productivity and the deadweight loss reduced from increased competition will be split between consumers and producers in a Pareto-improving distribution.

Economic geography in an era of global competition involves a paradox. It is widely recognized that changes in technology and competition have diminished many of the traditional roles of location. Resources, capital, technology, and other inputs can be efficiently sourced in the international markets. Local firms can access the immobile inputs via the corporate networks. Thus, it is no longer necessary to locate near large markets to serve them. Governments are loosing their influence over competition to global forces, so it is easy to conclude that location is diminishing in importance. But, how far this hypothesis is correct for the developing economies rather is it hard to reconcile this with competitive reality. In the Competitive Advantage of Nations (Porter, 1990) the microeconomic-based theory of national, state, and local competitiveness in the global economy maintains that regional clusters have a prominent role to play.

[2] In the Empirical paper measuring technology spillover, the examples include Blomstrom and Wolff (1994), Haddad and Harrison (1993), Kokko (1994), Aitken and Harrison (1999), and Haskel (2002), etc.

Clusters are geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (like universities, standard agencies, trade associations) in a particular field that compete but also cooperate. Clusters or critical masses of unusual competitive success in particular business areas are a striking feature of virtually every national, regional state, and even metropolitan economy, especially in advanced nations (Porter, 1998). The regional clusters of a country represent a new way of thinking about national, state, and local economies, and to various levels of governments and for other institutions they represent new roles for companies in enhancing the competitiveness. Clusters represent a good deal of competitive advantage that lies outside companies and even outside their industries residing instead in the locations at which their business units are based. Thus, clusters represent a new unit of competitive analysis along with the firms and industries. Cluster thinking suggests that companies have a tangible and pivotal stake in the business environment where they are located in ways that go far beyond taxes, electricity costs, cost for the infrastructure, and wage rates. Thus, the local business environment and health of particular regional province is important for the technology spillover of the local competitor. The importance of clusters suggests new roles for government at the federal, state, and at the local level. Thus, sound macroeconomic policies are necessary but not sufficient for governments more decisive and inevitable influences are at the microeconomic level. Among, which removing obstacles to the growth and upgradation of the existing technology of domestic firms and the emerging clusters take on a priority.

Regional provinces are the driving forces for increasing exports and are magnets for attracting the FDI. Hence, clusters represent a new type of forum where a new type of knowledge and technology spillovers can be spread across domestic firms and it can be done with proper coordination between government agencies and local market institutions. The present analysis here tries to examine the technology spillover across ten selected clusters in India. To measure the technology spillover across the selected ten different clusters in India the study has taken seven broad two-digit level industries (chemicals, metal products, non-metallic mineral products, non-electrical machinery, electrical machinery, transport equipment, and textiles industry) and the clusters have been selected on the basis of plant location of both domestic and foreign firms. To measure the technology spillover in particular clusters, foreign firm's presence is the basic requirement in a cluster. Thus, clusters have been selected in different regions in India on the basis of foreign firm's representatives within that cluster. The corresponding plant locations of domestic/foreign firms of an industry are distributed across different regional clusters/provinces. The main purpose of this analysis is to evaluate the impact of FDI and its technology spillover effect in seven selected industries across different clusters in India and make an inter-cluster comparative spillover analysis for some basic clusters/regions by means of specific variables in the empirical model.

The study is organized as follows:

Section 2 describes the conceptual issues regarding technology diffusion of FDI which covers both forward and backward linkages in the upstream and downstream markets. Section 3 presents the theoretical innovative production function and its empirical model for the present analysis. Section 4 presents the data and econometric approach of this analysis, while section 5 discusses the empirical results. Section 6 describes the conclusions of this analysis.

II. Conceptual Issues:

Technology diffusion at the industry level for host-country firms is one of the beneficial impacts of FDI. FDI brings with it new kinds of innovative ideas and benefits like technology transfer, management know-how, exchange of knowledge and export marketing access. Many developing countries are attracting FDI to reduce the technological gap in comparison to the advanced nations, to upgrade their managerial skills and to develop their export markets. Proponents offer three explanations for how technology spillovers occur from multinational to domestic firms. First, local firms may be able to learn the technological know-how from the foreign counterparts. Second, employees may leave multinationals to create or join domestic firms of a particular region. Third, multinational investment may encourage the entry of international trade brokers, accounting firms, consultant companies and other professional services which there after become available to the local firms.

Rodrik (1999) in a summary of evidence, states that the local firms enjoy a positive spillover generated by the multinationals firm entry in the same industry. The fruit of technology spillover over in particular regional provinces depend upon a number of factors that are linked to the quality of microeconomic business environment. Some aspect of the business environment include for example, the road system of a cluster, corporate taxes, the legal system of the particular area, local labour market regulation, and credit facilities of the particular clusters. However, these economy-wide (or horizontal) areas are important and represent the binding constraints to competitiveness in developing economies. Capturing the business environment in a location is challenging given the myriad locational influences on productivity and productivity growth. This is the main concern for it is hard to believe that such horizontal spillovers are likely. First, the technology gap between the foreign and local firms may often be wide in local markets. Local firms may be lacking the absorptive capacity needed to recognize and adopt the new kind of technology. Further, the degree of competition in the local markets of a particular cluster may vary between the local and foreign firms. Due to differences in the quality, technology and other attributes which occur because exported and domestically consumed goods entail different production methods; this reduces the potential for the technology transfer. Second, multinationals may enact measures to minimize technology leakages to the local competitors. And multinationals with non-secure technology may not enter the market at all if they rely on a technological advantage to sustain rents. In addition, foreign firms pay higher wages to discourage technology leakage through former employees. In fact, because of higher wages, foreign firms may even draw a capable manager away from the local to the foreign firm in a particular province.

In constrast, technological benefits to local firms through vertical linkages are much more likely, because foreign firms have incentives to provide technology to local firms/suppliers. Vertical technology transfer could occur through both backward (from buyer to supplier) and forward (from supplier to buyer) linkages. In fact, in the Indian context most of the foreign firms are upgrading their technology and supply their product to local and to foreign markets. So the main focus in the present study is to find out the degree and extent of the forward spillover (horizontal spillover) from suppliers to buyers. That is, we examine empirically the upstream effect of FDI on performance for the improvement of productivity of local suppliers/firms.

Many empirical studies are in favour of the technology spillovers through vertical supply chains. Kenney and Florida (1993) and MacDuffie and Helper (1997) provide a rich description regarding the technology transfer to US parts suppliers following the entry of Japanese automobile makers. Lall (1980) gives the analytical description regarding technology transfer from foreign firms through backward linkages in the Indian trucking industry. Blalock (2008) finds evidence of technology transfer through the supply chain in production function estimates in Indonesia, and Javorcik (2004) finds similar results in Lithuania.

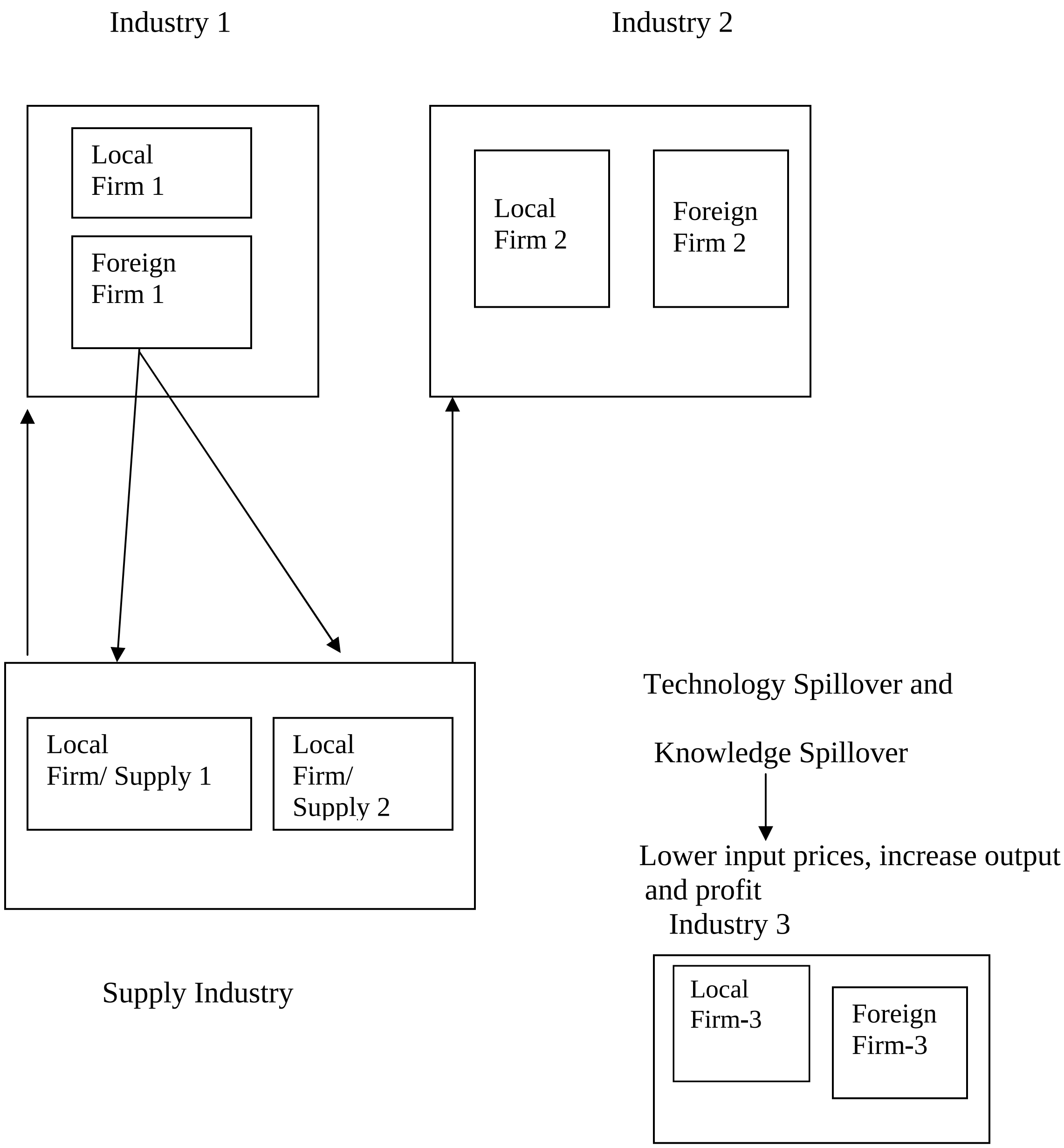
Multinational firms are transferring their technology to local firms and it will reduce the input costs and increase quality and finally increase the output and profits. Foreign firms have an incentive to transfer the technology to many buyers through the supply chain in the downstream and upstream markets. In other words, foreign firms cannot prevent its more productive supplier's firms also selling to the other rival foreign/local firms at lower prices. The lower supply prices may induce entry and increase competition so that the price falls in both the upstream/downstream markets. And overall these actions reduce the cost of production by reducing the deadweight loss from the imperfect competition. Thus, this reduction of the input prices and reduction of the cost not only reduces the deadweight loss but it also improves the benefit to both consumer and producer in the upstream/downstream markets of a particular cluster/regional province.

[3]The Pack and Saggi (2001) structural model show that the benefits of a competitive supply base to the multinational buyers outweighs the rents lost to free-loading rivals. In fact, technology diffusion and leakages to other local suppliers can also benefit the initial local recipient. In case technology diffusion to the other upstream firms allows the more capable supplier to enter, then the market concentration and input prices of the provinces are going to fall. Further, given the benefit of the lower input prices, new firms enter into the market. And a stronger demand in the downstream would in turn prompt a higher output in the upstream and that would help the initial recipient. Lower prices and greater

[3]Pack and Saggi (2001) provide a detailed description regarding technology transfer from the foreign firms to the local firms by explaining the vertical inter-linkages between the foreign firms and the local supply firms in both the downstream and upstream markets. However, the vertical inter-linkages can reduce the dead weight loss and improve the Pareto improvement both for consumer and producer.

volume of output really increases the welfare of the consumer. The benefits of lower input prices and higher volume outweigh the cost of the greater competition.

Fig 1: Technology Spillover and Flow of Technology from FDI in a Cluster



The benefit of the lower input prices and higher volume will be reflected in the third local firms which lie outside the affiliation, and these things happen due to the knowledge and technology spillover of the domestic firms in a particular cluster. The structural framework of technology flow, transfer and technology spillover has been depicted in Fig 1. From the Fig 1, the mechanism of inter-industry technology transfer which is part of vertical linkages has been explained covering both backward (from buyer to supplier) and forward (from supplier to buyer) linkages. And also it covers the flow of technology and knowledge spillover to the third industry domestic firms which is not affiliated to the foreign firms. This is the technology spillover to the third industry domestic firms of a cluster/regional province without bearing any cost for this technology.

III. The Models:

The technology spillovers of the different clusters have been analyzed with respect to the different cluster-specific effect, region-specific effect, industry-specific effect and the firms-specific effect. The different kinds of variables have a special effect upon the productivity of domestic firms within a cluster. To analyze the concept more clearly we develop an innovative production function for clusters i at time t which has the form of N-factor of constant elasticity of substitution function, which is as follows:

$$A_{kt} = \tilde{A}_k \cdot e^{\delta t} \cdot \left(\sum_{j=1}^{N} r_{kl} R_{jt}^{-\rho} \right)^{-\frac{1}{\rho}} \qquad k = 1,.................n. \tag{1}$$

If we take the regions $h = 1,........,4$ means we are considering four regions in our study as northern, western, eastern and southern regions in India and if $k = 1,........,10$ means we are taking the 10 selected clusters in our study. Whereas A_{kt} denotes the level of technology in cluster k at time t, R_{jt} is the variety stock of technological knowledge developed in region h during time period t (the variety of technological stock developed in a region varies from 1 to N), $\tilde{A}_k$ is a cluster-specific constant term which captures the intrinsic efficiency in the technological production function, and the component $e^{\delta t}$ is introduced in order to catch the growth path of the region-specific efficiency for producing technology. However, ρ is the substitution parameter and weights r_{kl} in the row standardized form and it is called as the distribution parameter and it explains the relative factor share of different clusters. But in fact, $0 < r_{kl} < 1$ for each k and l .

Moreover, each cluster of a particular region h' gets the benefit of a level of technology which is the combination of own domestic stock of technological knowledge, with weight r_{kk}, other clusters technological knowledge, with weight r_{kl} $(l \neq k)$, and the stock of the technological knowledge from that regions, with weight r_{kh}. However, the relative factor share or the distribution parameter matrix $\lfloor r_{kl} \rfloor$ $k, l = 1, \ldots\ldots\ldots\ldots, N$ can then be referred to as the inter-cluster spillover structural matrix. The special case of constant elasticity of the substitution production function is converted to the constant returns to scale Cobb-Douglas production function when $\rho = 0$. Hence, the innovative production function can be easily re-expressed by logarithmic second order Taylor series expansion around the point $\rho = 0$, which is as follows:

$$\ln A_{kt} = \ln \tilde{A}_k + r_{kk}.\ln R_{kt} + r_{kh}.\ln R_{ht} + \frac{\rho}{2} \sum_{h=1}^{N} \sum_{k=1}^{N} r_{kl}.(\ln R_{ht} - \ln R_{kt})^2 + \delta t \quad ....(2)$$

In fact, here $r_{kl} = r_{kk} * r_{kh}$.

Let a general form of the production function can be written as:

$$Y = AF(K, L, I) \qquad ....(3)$$

Whereas A stands for technological efficiency but here we take it as the technological stock of a cluster and it gives spatial structure about the interregional or inter-cluster technology spillover analysis. K stands for the capital, L stands for the labour, and I stand for the intermediate inputs. The main focus of the present analysis is to measure the technology spillover across different clusters in India and its inter-cluster comparative technology spillover with respect to the some basic parameter. The basic parameter of the present model is the inter cluster/regional technology stock, intermediate input like horizontal FDI, capital, capital intensity, cluster-specific factor like market concentration, etc. Hence, to measure the technology spillover of a particular cluster we consider the output of the firms of an industry in a particular cluster is as follows:

$$Y_{ijkt} = A_{kt}\, F(K_{ijkt}, L_{ijkt}, I_{jkt})$$

The above functional from of the model can be written as:

$$Y_{ijkt} = A_{kt} (K)^{\alpha}_{ijkt} (L)^{\beta}_{ijkt} (I)^{\sigma}_{jkt}\, e_{ijt} \quad ....(4)$$

If we divide both sides of the equation (5) by L, then the equation becomes as:

$$y_{ijkt} = A_{kt}(k)_{ijkt}^{1-\beta}\,(K)_{ijkt}^{\alpha+\beta-1}(I)_{jkt}^{\sigma}\,e_{ijt} \quad ....(5)$$

Now if we take the logarithmic transformation of the above equation then it becomes:

$$\ln(y)_{ijkt} = \ln(A)_{kt} + \beta_1(k)_{ijkt} + \beta_2(K)_{ijkt} + \beta_3(I)_{jkt} + \varepsilon_{ijt} \ldots\ldots\ldots\ldots\ldots(6)$$

The A_{kt} stands for level of technology developed in clusters k at time t and it is referred to as the cluster/region-specific effect in the model. Whereas, $(y)_{ijkt}$ stands for the labour productivity of ith firm in jth industry of the $k'th$ cluster over the interval of time period from 2000s to 2007s. $(K)_{ijkt}$ represents the capital of the ith firm in jth industry in the $k'th$ clusters over the corresponding interval of time from 2000s to 2007s. Whereas $(k)_{ijkt}$ stands for the capital intensity of ith firm in jth industry in the $k'th$ clusters over the interval of time from 2000s to 2007s. And $(I)_{jkt}$ is referred as intermediate factor for $j'th$ industry like industry-specific horizontal FDI of a given cluster ($k'th$) in the model.

If we substitute the value of $\ln(A)_{kt}$ from equation (2) in equation (6) then the extended model becomes:

$$\ln(y)_{ijkt} = \ln\tilde{A}_k + r_{kk}\ln R_{kt} + r_{kh}\ln R_{ht} + \sum_h^N\sum_k^N \frac{\rho}{2} r_{kl}.(\ln R_{ht} - \ln R_{kt})^2 + \delta t + \beta_1(k)_{ijkt} + \beta_2(K)_{ijkt} + \beta_3(I)_{jkt} + \varepsilon_{ijt} \ldots\ldots\ldots\ldots\ldots(7)$$

Here I stand for the intermediate factor which is the different kind of horizontal FDI in our above discussed model (7). Again the intermediate input like horizontal FDI can be categorized into three different parts. As the horizontal FDI of the clusters (first kind of horizontal FDI, H_FDI), horizontal FDI of the corresponding region (second kind of horizontal FDI, H_FDIR) where a particular cluster belongs to that region, and the third kind of horizontal FDI (H_FDIO) is the output share of the foreign firms to the industry output in a cluster and it is outside of own industry. However, the detailed compilation and discussion of these three different kinds of horizontal FDI has been given in the appendix. Thus, after inclusion of these three different kinds of horizontal FDI in place of I, the corresponding equation becomes:

$$\ln(y)_{ijkt} = \ln \tilde{A}_k + r_{kk}.\ln R_{kt} + r_{kh}.\ln R_{ht} + \sum_{h}^{N}\sum_{k}^{N} \frac{\rho}{2} r_{kl} .(\ln R_{ht} - \ln R_{kt})^2 + \delta t + \beta_1(k)_{ijkt} + \beta_2(K)_{ijkt} + \beta_3(H\_FDI)_{jkt} + \beta_4(H\_FDIR)_{jht} + \beta_5(H\_FDIO)_{jkt} + \varepsilon_{ijt} \text{....................}(8)$$

However, the present analysis considers only the labour productivity of the domestic firms, so the right hand side variable is referred to the productivity over the domestic firms of different industries of a particular cluster. In addition, in the present analysis we are taking only domestic firms of seven industries in a cluster. And if we specify the cluster/region-specific effect technological stock variable coefficient by the symbol γ, then the above discussed model becomes:

$$\ln(y)_{ijkt}^{d} = \overline{\chi}_k + \gamma_1 \ln R_{kt} + \gamma_2 \ln R_{ht} + \gamma_3 \ln R_{lt} + \delta t + \beta_1(k)_{ijkt} + \beta_2(K)_{ijkt} + \beta_3(H\_FDI)_{jkt} + \beta_4(H\_FDIR)_{jht} + \beta_5(H\_FDIO)_{jkt} + \beta_6(x)_{jkt} + \varepsilon_{ijt} \text{.......... ....}(9)$$

Where $\overline{\chi}_k = \ln \tilde{A}_k$ and $\ln(y)_{ijkt}^{d}$ represents the labour productivity over domestic firms of a particular cluster $(k'th)$.

$\gamma_1 = r_{kk}$, $\gamma_2 = r_{kh}$

$\gamma_3 = \frac{\rho}{2} r_{kl}$

$R_{lt} = \sum_{h}^{N}\sum_{k}^{N} (\ln R_{ht} - \ln R_{kt})^2$

Here, in spite of the above factors, the cluster-specific factor like market-concentration index of a particular cluster cannot be ignored, because the two industries may have the same technical efficiency in a cluster. However, they show different value added per worker because of the different extent of domestic market concentration. Thus, the market concentration of a particular cluster has a significant effect upon the domestic firms while the domestic firm’s labour productivity in a cluster is conditional upon the domestic market concentration of that cluster. In the above equation, x represents the market concentration index of a cluster. For particular clusters, the role of the lagged effect of the endogenous variables cannot be ignored in the group of other regressors. For the dynamic adjustments of lagged effect of the individual heterogeneity in the model, the present analysis investigates the lagged effect of endogenous variables for an inter-cluster comparative analysis of technology spillover across different clusters in India.

Further, the significant effect of investment climate cannot be ignored for the determination and comparison of inter-cluster technology spillover. The role of distance cannot be ignored in our present analysis. Firms belong to a particular cluster (to the underdeveloped/semi-developed and or developed city area) or they are out of the clusters but nearer to the city area. Thus, we develop the first hypothesis that if the firms' plant locations are part away from the clusters but nearer to the cluster areas then they have lesser gain for the development of productivity in comparison to the firms' plant location in the centre of the clusters. Moreover, firms that are in the centre of the cluster (city) are bigger gainers and their productivity would be higher. In order to capture the scientific, technological and institutional infrastructure for instance, banking and credit facilities of an area we develop another hypothesis for the second kind of dummy variable. This hypothesis indicates that if the firms' plant location is in the city area of a cluster then they are availing greater credit facilities from the banking sector to increase their productivity. Hence, the city area firms' plant location has more labour productivity in comparison to the firms located in rural areas. This is because in rural area there is a lack of banking sector and credit facilities and credit is required for a firm to expand its productivity and production. And finally, to capture the different effect of physical infrastructure like roads, telecommunication, electricity, etc. of investment climate we develop a third hypothesis for another kind of dummy variable. This hypothesis indicates that if the firm's plant location is in the rural area then it may not have adequate facilities for basic infrastructure like road, telecommunication, electricity, etc. Thus, firms' plant locations in the rural area will have a low capacity for production and a low labour productivity in comparison to the firms' plant location in the city area. Hence, by inclusion of these three different kinds of qualitative variables and the lagged endogenous variable, the proposed empirical model becomes:

$$\ln(y)_{ijkt}^{d} = \bar{\chi}_k + \rho(y)_{ijk,t-1}^{d} + \gamma_1 \ln R_{kt} + \gamma_2 \ln R_{ht} + \gamma_3 \ln R_{lt} + \delta t + \beta_1(k)_{ijkt} + \beta_2(K)_{ijkt} + \beta_3(H\_FDI)_{jkt}$$
$$+ \beta_4(H\_FDIR)_{jht} + \beta_5(H\_FDIO)_{jkt} + \beta_6(CON)_{jkt} + \beta_7(D1)_{ij} + \beta_8(D2)_{ij} + \beta_9(D3)_{ij} + \varepsilon_{ijt} \quad . \qquad (10)$$

IV. Econometric Approach and the Data Set:

Our approach to measuring technology spillovers is to run a set of regressions for each cluster. We have selected ten clusters across different regions in India. The present analysis is based on an inter-cluster comparison of the technology spillover with respect to some basic parameters like firm-specific, industry-specific, cluster-specific, and region-specific effect and partial effect of the investment climate across different clusters in India. And from an econometric point of view, the analysis follows three familiar estimation methods for the above discussed dynamic panel data model (10). The usual practice is to investigate the relationship between the explanatory variables and the explained variable in our model. To investigate this relationship, the analysis follows the pooled OLS estimates, fixed effect (within group) estimates, and finally, the Generalized Methods of Moments (GMM) estimates in order to capture the lagged effect of the endogenous variable. In addition, in the present analysis, the application of difference GMM is to capture the lagged effect of the endogenous variables among the group of explanatory variables either in the level or lagged form. However, the dynamic feature of the model is the presence of the lagged dependent variable, and not the serial correlation that lies in the error term. Thus, to get a complete exercise of technology spillover of selected seven industries in a cluster and inter-cluster comparisons of spillover across ten selected clusters in India, we run a set of three regressions namely pooled OLS estimate, Fixed Effect (WG effect) estimate, and GMM estimate for each of the cluster in the following empirical model.

$$\ln(y)_{ijkt}^{d} = \bar{\chi}_k + \rho(y)_{ijk,t-1}^{d} + \gamma_1 \ln R_{kt} + \gamma_2 \ln R_{ht} + \gamma_3 \ln R_{lt} + \delta t + \beta_1(k)_{ijkt} + \beta_2(K)_{ijkt} + \beta_3(H\_FDI)_{jkt}$$
$$+ \beta_4(H\_FDIR)_{jht} + \beta_5(H\_FDIO)_{jkt} + \beta_6(CON)_{jkt} + \beta_7(D1)_{ij} + \beta_8(D2)_{ij} + \beta_9(D3)_{ij} + \varepsilon_{ijt}. \qquad (11)$$

From this empirical model, i stands for the cross-sectional units that is firms in a cluster and j stands for the industry, k stands for the different selected clusters in India, h stands for the different regions (north, south, east and west regions) in India, l stands for the other clusters excluding k but it is in a region, and finally, t stands for the time subscripts, that is the data range varies from 2000s to 2007s in our case. In fact, classifications of the firms out of seven industries according to different clusters have been given in the Appendix B, Table B1.

The data set was basically built for an analysis of cluster-specific technology spillovers. The discussed variables have been carefully compiled from different sources of data. The primary source is the Center for Monitoring Indian Economy (CMIE)-based data set 'Prowess' over the time interval of 2000s to 2007s. Next, related data sources are from the National Accounts of Statistics (NAS) and from the Annual Survey of Industries (ASI).

V. Empirical Results:

From the Baddi and Noida cluster of the northern region, the first-order autoregressive parameter(ρ) coefficient is not free from the upward bias because the estimated value of the first difference GMM estimate is not close to the WG estimate. In the Baddi cluster, the ρ coefficient indicates the upward bias and the same implications have been obtained in the Noida cluster (see Table 1). From the other northern region clusters like Gurgaon and Bhiwadi, the AR (1) coefficient $'\rho'$ is also not free from the bias. Thus, it indicates that the instrument which we implicated in this dynamic model is not suggestive and informative. In fact, in the Gurgaon cluster, the first difference GMM estimates for the lagged endogenous variable is to some extent closer to the WG estimate. This implies that the instruments associated in this regression model for the Gurgaon cluster are more reliable and provide very suggestive information into the model and for the determination of cluster-specific technology spillover (see Table 2). The other parameters in the empirical model of different clusters in the northern region like cluster/region-specific technological stock variables, the own technology stock variable in the Baddi cluster is not statistically significant in the OLS and WG level estimate but its coefficient is positive and statistically significant in the first difference GMM estimate. This indicates that technology stocks have a positive impact on the labour productivity of domestic firms. But in Noida and other clusters like Gurgaon and Bhiwadi the clusters own and its regions technological stock variables have a positive impact on the labour productivity of domestic firms. This implies that greater R&D expenditure of firms in a particular area provides more useful results for the improvement of domestic firms' labour productivity for that area. Moreover, from the OLS-level estimates in the Bhiwadi region all kinds of technology stock variables like its own cluster-specific, region-specific and other clusters technology stocks of the northern region positively affect the labour productivity over the domestic firms.

Domestic firm's labour productivity in all clusters in the northern region has been positively affected by the gross fixed capital stock and capital intensity. Here we got the expected sign and positive coefficient for capital and capital intensity variables in northern region clusters. The key inference that can be drawn for the cluster-specific technology spillover is the horizontal FDI. From the reported results of Table 1, the own cluster horizontal FDI does not have a positive impact upon labour productivity in the Gurgaon, Baddi and Noida regional provinces. However, in the Bhiwadi regional area the results are to some extent satisfactory and so the spillover results are partially better in comparison to other northern zone clusters, which seems to be based on the different angles of horizontal FDI. Region-specific horizontal FDI is quite effective in all clusters. This implies that all domestic firms are getting some benefit from the northern region rather than their own cluster-specific foreign presence. From the OLS-level estimate, the third kind of horizontal FDI is statistically significant in the Gurgaon and Bhiwadi region. This implies that in the Gurgaon and Bhiwadi region, the domestic firms' labour productivity is higher due to the positive impact of the foreign presence of other clusters apart from its own clusters in the northern region. The analysis is not getting any viable and supportive results for the concentration index of all clusters in the northern zone.

Table 1: Dependent variable: $(y)^{d}_{ijkt}$

	Baddi			Noida		
Estimation	OLS	WG	GMM (Diff.)	OLS	WG	GMM (Diff.)
Observations	238	238	198	149	149	125
$(y)^{d}_{ijk,t-1}$	0.786* (0.032)	0.503* (0.044)	0.261** (0.141)	0.715* (0.061)	0.189** (0.095)	0.118 (0.042)
R_{kt}	-0.014 (0.051)	0.017 (0.067)	0.130*** (0.080)	0.081 (0.574)	0.686 (0.689)	2.234** (1.140)
R_{ht}	0.479 (0.938)	0.172 (0.908)	-0.354 (0.884)	1.482 (39.519)	33.609 (42.699)	2.662** (5.663)
R_{lt}	-0.241 (0.449)	-0.093 (0.433)	0.183 (0.424)	-0.738 (19.580)	-16.583 (21.152)	-5.737** (27.546)
$(k)_{ijt}$	0.034* (0.015)	0.178* (0.025)	0.498* (0.041)	0.103** (0.105)	0.237*** (0.166)	-0.149 (0.517)
$(K)_{ijt}$	-0.004 (0.006)	0.053* (0.022)	-0.270* (0.058)	0.054** (0.044)	0.219** (0.196)	1.378* (0.444)
$(H\_FDI)_{jkt}$	-0.038 (0.058)	-0.097 (0.099)	-0.409 (0.208)	-1.054 (0.782)	1.669 (1.733)	2.682 (2.371)
$(H\_FDIR)_{jht}$	0.055 (0.075)	0.092** (0.508)	1.528** (0.956)	2.009** (1.044)	2.285 (3.707)	7.290*** (5.193)
$(H\_FDIO)_{jkt}$	-0.0308 (0.420)	0.174 (0.899)	-0.690 (0.852)	0.324 (0.394)	0.488 (1.156)	-0.200 (0.186)
$(CON)_{jkt}$	-0.049 (0.093)	0.371* (0.136)	-1.282* (0.522)	-0.033 (0.441)	-8.045 (6.681)	-8.502*** (5.375)
$(D1)_{ij}$	-0.109* (0.048)					
$(D2)_{ij}$	0.0908** (0.050)					
$(D3)_{ij}$						
R^2	0.858	0.719 (overall)		0.643	0.084 (overall)	
Sargan test of restriction			0.030 (p-value)			0.000 (p-value)

Note: * significant at 1%, ** significant at 5%, and *** significant at 10% level. Standard errors are in parenthesis. For the region Baddi and Noida the GMM-Difference instruments are $(y)^{d}_{ij,t-1}, (H\_FDI)_{jk,t-1}, (H\_FDIR)_{jh,t-1}, (H\_FDIO)_{jk,t-1}, R_{k,t-1}, R_{h,t-1}, R_{l,t-1}$.
The generated dummy variables have been dropped in some regression because of the collinearity problem.

Table 2: Dependent variable: $(y)^{d}_{ijkt}$

	Gurgaon			Bhiwadi		
Estimation	OLS	WG	GMM (Diff.)	OLS	WG	GMM (Diff.)
Observations	165	165	134	101	101	101
$(y)^{d}_{ijk,t-1}$	0.802* (0.036)	0.649* (0.064)	0.635* (0.069)	0.812* (0.044)	0.436* (0.085)	0.625* (0.238)
R_{kt}	0.033 (0.167)	0.170 (0.320)	0.151 (0.351)	0.291** (0.144)	0.011 (0.164)	0.762* (0.338)
R_{ht}	0.308 (0.868)	-0.602 (1.448)	-0.603 (1.632)	12.904* (5.221)	6.750*** (5.058)	-4.145 (7.583)
R_{lt}	-0.135 (0.364)	0.285 (0.603)	0.321 (0.683)	6.363* (2.580)	-3.356 (2.499)	2.077 (3.753)
$(k)_{ijt}$	0.187* (0.044)	0.442* (0.087)	0.979* (0.336)	0.124* (0.039)	0.002 (0.097)	0.835** (0.386)
$(K)_{ijt}$	0.055* (0.020)	0.248* (0.061)	0.693* (0.230)	0.061* (0.023)	-0.161** (0.092)	1.124* (0.326)
$(H\_FDI)_{jkt}$	-0.0809 (0.115)	-0.103 (0.629)	-0.389 (1.221)	0.487* (0.217)	-1.259 (0.843)	0.408 (1.366)
$(H\_FDIR)_{jht}$	0.832** (0.410)	0.051 (0.828)	-0.655 (1.217)	0.787* (0.227)	-1.392 (1.117)	-2.347 1.728
$(H\_FDIO)_{jkt}$	0.561*** (0.346)	-2.009 (1.444)	-4.594* (1.443)	1.725* (0.544)	4.839* (1.292)	7.352* (2.013)
$(CON)_{jkt}$	-0.098 (0.119)	-1.026 (0.871)	-3.566 (2.858)	0.198 (0.172)	1.053** (0.536)	-0.809 (1.234)
$(D1)_{ij}$	0.029 (0.085)			-0.345** (0.163)		
$(D2)_{ij}$	0.017 (0.089)			0.256* (0.112)		
$(D3)_{ij}$	0.091 (0.073)			-0.0002 (0.143)		
R^2	0.896	0.476 (overall)		0.961	0.165 (overall)	
Sargan test of restriction			0.000 (p-value)			0.038 (p-value)

Note: * significant at 1%, ** significant at 5%, and *** significant at 10% level. Standard errors are in parenthesis. For the region Gurgaon and Bhiwadi the GMM-Difference instruments are

$$(y)^{d}_{ij,t-1}, (H\_FDI)_{jk,t-1}, (H\_FDIR)_{jh,t-1}, (H\_FDIO)_{jk,t-1}, R_{k,t-1}, R_{h,t-1}, R_{l,t-1}$$

The investment climate variables as three different kind of dummy variables are giving separate results at different clusters in the northern region. From the Baddi and Bhiwadi region, the analysis becomes clear that firms plant location in the centre of the cluster and firms nearer to the cluster are getting the same kind of benefit from the foreign firms.

Hence, our hypothesis that firms who are in the centre of the cluster are getting more benefit in comparison to the firms who are nearer to the cluster area is not valid here. In fact, in the present study the analysis covers only firms with a plant location within a radius of a maximum of 30 to 40 kilometres from the cluster area. Moreover, from the Baddi and Bhiwadi area, the second hypothesis is true, namely that firms located in the centre of an urban area cluster greater benefits in terms of scientific and technological, institutional environment covering credit facilities of banking in comparison to the firm's plant location in the rural areas. Hence, firms in urban area avail of more credit from the banks and improve their productivity in comparison to the firm's plant location in rural areas.

Form the results reported in Table 3 (Kolkata regional provinces); the first order autoregressive coefficient at GMM estimate is not free from the sample bias because it lies below the WG estimate. This implies that the instruments used here for the estimation of first difference GMM are not providing sufficient information to estimate the labour productivity. However, from the OLS and WG estimate, the first-order autoregressive coefficient is statistically significant and gives the expected sign. In the Kolkata cluster, the labour productivity over domestic firms is highly affected by all type of technological stock variables which is compiled by regional R&D expenditure of a cluster/region. The influence of region-specific and other industry foreign presence to a particular industry in Kolkata region upon the domestic firms' productivity are statistically significant and give the positive coefficients. In fact, both estimated values at first difference GMM are not free from the sample bias. Furthermore, after this estimation and the presence of a sample bias in this cluster there is the existence of a spillover due to the positive coefficient of the above two discussed variables. In addition, domestic firm's labour productivity has been increased due to the presence of foreign firms in the eastern region and other industry foreign presence in this cluster. The analysis has derived the same conclusion again for the concentration index variable as in the northern region cluster that is the concentration index here is again not statistically significant. And finally, constrant results for the first hypothesis of first qualitative variable in the model. These investigate that firm's plant location in the centre of the cluster and nearer to the cluster/city obtain the same benefit from the foreign firms in terms of knowledge and technology spillover.

Table 3: Dependent variable: $(y)_{ijkt}^{d}$

	Kolkata			Ankleswar		
Estimation	OLS	WG	GMM (Diff.)	OLS	WG	GMM (Diff.)
Observations	105	105		200	200	167
$(y)_{ijk,t-1}^{d}$	0.791* (0.051)	0.378* (0.079)	0.092 (0.182)	0.914* (0.029)	0.552 (0.065)	0.233 (0.190)
R_{kt}	13.724** (6.551)	-14.968 (16.138)	0 .159*** (0.109)	-0.009 (0.065)	0.018 (0.066)	0.021 (0.062)
R_{ht}	8.132** (13.290)	30.570 (32.902)	30.570 (32.902)	0.897 (1.173)	0.389 (1.105)	-0.154 (0.978)
R_{lt}	6.368* (2.866)	-6.589 (7.149)	-6.589 (7.149)	-0.422 (0.549)	-0.183 (0.518)	0.075 (0.461)
$(k)_{ijt}$	0.220* (0.056)	0.368* (0.084)	0.301 (0.402)	0.097*** (0.027)	0.106** (0.052)	0.188* (0.056)
$(K)_{ijt}$	0.078* (0.023)	0.372* (0.083)	0.094 (0.408)	-0.005 (0.008)	0.073*** (0.052)	0.148* (0.062)
$(H\_FDI)_{jkt}$	0.073 (0.412)	1.301 (1.061)	4.073 (3.361)	-0.697* (0.220)	-1.443* (0.494)	-1.109** (0.592)
$(H\_FDIR)_{jht}$	0.391 (0.448)	0.021 (1.102)	2.437*** (1.910)	0.266*** (0.178)	2.652*** (1.506)	2.491*** (1.839)
$(H\_FDIO)_{jkt}$	3.594* (1.488)	-0.104 (8.331)	8.658*** (6.187)	0.108 (1.896)	-0.238 (1.856)	-0.604 1.607
$(CON)_{jkt}$	-0.330 (0.302)	0.366 (0.625)	-0.1476 (1.672)	0.063 (0.130)	1.723*** (1.080)	1.902** (1.027)
$(D1)_{ij}$	-0.372* (0.194)			0.076 (0.065)		
$(D2)_{ij}$	-0.032 (0.160)			0.166*** (0.121)		
$(D3)_{ij}$	0.136 (0.173)			-0.018 (0.077)		
R^2	0.887	0.335 (overall)		0.953	0.384 (overall)	
Sargan test of restriction			0.006 (p-value)			0.000 (p-value)

Note: * significant at 1%, ** significant at 5%, and *** significant at 10% level. Standard errors are in parenthesis. For the region Kolkata the GMM-Difference instruments are

$(y)_{ij,t-1}^{d}, (H\_FDI)_{jk,t-1}, (H\_FDIR)_{jh,t-1}, (H\_FDIO)_{jk,t-1}$

The instruments for Ankleswar region regression are

$(y)_{ij,t-1}^{d} (CON)_{jk,t-1}, (k)_{ij,t-1}, (K)_{ij,t-1}$

$(H\_FDI)_{jk,t-1}, (H\_FDIR)_{jh,t-1}, (H\_FDIO)_{jk,t-1}, R_{k,t-1}, R_{h,t-1}, R_{l,t-1}$

From the results reported in Tables 3 and 4, we analyze the inter-cluster technology spillover analysis of the western region. From the western region both in Ankleswar and Thane region, the first and third kinds of horizontal FDI do not statistically provide useful results for our analysis. This implies that domestic firm's productivity is not affected by this above factor. Both clusters show a low level of spillover in comparison to clusters of other regions. One critical reason is that in these clusters the numbers of foreign firms' representatives are few. In fact, in the Thane and Ankleswar area the western region horizontal FDI is statistically significant at the OLS-level estimate. Thus, domestic firms benefit only from their western region foreign firms rather than their own cluster-specific foreign firms.

The different kinds of generated technological stock variables at different levels (at clusters, region and other cluster of a region) are not statistically significant in the Ankleswar and Thane regional provinces. Hence, the regional R&D expenditure could not affect the productivity of domestic firms in these clusters. The second kind of dummy variable in Ankleswar cluster is positive and statistically significant. This indicates that the firm's plant location in the rural areas is disadvantageous to increase their productivity in comparison to the city area plant located firms. And this is obvious from the above results that firms' plant locations in the city area of a cluster have the adequate credit facilities to increase and upgrade their existing technology. Moreover, a firm will increase their productivity to meet the local market demands and demand conditions of these corresponding city area customers.

The result reported in Tables 4 and 5 analyze the spillover across southern region clusters. All southern region clusters show a higher level of labour productivity and so their corresponding technology spillover becomes higher. In addition, if we compare the Hyderabad and Bangalore clusters then all kinds of horizontal FDI are quite significant with the expected sign at the OLS-level estimate in the Bangalore clusters. And in the Bangalore clusters, these estimated values are not free from the sample bias because the first difference GMM estimate lies below the WG estimate. This downward bias investigates the presence of weak instruments which seem to be used here in this discussed dynamic panel model.

Table 4: Dependent variable: $(y)^d_{ijkt}$

	Thane			Chennai		
Estimation	OLS	WG	GMM (Diff.)	OLS	WG	GMM (Diff.)
Observations	155	155	126	148	148	126
$(y)^d_{ijk,t-1}$	0.752* (0.042)	0.387 (0.066)	0.212 (0.165)	0.780* (0.051)	0.385* (0.081)	0.132 (0.114)
R_{kt}	-0.018 (0.060)	0.012 (0.069)	0.051 (0.075)	0.630 (0.869)	-0.303 (0.835)	-0.534 (0.731)
R_{ht}	-0.152 (0.851)	-0.603 (0.904)	-1.022 (0.913)	-2.924 (6.361)	3.692 (6.210)	4.748 (5.447)
R_{lt}	0.081 (0.407)	0.317 (0.438)	0.523 (0.446)	1.123 (2.733)	1.664 (2.675)	-2.047 (2.346)
$(k)_{ijt}$	0.119* (0.039)	0.248* (0.072)	0.320* (0.093)	0.112* (0.045)	0.444* (0.091)	0.601* (0.099)
$(K)_{ijt}$	-0.028 (0.019)	-0.172* (0.062)	0.262* 0.084	0.030* (0.016)	0.079 (0.060)	0.102* (0.064)
$(H\_FDI)_{jkt}$	0.212 (0.404)	0.171 (0.897)	0.013 (1.032)	0.183*** (0.245)	0.161 (0.451)	0.398 (0.456)
$(H\_FDIR)_{jht}$	0.598* (0.239)	1.799 (2.098)	0.945 (2.625)	0.056 (0.258)	0.202 (1.204)	0.309 (1.198)
$(H\_FDIO)_{jkt}$	-0.471 (0.720)	-2.685* (1.198)	-2.227 (1.624)	-0.168 (0.523)	-0.800 (0.601)	-0.712 (0.529)
$(CON)_{jkt}$	6.760 (3.390)	-6.780 (3.080)	-4.210 (3.600)	-0.477 (0.421)	1.212** (0.597)	-2.296* (0.782)
$(D1)_{ij}$	-0.121 (0.125)			0.032 (0.176)		
$(D2)_{ij}$	0.157 (0.148)			-0.178 (0.171)		
$(D3)_{ij}$	0.018 (0.134)					
R^2	0.842	0.611 (overall)		0.892	0.759 (overall)	
Sargan test of restriction			0.000 (p-value)			0.000 (p-value)

Note: * significant at 1%, ** significant at 5%, and *** significant at 10% level. Standard errors are in parenthesis. The GMM-Difference instruments for the Thane and Chennai region regressions are

$(y)^d_{ij,t-1}(CON)_{jk,t-1},(k)_{ij,t-1},\ (K)_{ij,t-1}$

$(H\_FDI)_{jk,t-1},(H\_FDIR)_{jh,t-1},\ (H\_FDIO)_{jk,t-1},\ R_{k,t-1},\ R_{h,t-1},\ R_{l,t-1}$

From the Chennai cluster, all kinds of horizontal FDI do not give useful results for the growth of labour productivity in this regional province. The first order autoregressive parameter results are better in Bangalore in comparison to the other clusters of the southern region as in Chennai and in Hyderabad. This is because in the Bangalore cluster, the autoregressive parameter first difference GMM estimate is relatively closer to the WG estimate in comparison to other cluster results in the southern region. This implies that in the Bangalore cluster, all the first lagged exogenous instruments used here in this case are quite substantial and provide useful results for labour productivity and technology spillover.

Table 5: Dependent variable: $(y)^{d}_{ijkt}$

	Hyderabad			Bangalore		
Estimation	OLS	WG	GMM (Diff.)	OLS	WG	GMM (Diff.)
Observations	187	187	155	228	228	187
$(y)^{d}_{ijk,t-1}$	0.881* (0.026)	0.686* (0.064)	0.240* (0.086)	0.861* (0.032)	0.474* (0.062)	0.396* (0.096)
R_{kt}	-0.062 (0.059)	0.003 (0.077)	0.187* (0.070)	1.246 (2.052)	3.527*** (2.49)	3.079*** (2.181)
R_{ht}	0.337*** (0.193)	0.082 (0.290)	1.025* (0.296)	4.310 (6.761)	11.722*** (8.180)	10.313*** (7.157)
R_{lt}	-0.049 (0.078)	-0.033 (0.080)	0.123** (0.062)	1.548 (2.318)	3.967*** (2.851)	3.428*** (2.501)
$(k)_{ijt}$	0.046*** (0.032)	0.166** (0.087)	0.553* (0.099)	0.053*** (0.034)	0.272* (0.080)	0.406* (0.084)
$(K)_{ijt}$	0.028*** (0.019)	-0.050 (0.110)	0.727* (0.150)	0.010 (0.011)	0.322* (0.045)	0.406* (0.049)
$(H\_FDI)_{jkt}$	0.034 (0.255)	2.230*** (1.268)	1.697*** (1.229)	0.182*** (0.199)	1.188*** (0.737)	0.893 (0.837)
$(H\_FDIR)_{jht}$	0.024 (0.270)	0.263 (2.319)	4.175** (2.122)	0.475* (0.197)	2.389*** (1.601)	1.009 (1.783)
$(H\_FDIO)_{jkt}$	1.608 (1.397)	3.476 (2.824)	-1.047 (2.784)	0.894*** (0.951)	2.031 (2.725)	0.9005 (2.560)
$(CON)_{jkt}$	0.507*** (0.300)	0.571 (0.561)	1.009** (0.501)	-0.018 (0.186)	0.411 (0.673)	0.122 (0.665)
$(D1)_{ij}$	-0.052 (0.145)			0.067 (0.092)		
$(D2)_{ij}$	0.016 (0.219)			-0.031 (0.093)		
$(D3)_{ij}$	0.025 (0.152)			-0.060 (0.097)		
R^2	0.909	0.722 (overall)		0.872	0.378 (overall)	
Sargan test of restriction			0.001 (p-value)			0.000 (p-value)

Note: * significant at 1%, ** significant at 5%, and *** significant at 10% level. Standard errors are in parenthesis. The GMM-Difference instruments for the Hyderabad and Bangalore region regressions are $(CON)_{jk,t-1}$, $(k)_{ij,t-1}$, $(K)_{ij,t-1}$
$(H\_FDI)_{jk,t-1}$, $(H\_FDIR)_{jh,t-1}$, $(H\_FDIO)_{jk,t-1}$, $R_{k,t-1}$, $R_{h,t-1}$, $R_{l,t-1}$

Thus, inclusion of the lagged endogenous variable here in this dynamic model is more effective and quite relevant for the determination of technology spillover in Bangalore clusters. The analysis does not get very good results here for all the technological variables which we generated for the determination of the inter-cluster technology spillover in Chennai regional province. However, the importance and significance of these technological stock variables to some extent give better results in the Hyderabad and Bangalore clusters. This implies that localized firms in the corresponding clusters really benefit in relation to the more regional R&D expenditure of all firms.

We got good results for capital stock and capital intensity at all cluster levels in the southern region. However, in some instances these estimated values are not free from the sample bias. In fact, all estimated values for capital and capital per capita are significant at the OLS-level estimates in Chennai, Bangalore and Hyderabad. Hence, intensity of capital per capita and gross fixed capital stock have an impressive impact upon the improvement of productivity over localized firms in these clusters. And the concentration index here is quite significant in the Hyderabad cluster in comparison to the other clusters of southern region. Therefore, the analysis clearly illustrates that a higher volume of sales leads to a greater concentration index of industries in Hyderabad which would lead to a substantial improvement of labour productivity in local firms. Thus, the role of the industry-specific effect like concentration index of a cluster has a significant impact upon the technology spillover.

From the present analysis, the generated dummy variables do not give any substantial support for hypothesis, which we developed in the current empirical regression model (11), because these variables for three selected clusters of the southern region are not statistically significant. Thus, the analysis does not come to a concrete conclusion namely whether firm’s plant location in the city is more beneficial in comparison to a rural location nearer the city area or not. And whether firms’ plant location in the city area of cluster is getting more benefits from the banking sector for the development of their productivity in comparison to the firms’ plant location in rural areas. This is not valid in the southern region. And finally, the last hypothesis which we developed for the firm’s plant location in the rural areas can be a bottleneck because cannot access the basic infrastructure communication by road, rail, air; telecomm and electricity, etc. Thus, firm's plant locations in the rural areas are beneficial in upgradation of their technology and improvement of their labour productivity. Thus, they cannot face competition in local or international markets. This hypothesis is also not applicable to the southern region clusters because of the unreliable results in our present analysis.

VI. Concluding Remarks:

The present analysis examined the inter-cluster technology spillover across ten different selected clusters in India. In this work we have been concerned with the evaluation of technology spillover in different clusters in India, stressing the role of both technological innovation variables and intermediate factors like horizontal FDI to the labour productivity in domestic firms of a particular cluster.

In this regard we develop an innovative production function which measures the technology spillover across different clusters in India. The methodology which is being developed by Coe and Helpman to measure the total technology stock of a cluster or region has been used here as an important component for the determination of the technology spillover of a cluster. The analysis used here is the OLS, WG effect estimate and dynamic panel data model of GMM estimate to overcome the problem of endogeneity and serial correlation problem in the regression model.

The main findings can be summarized as follows.

(a) From the northern region clusters, all four clusters show a positive spillover from the regional foreign presence rather than due to their own cluster-specific foreign presence. This implies that domestic firms are only getting benefits from the presence of their northern region foreign counterparts rather than from their own cluster-specific foreign firms.

(b) The technology stock variable which is generated by the regional R&D expenditure of a cluster cannot provide good results for the improvement of productivity over domestic firms in the northern region clusters.

(c) The investment climate variable as considering the scientific, technological, institutional environment like credit facilities of the banking system are quite effective in the Baddi and Bhiwadi regional provinces. This implies that firm's plant location in the centre of the cluster basically in the urban area of clusters are availing of more credit facilities rather than the plants located in the rural areas.

(d) Technological stock variables being generated by the regional R&D expenditures are giving positive effect to the productivity of domestic firms in the Kolkata cluster. This indicates that domestic firms are getting a greater benefit by using more funds for R&D spending which is clearly suggested by this analysis. Other important variables for the spillover analysis are the cluster-specific and region-specific foreign presence. From this analysis in the Kolkata cluster, it is apparent that domestic firms in this cluster benefit from their eastern region foreign firms and foreign firms outside their own clusters rather than foreign firms that lie in the Kolkata region. This issue should be addressed by West-Bengal state government policy. Why cannot domestic firms in these regions absorb the knowledge, and technology from their foreign counterparts which have plant locations in the Kolkata regional provinces.

(e) The analysis here does not obtain any proper evidence regarding the viability of the investment climate variable in the Kolkata cluster. This implies that firms' plant locations at the centre of a cluster and nearer to a city/cluster are getting the same kind of information and knowledge spillover from the foreign firms.

(f) The technology stock at different levels and foreign presence at the region and cluster level cannot affect the productivity of labour in the western region clusters. In the Ankleswar and Thane regional provinces, technology spillover is quite insignificant as it is clear from this study because of the low representation of foreign firms in this region. However, the second kind of qualitative variable for investment climate is quite significant in the Ankleswar cluster. This implies that firm's plant located in the city is taking more credit facilities to upgrade their technology from banks rather than rural area located firms.

(g) All southern region clusters are showing good results for this inter-cluster technology spillover analysis. The level of productivity and spillovers are high in comparison to any other cluster of other region in India. This is because of the greater presence of foreign firms in the southern region. Particularly in the Bangalore cluster all kinds of horizontal FDI are statistically significant. This suggests that domestic firms in this regional province are getting greater benefits from their foreign counterpart in increase of their labour productivity and ultimately, the spillover becomes high in this province. We do not get any valid and applicable results for the investment climate variables which can give support to our hypothesis in the southern region clusters.

Appendix A:

Variables:

Dependent Variable:

$(y)^{d}_{ijkt}$: Value added per worker of $i'th$ domestic firms of $j'th$ industry in the $k'th$ clusters over different time period. Here t represents the time subscript over 2000s to 2007s i.e., eight-year period has been taken into consideration. Labour productivity of the domestic firms is compiled from the prowess data base by dividing the gross value added of domestic firms to the number of man days (labour) per firm of each industry of that particular cluster.

Explanatory variables:

Capital $(K)_{ijkt}$ **:** Capital has been taken as proxy for the gross fixed asset at the firm level at the beginning of each year.

Labor: The 'Prowess' data base does not provide the exact information regarding labour per firm. So, 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 at the firm level by the average wage rate of the industry to which the firm belongs. Thus, the man days per firm are given below:

Number of man days per Firm = Salaries and Wages / Average Wage Rate

To get the average wage rate, we have to use information from the Annual Survey of Industries (ASI) data. ASI contains information on total emoluments as well as total man days for relevant industry groups. And the average wage rate can be obtained by dividing total emoluments by the total man days for relevant industry groups.

Average Wage Rate = Total emoluments/ Total Man days

Capital Intensity $(k)_{ijkt}$ **:** Capital intensity or capital per capita of $i'th$ firm in $j'th$ industry in $k'th$ clusters over different time period has been compiled by dividing the capital to the number of man days for each firm in the cluster.

Horizontal FDI of the clusters $\left(H\_FDI\right)_{jkt}$: Horizontal FDI is the share of an industry's output in a particular clusters/regional provinces that is produced by the foreign firms.

$$\left(H\_FDI\right)_{jkt}=\frac{\sum_{i\in jkt}\left(foreign\_output\right)_{it}}{\sum_{i\in jkt}\left(output\right)_{it}}$$

, where $i\in jkt$ refers to the $i'th$ firms in $j'th$ industry in $k'th$ clusters over different time periods. Thus, the numerator indicates the sum of foreign firm's output of $j'th$ industry of a given cluster ($k'th$) over time period 2000s to 2007s. And the denominator indicates the sum total output of $j'th$ industry over the time period of that cluster ($k'th$).

Horizontal FDI of the Region $\left(H\_FDIR\right)_{jht}$: Regional horizontal FDI of a given region has been obtained in the same way as the horizontal FDI of particular clusters. Thus, the horizontal FDI of a given region has been given as:

$$\left(H\_FDIR\right)_{jht}=\frac{\sum_{i\in jht}\left(foreign\_output\right)_{it}}{\sum_{i\in jht}\left(output\right)_{it}}$$

So, the numerator here represents the sum of the foreign firms output in the $j'th$ industry of a given region h, over time period 2000s to 2007s. And the denominator here represents the sum of the total output of firms in the $j'th$ industry over the above time period of that region. In fact, in our study we consider only four regions namely north, south, east and west across India. Hence, we compile the regional FDI of each industry of a given region as it may belong to one among the four regions across India.

Horizontal FDI of Other $\left(H\_FDIO\right)_{jkt}$: This is the third kind of horizontal FDI that has been compiled to capture the effect of other industries foreign firm's output to particular industry domestic firms within a cluster. In our study we consider the seven industries of a particular cluster, which is given in the appendix (Table 6) as a classification of firms of seven select industries according to different clusters. If we consider the third kind of horizontal FDI for the chemical industry in the BADDI regional provinces, then we take the sum of all the remaining six industries foreign firm's output excluding chemical industry foreign firms over different time periods from 2000s to 2007s in that cluster to the sum of output of all the firms of the remaining six industries (excluding chemical industry) over the above time period within that cluster. In this way we are compiling the third kind of horizontal FDI for different industries within a given cluster.

Technology Stock of Clusters (R_{kt}): The technology stock of a cluster is obtained by using the annual R&D expenditure followed by Coe and Helpman (1995) and resorting to a method again proposed by the Griliches (1979). Thus, according to this method, the stock of technological knowledge is obtained by the following procedure:

$$R_0 = \frac{(RD)_0}{g+d};$$

Where $(RD)_0$ is called as the R&D expenditure at the time 0 which is the 2000s in our case because our coverage of data is from 2000s to 2007s. While g stands for the growth rate of the R&D expenditure, i.e. $g = \frac{(RD)_t - (RD)_{t-1}}{(RD)_{t-1}}$, d indicates the depreciation rate, and our proposed fixed rate of depreciation is at 15%. Hence, the technological stock at time period t for $t > 0$ is:

$$R_t = (1-d).R_{t-1} + (RD)_{t-1}$$

The above concept has been applied to a particular cluster and by following the above methodology, the technological stock of a given clusters k can be obtained which is as follows:

$R_{kt} = (1-d).R_{k,t-1} + (RD)_{k,t-1}$. Here $R_{k,t-1}$ indicates the technological stock of the $k'th$ clusters at the period $t-1$, and $(RD)_{k,t-1}$ indicates the R&D expenditure of all those firms that are part of the $k'th$ clusters in the time period $t-1$. Thus, from the above analysis, the cluster-specific technological knowledge at time t is obtained by the addition of the last years technological stock deviated by depreciation rate and R&D expenditure of the last year.

Technology Stock of Regions (R_{ht})**:** The same methodology which is developed by Coe and Helpman (1995) and by Griliches (1979) has been used to construct the technological stock of a given region h which is obtained as:

$$R_{ht} = (1-d).R_{h,t-1} + (RD)_{h,t-1}.$$

From the above equation, $R_{h,t-1}$ indicates the technological stock of a region h in the last year. Here region stands for north, south, east, and west region of India. So, a region specific technological stock has been obtained by the help of the annual R&D expenditure of all firms of all selected industries within that region. And $(RD)_{h,t-1}$ indicates the sum of annual R&D expenditure of all firms in all selected industries within that region in the time period $t-1$.

Technology Stock of other Clusters (R_{lt})**:** This is another kind of technological stock variable which is generated within a cluster but it would lie within that region. The technological stock of other clusters as $l'th$ cluster within a region has been obtained by subtracting region-specific technological stock with respect to the cluster-specific technological stock which belongs to that cluster. After subtraction we square this factor in order to take the full effect of the technological knowledge which is developed by all other clusters within a region. Moreover, the technological knowledge of a given cluster is associated with the technological knowledge of the own cluster in its region and other technological stock of other clusters which are belonging to that region. Thus, the technology stock of the other clusters (l) of a given region h is as follows:

$$R_{lt} = \sum_{h}^{N}\sum_{k}^{N} (\ln R_{ht} - \ln R_{kt})^2.$$

But from the above equation if we consider the effect of the technological stock of other clusters to a particular cluster k associated with respect to a given region h then we take only one cluster k and one region h for easy convenience and for the compilation of the third kind of technology stock variable. Thus, omitting the variability of the summation sign R_{lt} becomes:

$$R_{lt} = \left[(1-d).R_{h,t-1} + (RD)_{h,t-1} - \left\{(1-d).R_{k,t-1} + (RD)_{k,t-1}\right\}\right]^2.$$

Market Concentration $(CON)_{jt}$ **:** This is another kind of the cluster-specific effect, and it is obtained by the Herfindahl –Hirschman index (HHI) ratio of market concentration. And the formula for the HHI concentration index of a cluster becomes:

[4] $$HHI = \sum_i \left(\frac{(S)_{ijk}}{\sum (S)_{ijk}} \right)^2 ;$$

Where $(S)_{ijk}$ indicates the sales of the $i'th$ firm in the $j'th$ industry of a cluster k. And the denominator is the summation over the sales of all firms in the $j'th$ industry within that cluster.

$(D1)_{ij}$: This is stands for the dummy variable of firm plant location belonging to the centre of a cluster or firms are not geographically located in the centre of a cluster. That is firms those that are not in the cluster but may be nearer to the cluster (city, or semi-developed area or rural area) are taken as zeros and firms are within the clusters areas are taken as 1s.

$(D2)_{ij}$: This dummy variable stands for institutional variables like credit and banking infrastructure of the clusters. We hypothetically assume that firms whose plant location is in the cluster or in an urban area are at a greater advantage in comparison to those firms nearer to the clusters but located in the country side. Because banking infrastructure is more efficient in the urban area in comparison to the rural areas. Thus, firm's pant location in the city clusters is taken as 1s and firms whose plant location is in the rural area are taken as 0s.

$(D3)_{ij}$: This is another kind of dummy variable and stands for the physical infrastructure like road, telecommunication, electricity, etc. Firms whose plant location is in the rural area are taken as 0s and firms whose plant location is in the city area of a cluster are taken as

[4] For the estimation of the market concentration of an industry most of the study generally uses the Herfindahl-Hirschman index (HHI) as the concentration index. In fact, in our present analysis to analyze the inter-cluster technology spillover and to find out the role of market concentration upon the domestic firms labour productivity, we hypothetically assume and apply the same methodology (HHI) to estimate the market concentration index of an industry in a particular cluster.

1s. However, rural areas have access to a very poor physical infrastructure in comparison to the city area.

Appendix B:

Table B1: Classification of Firms (Out of Selected Seven Industries) according to the Different Clusters/Regional Provinces:

Regional Provinces	Domestic firms	Foreign firms	Total firms
Baddi	39	4	43
Noida	35	6	41
Gurgaon	37	11	48
Bhiwadi	21	3	24
Thane	33	2	35
Ankleswar	35	5	40
Kolkata	35	10	45
Chennai	29	14	43
Hyderabad	32	7	39
Bangalore	51	20	71

Source: Own compilation from the CMIE data base Prowess

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