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## DEPARTMENT OF ECONOMICS
**(AUTONOMOUS)**

# PRODUCTIVITY SPILLOVERS FROM FOREIGN DIRECT INVESTMENT IN THE MANUFACTURING SECTOR OF INDIA

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***Abstract***

The paper tried to study spillovers from foreign direct investment (FDI) in the manufacturing sector of India, using firm level data for the period 2000 to 2010. Both, horizontal and vertical (backward and forward) spillovers were tested with the help of panel data fixed effects 'within' model. Spillovers across different manufacturing industries were also examined in order to find out whether spillovers varied across industries. It was inferred that spillovers from backward and forward vertical linkages positively affected the Total Factor Productivity (TFP) of the manufacturing sector. Spillovers through horizontal channels were, however, encountered to be negative. The results at the dis-aggregated industry level showed mixed evidence. Most of the industries gained from backward vertical spillovers followed by forward vertical spillovers and lastly horizontal spillovers. Industries like paper products and non-electrical machinery were the only ones benefitting significantly through productivity spillovers from FDI. On the other hand, industries such as cosmetics, chemicals and fertilizers and drugs and pharmaceuticals gained solely through backward vertical spillovers. The absorptive capacity (particularly human capital) of the manufacturing sector was, however, found to be low. Moreover, it was observed that industries witnessing considerable amount of FDI inflows did not benefit from the spillovers in the similar manner. These include automobile industry, electrical machinery, electronics and miscellaneous manufacturing.



***Key Words*:** Spillovers, Foreign Direct Investment, Manufacturing, Absorptive capacity

***JEL Code(s)*:** F21, F23, L60, O30, O47

# PRODUCTIVITY SPILLOVERS FROM FOREIGN DIRECT INVESTMENT IN THE MANUFACTURING SECTOR OF INDIA*

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## 1. INTRODUCTION:

The neo liberal reforms of 1991 widened the scope of FDI in India. One of the reasons behind this was to gain from access to new technology, products and processes that multinational enterprises (MNEs), which are the main purveyors of FDI, bring along with them. It is often argued that MNEs possess proprietary advantages in the form of firm-specific non-tangible assets like technical knowhow, marketing and managerial skills, access to cheap raw materials, well-developed export markets etc, which help them compete with domestic firms in the host country (Hymer, 1976). Since these advantages have the characteristics of a public good, domestic firms can benefit through indirect channels known as the productivity spillovers. Spillovers take place when entry of MNEs lead to productivity increase in the host country firms and MNEs are not able to fully extract the quasi-rents out of it (Blomström and Kokko, 1998; Caves, 1974; Javorcik, 2004; Kokko, 1992; Kugler, 2006).

Spillovers from MNE's activities can be classified as 'horizontal spillovers' and 'vertical spillovers'. Horizontal spillovers occur within the industries in which MNEs operate and are also called as *intra-industry* spillovers. They take place through competition, demonstration and labour turnover. According to Blomström (1999), the entry of MNEs disturbs the existing equilibrium in domestic industry and forces domestic firms to upgrade themselves in order to retain their market share and profits. Foreign presence, therefore, increases competition and induces host country firms to introduce new technologies and use existing resources more efficiently. This, in turn, improves their allocative efficiency and increases production. Moreover, Blomström and Kokko

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(1997, 1998) further state that spillovers from FDI are important because the technology brought in by MNEs is not easily available. MNEs often introduce new products and processes in the host country markets which domestic firms can adopt through observation and demonstration. With the diffusion of technology, domestic firms can upgrade themselves by demonstrating new methods and techniques of production and, thereby, reduce their x-inefficiency (Caves, 1974). Lastly, spillovers might also occur through labour turnover, especially when trained labour from MNEs migrates to domestic firms. MNEs place significant importance on training of labour and, hence, domestic labour can learn from migrated labour and raise their human capital skills. However, Aitken and Harrison (1999) point out that, since MNEs possess technical expertise, their marginal cost of production is lower. Due to this, foreign firms can produce more than their domestic counterparts and steal away market demand from them. Thus, in this case, the negative effect from competition would dominate the positive knowledge spillover effect. In addition to this, Javorcik (2004), Kugler (2006) and Wang (2010) argue that as the main objective of MNEs is to earn profits, they generally try to prevent any type of leakage of their technical knowledge to domestic firms. The spillover effects within the industries can, therefore, be limited.

Vertical spillovers, on the other hand, occur when foreign firms establish linkages with domestic firms operating in different industries in the host country. Such types of spillovers are also known as *inter-industry* spillovers. Inter-industry spillovers can be, further categorised as spillovers from 'backward linkages' and spillovers from 'forward linkages'. Backward linkages are created when foreign firms in the downstream sectors develop relationships with the upstream domestic firms. In backward linkages, foreign firms are the customers of raw materials and intermediate products from local suppliers. According to Blomström and Kokko (1998) and Javorcik (2004), backward linkages create demand for inputs of local firms and help them set up new production facilities. Moreover, since the product requirements of MNEs are high in quality, they generally support local firms in the purchase of raw materials, provide technical assistance and training, thereby assisting them to upgrade their production and management techniques. Training provided to the employees of domestic firms also helps in raising the levels of

human capital. In the case of forward linkages, foreign firms play the role of suppliers of intermediate products to domestic firms. Domestic firms are provided with better quality inputs and costumer services at a lower cost. According to Clare (1996), spillovers through linkages are strong when the demand for intermediate products by MNEs is comparatively large and the communication costs between MNEs and their head quarters are significant. Otherwise, MNEs can impact negatively by creating their own enclaves and preventing any linkages to occur.

**Figure 1**: Productivity Spillovers from FDI

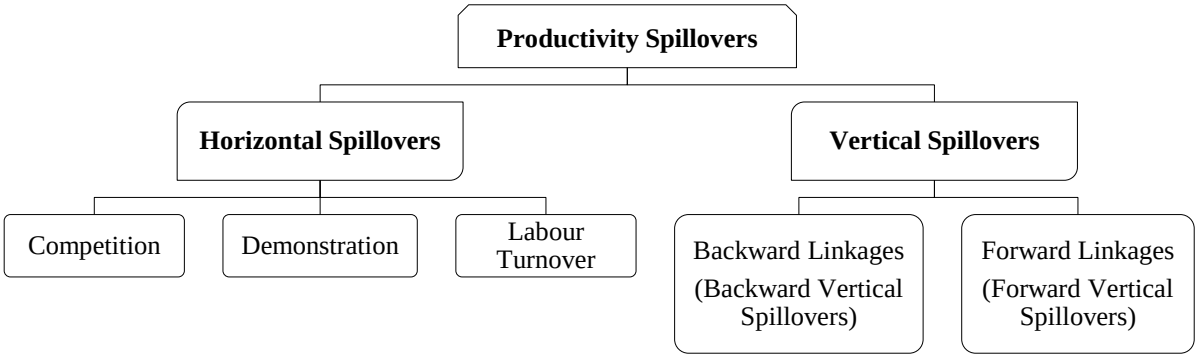


Figure 1 explains, in brief, the channels through which productivity spillovers take place. Against this backdrop, the paper tries to assess productivity spillovers from FDI in the manufacturing sector of India. The objective of the study is to find out whether horizontal (mainly through competition and demonstration) and vertical (backward and forward) spillovers exist in the Indian manufacturing sector. In addition to this, an attempt has been made to check for spillover effects across different manufacturing industries to analyse whether spillovers vary across industries. Moreover, the role of the absorptive capacity of the host economy is also recognized in the paper.

The rest of the paper is organised as follows: The *second* Section reviews the empirical literature related to horizontal and vertical spillovers from FDI. Section *three* deals with data sources and methodology applied for the purpose of analysis. The *fourth* Section explains, in detail, construction of the model and the underlying variables. The

results from the analysis are presented in Section *five*, while the *last* Section concludes the paper.

## 2. REVIEW OF LITERATURE:

The empirical literature on spillovers from FDI is extensive. Blomström and Kokko (1997) argue that the earliest discussion on productivity spillovers can be traced back to the early 1960s. However, the investigation was mainly in the form of case studies. Moreover, the type of spillovers examined was principally horizontal spillovers. Caves (1974) and Globerman (1979) were the first to test productivity spillovers for Canada and Australia with the help of cross-sectional data. While Caves (1974) found horizontal spillovers for Australia to be significant for the year 1965, Globerman's (1979) study asserted that labour productivity in the Canadian manufacturing sector for the year 1972 was positively related to foreign presence. A similar type of cross-sectional investigations were undertaken by Blomström (1986) for Mexico, Blomström and Sjokhölm (1999) for Indonesia, Kokko (1996) in the case of Mexico, Kokko, Tansini and Zejan (1996) for of Uruguay and Liu and Wang (2003) in the case of China. One of the drawbacks of all these studies was their reliance on cross-sectional analysis. Görg and Greenway (2001) argued, in this context, that cross-sectional data failed to explain time-invariant and heterogeneous factors that affect productivity. Panel data methods, on the other hand, captured unobserved heterogeneity, thereby making the estimation procedure unbiased. It would be, thus, more appropriate to use panel data techniques while testing productivity spillovers from FDI. In addition to this, Kugler (2006) stated that empirical evidence on intra-industry spillovers was likely to be weak since MNEs might be able to prevent leakage of knowledge in the same industries effectively. Therefore, rivalry effects from FDI would be more dominant than knowledge-sharing effects in the competing industries. Diffusion of knowledge in non-competing and complementary industries was more probable, thus, providing support for inter-industry linkages.

Most of the recent studies, therefore, take into account vertical spillovers along with the horizontal ones, in order to, appropriate the indirect gains from FDI. These

include Smarzynska (2002) and Javorcik (2004) for Lithuania, Damijan, et al. (2003) for transition economies, Kee (2005) in the case of Bangladesh, Bitzer and Görg (2007) for OECD countries, Filippo and Sica (2007) for Italy, Blalock and Gertler (2008) in the case of Indonesia, Liu (2008) for the Chinese economy, Stančík and Ei (2009) in the case of Czech Republic and Wang (2010) for Canada. Most of these studies supported the evidence of spillovers through vertical channels rather than horizontal ones. In addition to it, absorptive capacity of the host economy was also argued to be one of the important factors determining the gains from spillovers. These comprise of studies by Joseph (2007), Kathuria (2001), Kohpaiboon (2009), Liu, Siler, Wang and Wei (2000), Pradhan (2004), Smarzynska (2002), Todo and Mujamoto (2006), Xu (2000), Wang and Gu (2006) and Wang (2010). All the studies stressed that the incoming benefits from productivity spillovers were dependent on the host country's absorptive capacity, particularly research and development and human capital.

In the case of India, the empirical studies dealing specifically with horizontal and vertical spillovers are those of Joseph (2007) and Sasidharan and Ramanathan (2007). Joseph (2007) examined the existence of productivity spillovers from FDI through horizontal and backward vertical spillovers in the manufacturing sector of India. For the purpose of analysis, firm level data for the period 1993 to 2004 was estimated using panel data fixed effects model. The results indicated the positive impact of foreign presence on the productivity of domestic firms. It was inferred that both horizontal spillovers (competition effect) and backward vertical spillovers (complementary effect) helped in improving the productivity of domestic firms. In addition, it was also found out that the efforts taken by domestic firms in their research and development activities provided a cushion for reaping the incoming benefits. Thus, the absorptive capacity of domestic firms in the form of technological upgradation was depicted to play a crucial role in generating spillovers.

Sasidharan and Ramanathan (2007) analysed horizontal and backward vertical spillovers from FDI in the Indian manufacturing sector for the period 1994 to 2002. In the first step, a study of the presence of foreign ownership on productivity levels across all

industries was undertaken. The results were found to be positive, suggesting that foreign presence affected domestic productivity levels. In the next step, a scrutiny of spillovers with the help of a first difference model was carried out. The results indicated insignificant horizontal spillovers while backward vertical spillovers turned out to be negative. The study, thus, signalled that domestic firms were adversely affected due to foreign presence and FDI did not cater in developing relations between domestic firms and MNEs.

It can, therefore, be deduced that spillovers from FDI can help domestic firms to upgrade themselves, improve their production techniques and become more competitive. The absorptive capacity of the host economy is crucial in order to reap these gains. In the paper, an attempt has been made to test productivity spillovers for the entire manufacturing sector. As the empirical literature suggests, vertical spillovers are expected to be more pronounced than the horizontal ones. A separate analysis at industry level is also aimed at, which most of the studies did not capture. The main reason behind this is to determine whether spillovers vary across different industries. The results are further compared with FDI inflows in the corresponding industries in order to find whether industries witnessing considerable FDI inflows are experiencing spillovers in the same manner. Though the study does not deal with interactions between spillovers and absorptive capacity in particular, the importance of research and development is pointed out in the study.

## 3. DATA SOURCES AND METHODOLOGY:

The study makes use of a secondary database 'PROWESS' compiled by the Centre for Monitoring Indian Economy (CMIE). Prowess covers listed and unlisted companies. For listed companies the database includes data sourced from the stock exchanges. Data on the manufacturing sector, both aggregate and industry-wise, has been extracted for variables like sales, net fixed assets, salaries and wages, research and development expenses and expenses on staff training and welfare. The data on these variables is taken from the annual financial statements of companies for the period 2000

to 2010. The original data set consisted of more than 10,000 firms. However, firms with value zero for any of the variables and those with missing values have not been included in the analysis. After cleaning the data, the study constitutes 3208 firms, out of which 2881 are domestic firms and 327 are foreign firms. A detailed description of number of domestic and foreign firms at industry level is presented in Appendix-A. Foreign firms are defined as firms with more than 10 percent foreign equity as per IMF guidelines, data on which is provided in the CMIE. The final structure of data is unbalanced in nature (unbalanced panel).

Since the data involves observations on the number of firms across several time periods, the paper relies on panel data techniques for estimation purposes. Panel data methods take into consideration the fact that firms or individuals under observation vary in their characteristics over time. Panel data models capture the unobserved heterogeneity which the pure cross-sectional or the time series analysis does not (Baltagi, 1995; Hsiao, 2005). Panel data sets can be estimated using a 'fixed effects model' or a 'random effects model'. In the case of a fixed effects model, the unobserved time and individual characteristics are considered as parameters to be estimated. The random effects model, on the other hand, treats this unobserved heterogeneity as arising out of random factors. In the present study, a fixed effects model has been used for the analysis. This is because the data comprises of different firms with their own peculiar characteristics. It would, therefore, be appropriate to model these factors as separate variables to be estimated.

There are three methods by means of which the fixed effects model can be estimated. First is the 'least square dummy variable model' where each firm is assigned individual dummies to account for the unobserved effects. One of the backdrops of this model is that if number of cross-sectional units is too large, adding too many dummies may lead to considerable loss of degrees of freedom and also create the problem of multicollinearity. The second model is the 'within model', where data is transformed into mean deviation form. Such a transformation wipes away the unobserved effects and prevents loss of degrees of freedom. The third type is the 'between model', where the data is transformed by differencing. This method also eliminates unobserved

heterogeneity and preserves the degrees of freedom. Out of the three methods, the '*within approach'* has been adopted, as the number of firms in our data set is large. Moreover, the empirical literature supports the within model more than the between model (Baltagi, 1995; Greene, 2003; Hsiao, 2005; Wooldridge, 2003). The results of the panel data fixed effects within model are computed using the 'R' Statistical Software (Croissant and Millo, 2008).

## 4. MODEL:

This section explains the method adopted to develop the model and its underlying variables. These variables are then fitted into the model in order to test spillovers from FDI into the manufacturing sector of India.

### 4.1. *Description of the model*:

In order to test productivity spillovers from FDI, in the first step TFP is estimated using Cobb-Douglas production function (Anwar and Nyugen, 2010):

$$Y_{jit}=A_{jit}K_{jit}^{\alpha} L_{jit}^{\beta} \quad \text{..... (1)}$$

where,

$Y_{jit}$ = Output of the $j^{th}$ firm in $i^{th}$ industry at time period t.

$K_{jit}$ = Capital used by the $j^{th}$ firm in $i^{th}$ industry at time period t.

$L_{jit}$ = Labour of the $j^{th}$ firm in $i^{th}$ industry at time period t.

$A_{jit}$ = Technology parameter capturing TFP of $j^{th}$ firm in $i^{th}$ industry at time period t.

$\alpha$ and $\beta$ are the capital and labour coefficients respectively.

Taking log on both the sides, TFP is calculated as,

$$\ln A_{jit} = \ln Y_{jit} - \alpha \ln(K_{jit}) - \beta \ln(L_{jit}) \quad \text{..... (2)}$$

In the second step, the impact of spillovers on TFP is analysed with the help of the following log-linear equation, using panel data fixed effects 'within' model:

$$\ln \Delta A_{jit} = \beta_1 \ln \Delta RD_{jit} + \beta_2 \ln \Delta HK_{jit} + \beta_3 \ln \Delta HFDI_{it} + \beta_4 \ln \Delta BFDI_{it} + \beta_5 \ln \Delta FFDI_{it} + \Delta \varepsilon_{jit} \quad \ldots\ldots\ldots\ldots (3)$$

where,

$RD_{jit}$ = Research and development activities of the $j^{th}$ firm in $i^{th}$ industry at time period t.

$HK_{jit}$ = Human capital of the $j^{th}$ firm in $i^{th}$ industry at time period t.

$HFDI_{it}$ = Horizontal spillovers in the $i^{th}$ industry at time period t.

$BFDI_{it}$ = Backward Vertical spillovers in the $i^{th}$ industry at time period t.

$FFDI_{it}$ = Forward Vertical spillovers in the $i^{th}$ industry at time period t.

$\Delta$ symbolises that the variables are in mean deviation form.

In the third step, a ratio of research and development expenses to total sales is computed separately for all the industries. The purpose behind this is to estimate research and development intensity (RI) across all the industries, in order to, test whether industries with high RI experience more spillovers than those with low RI. Following Wang and Gu (2006), RI is defined as:

$$RI_{it} = \frac{\sum_{j=1}^{n} RD_{jit}}{\sum_{j=1}^{n} TS_{jit}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where,

$RI_{it}$ = Research Intensity of the $i^{th}$ industry at time period t.

$RD_{jit}$ = Research and development expenses of the $j^{th}$ firm in the $i^{th}$ industry at time period t.

$TS_{jit}$ = Total sales of the $j^{th}$ firm in the $i^{th}$ industry at time period t.

After estimating RI, the industries are divided in to three groups, those with high RI, medium RI and low RI. Equation 3 is then re-estimated to arrest spillover effects for these groups. Lastly, spillovers across all industries of the manufacturing sector are tested using Equation (3).

**4.2.** ***Explanation of variables*****:**

The variables used for the purpose of estimation are defined as follows:

**4.2.1. Output ($Y_{jit}$):** Output is defined as total sales of the $j^{th}$ firm in $i^{th}$ industry at time period t. The total sales are deflated by the Wholesale Price Index (WPI) with 2004-05 as the base year, to convert them in to constant prices (GOI, 2012c).

**4.2.2. Capital ($K_{jit}$):** Capital is constructed using net fixed assets of the $j^{th}$ firm in $i^{th}$ industry at time period t. It is deflated using the WPI (average) of machinery and machine tools and transport equipments with the year 2004-05 being the base year.

**4.2.3. Labour ($L_{jit}$):** Labour is estimated by the variable salaries and wages paid by the $j^{th}$ firm in $i^{th}$ industry at time period t. It is computed as the ratio of $j^{th}$ firm's wage to the average industry wage at a particular time period.

**4.2.4. Research and Development ($RD_{jit}$):** Research and development is defined as the expenses of $j^{th}$ firm in $i^{th}$ industry on research and development activities.

**4.2.5. Human Capital ($HK_{jit}$):** Human capital constitutes of the expenses of the $j^{th}$ firm in the $i^{th}$ industry on training and upgrading its employees at time period t.

**4.2.6. Horizontal Spillovers ($HFDI_{it}$):** Horizontal spillovers are defined as the share of output of foreign firms in total output of a particular industry (Javorcik, 2004). This variable appropriates foreign presence in a given industry, thus, assisting in examining the spillovers through competition and demonstration.

$$HFDI_{it} = \frac{\sum_{j \in i} FS_{jt}}{\sum_{j \in i} TS_{it}} \quad \text{……..……} \quad (5)$$

where,

$FS_{jt}$ is the share of $j^{th}$ foreign firm in $i^{th}$ industry at time period t.

$TS_{it}$ is the total output of $i^{th}$ industry at time period t.

**4.2.7. Vertical Spillovers**: Vertical spillovers comprise of spillovers through backward and forward linkages. They represent the relationships of MNEs with their local counterparts. A detailed description of the construction of vertical linkages is explained in Appendix-B.

- **Backward Vertical Spillovers ($BFDI_{it}$):** Backward vertical spillovers capture the linkages created by MNEs as downstream customers with upstream domestic suppliers of intermediate products. It is defined as,

$$BFDI_{it} = \sum_{\forall\, k \neq i} \delta_{ik}\ HFDI_{kt} \quad \text{…….. (6)}$$

where, $\delta_{ik}$ is the proportion of output of $i^{th}$ industry supplied to the $k^{th}$ industry. The variable $\delta_{ik}$ is calculated from the input-output tables for the years 1999-2000, 2003-04 and 2006-07 (GOI, 2012b). $\delta_{ik}$ is multiplied by $HFDI_{it}$ to take into account the spillovers from foreign firms to its domestic suppliers.

- **Forward Vertical Spillovers ($FFDI_{it}$):** Forward vertical spillovers capture the linkages created by MNEs as upstream suppliers of intermediate products to the downstream domestic firms. It is defined as,

$$FFDI_{it} = \sum_{\forall\, k \neq i} \sigma_{ki}\, HFDI_{it} \quad \text{…….. (7)}$$

where, $\sigma_{ki}$ is the proportion of output of the $k^{th}$ industry used as inputs by the $i^{th}$ industry, computed from the input-output tables for the years 1999-2000, 2003-04 and 2006-07. $\sigma_{ki}$ is also multiplied by $HFDI_{it}$ in order to detect spillovers from foreign firms to its local customers.

## 5. Empirical Results:

**Table 1:** Empirical Results from Fixed Effects 'Within' Model
(Manufacturing Sector)

| VARIABLES | ESTIMATED COEFFICIENTS |
|---|---|
| LNRD | 0.0674** |
| LNHK | 0.0019 |
| LNHFDI | -1.4033** |
| LNBFDI | 0.5654** |
| LNFFDI | 1.0552** |
| ** significant at 1 percent l.o.s | |

Table 1 represents the results from empirical investigation using a panel data fixed effects within model for the entire manufacturing sector. It can be observed from Table 1 that the Indian manufacturing sector witnessed positive spillovers from backward and forward vertical spillovers for the period 2000 to 2010. Both the coefficients were significant at 1 percent level of significance (l.o.s). The coefficient for horizontal spillovers, however, turned out to be negative. This indicates that domestic firms are adversely affected due to fierce competition from foreign firms within industries. MNEs are, therefore, preventing leakage of knowledge in the same industries. Significant backward vertical spillovers, on the other hand, connote that domestic producers are benefitting from the linkages with MNEs. This, in turn, is helping domestic firms to improve their product quality. The coefficient for forward vertical spillovers is also positive, suggesting that inputs provided by foreign firms are assisting local firms in their production process. The manufacturing sector as a whole is, thus, benefitting solely from vertical productivity spillovers through FDI.

The effect of human capital on TFP is also positive but insignificant. The result for research and development is positive and significant at 1 percent l.o.s. Research and

development activities are, hence, contributing positively to the productivity of the firms in the manufacturing sector. In addition, it is also argued that research and development initiatives of the host country firms are important source of productivity growth through spillovers (Kathuria, 2001; Pradhan, 2004; Wang and Gu, 2006; Wang, 2010). Industries who place significant importance on research-related activities are, therefore, more likely to benefit from spillovers. In order to evaluate the role of research and development in facilitating spillovers from FDI, RI is calculated at industry level by adopting the methodology applied by Wang and Gu (2006). However, Wang and Gu (2006) also considered human capital intensity along with RI while grouping industries. In the present study, groupings are done solely on the basis of RI.

**Table 2:** Industry-wise Research and Development Intensity (RI) of Manufacturing Sector

| NIC Code | INDUSTRY | RI | RANK | NIC Code | INDUSTRY | RI | RANK |
|---|---|---|---|---|---|---|---|
| 18 | Books and Cards | 1.7171 | 1 | 15 | Leather | 0.3787 | 12 |
| 21 | Drugs and Pharmaceuticals | 1.5135 | 2 | 30 | Automobile Industry | 0.3654 | 13 |
| 28 | Non-electrical Machinery | 1.0517 | 3 | 17 | Paper Products | 0.3136 | 14 |
| 26 | Electronics | 0.7671 | 4 | 24 | Ferrous Metals | 0.3134 | 15 |
| 27 | Electrical Machinery | 0.7171 | 5 | 10 | Food Products | 0.2634 | 16 |
| 12 | Tobacco | 0.6415 | 6 | 13 | Textiles | 0.2525 | 17 |
| 32 | Miscellaneous Manufacturing | 0.6203 | 7 | 22 | Tyres and Tubes | 0.1951 | 18 |
| 11 | Beverages | 0.5558 | 8 | 23 | Non-metallic Mineral Products | 0.1636 | 19 |
| 22 | Plastic and Rubber Products | 0.4645 | 9 | 19 | Petroleum Products | 0.1374 | 20 |
| 20 | Cosmetics | 0.4277 | 10 | 24 | Non-Ferrous Metals | 0.1173 | 21 |
| 20 | Chemicals and Fertilisers | 0.4271 | 11 | -- | -- | -- | -- |

Table 2 describes RI across various industries of the manufacturing sector. It can be noticed from the Table that overall RI across all manufacturing industries is considerably low. None of the industries spent more than 2 percent of income from their output on research and development activities. RI was highest for books and cards followed by drugs and pharmaceuticals, non-electrical machinery and electronics. Industries like non-ferrous metals and petroleum, on the other hand, exhibited low RI. Based on these RIs, the industries are, further, divided in to three groups; those with high

RI (RI ≥ 0.7), medium RI (0.7< RI ≤0.4) and those displaying low RI values (RI <0.4). The spillover effects for these groups are summarised in Table 3.

**Table 3:** Spillover Effects based on Research and Development Intensity (RI)

| INDUSTRY | LNRD | LNHK | LNHFDI | LNBFDI | LNFFDI |
|---|---|---|---|---|---|
| Industries with High RI | 0.1002** | -0.0698** | -0.9517** | 0.4954** | 0.7294** |
| Industries with Medium RI | 0.1248 | 0.1202 | 1.0356 | 2.5034** | -3.2001** |
| Industries with Low RI | 0.0131 | -0.0593** | -2.5913** | 0.5178** | 2.2754** |
| ****** significant at 1 percent l.o.s | | | | | |

It can be deciphered from Table 3 that spillovers from FDI differ across the RI groups. Out of the three groups, horizontal spillovers were negative for two, mainly, those with high and low RI. The value for industries with medium RI turned out to be insignificant. This implies that, irrespective of the research and development initiatives, domestic firms are losing out their market share and profits due to competition from foreign firms. Spillovers through demonstration effects are, thus, very weak in the Indian manufacturing sector. Backward vertical spillovers were, however, positive for all three RI groups, asserting significant linkages between MNEs and local firms. Forward vertical spillovers were also positive for two groups, except industries with medium RI where the coefficient value was negative (significant at 1 percent l.o.s). It can also be seen that value for human capital was negative for industries with high and low RI. Thus, despite the research activities, initiative of local firms on development of human skills is weak.

The above analysis, therefore, points out that, vertical spillovers from FDI were more prominent than horizontal spillovers for the entire manufacturing sector. It can, thus, be asserted that spillovers through the linkages with foreign firms are contributing more to TFP than spillovers through competition and demonstration. The classification based on RI also supported spillovers from backward vertical spillovers over the horizontal ones. MNEs are, therefore, stealing away market demand from domestic firms. On the basis of this aggregate picture, an analysis at the dis-aggregated level can be undertaken to check for spillover effects across all the manufacturing industries. This will help to arrive at a precise conclusion as to which industries are actually benefitting from spillovers regardless of them being high or low in RI. The spillovers can also be

compared with FDI inflows in the respective industries so as to detect whether industries with high amount of FDI inflows are witnessing any productivity spillovers.

**Table 4:** Empirical Results from Fixed Effects 'Within' Model (Industry-wise)

| NIC Code | INDUSTRY | LNRD | LNHK | LNHFDI | LNBFDI | LNFFDI |
|---|---|---|---|---|---|---|
| 10 | Food products | -0.0565 | 0.1065 | -0.29 | 2.5885** | -1.771 |
| 11 | Beverages[£] | -0.0368 | 0.1844 | -0.9778** | 0.7893** | -- |
| 13 | Textiles[£] | 0.07 | -0.2149** | -1.9745 | 2.0655 | -- |
| 17 | Paper Products | 0.2061** | -0.0929 | 5.2761* | 2.0138* | -6.5417* |
| 19 | Petroleum Products[£] | -0.1643 | -0.5792** | 0.0759 | 0.8477* | -- |
| 20 | Cosmetics | -0.2388^ | -0.1007 | -0.2835 | 5.4051** | -5.3536^ |
| 20 | Chemicals and Fertilisers | 0.0418^ | -0.0298 | -0.0495 | 1.2838** | -0.8453** |
| 21 | Drugs and Pharmaceuticals | 0.0415 | -0.1677** | 0.0882 | 3.4572** | -3.1498** |
| 22 | Plastic and Rubber Products | -0.0848^ | 0.0921^ | -2.9438** | -0.8171** | 4.3374** |
| 23 | Non-Metallic Mineral Products[£] | 0.7198* | -0.0939* | -1.9431* | 1.9441* | -- |
| 24 | Ferrous Metals[£] | 0.1485** | -0.0183 | -0.2234 | 0.3368 | -- |
| 24 | Non-Ferrous Metals | 3.2288* | -2.7764* | 2.2 | 0.9553 | -5.3049 |
| 26 | Electronics[£] | 0.0412 | -0.1346* | -0.1824** | 0.5303** | -- |
| 27 | Electrical Machinery | -0.0611^ | -0.2159** | -5.5649* | -0.3838 | 6.5635** |
| 28 | Non-Electrical Machinery | 0.0513 | -0.2015** | 7.2732** | 6.8553** | -13.7542** |
| 30 | Automobile Industry | 0.0821** | -0.0576 | -2.2011** | -0.15455^ | 2.9782** |
| 32 | Miscellaneous Manufacturing | -0.0652 | -0.0028 | -7.9174** | -1.2022** | 9.4922** |
| 10-32 | **Manufacturing Sector** | **0.0674**** | **0.0019** | **-1.4033**** | **0.5654**** | **1.0552**** |
| ****** significant at 1 percent l.o.s, ***** significant at 5 percent l.o.s, ^ significant at 10 percent l.o.s | | | | | | |
| [£] LNFFDI not estimated due to presence of multicollinearity | | | | | | |

Table 4 presents the results from fixed effects within model (Equation 3) for all industries of the manufacturing sector. However, while estimating the industry-wise productivity spillovers, some industries like tobacco (NIC-12), books and cards (NIC-18), leather (NIC-15), and tyres and tubes (NIC-22) had to be dropped due to problem of multicollinearity. Moreover, the same problem was encountered while estimating forward vertical spillovers for some industries like beverages, electronics, textiles etc. The fixed effects within model for all these industries were estimated by excluding this variable.

It can be seen from Table 4 that the findings across various industries illustrate a diverse picture. Out of the 17 industries, 2 experienced positive horizontal spillovers.

Backward vertical spillovers were encountered to be significant for 10 industries while forward vertical spillovers were positive for 4 industries. None of the industries displayed positive coefficients for all three spillover variables taken together. Industries like paper products and non-electrical machinery were the only ones benefitting from horizontal spillovers. This indicates that domestic firms in these industries are gaining through demonstration effects. This in turn, is helping them to upgrade themselves to shield against the competition from MNEs. On the other hand, coefficients for most of the industries like plastic and rubber products, electrical machinery, automobile and miscellaneous manufacturing industries and were negative. This implies that TFP of these industries has decreased due to fierce competition from MNEs. Foreign firms are, thus, surpassing domestic firms in terms of market demand and profits. The rivalry effect from FDI is, therefore, outweighing the positive effects from demonstration and observation in these industries.

It can be further, deduced from Table 4 that, in case of vertical spillovers, spillovers through backward linkages were more pronounced than the forward ones. Out of 17 industries, coefficients for food products, paper products (5 percent l.o.s), cosmetics, chemicals and fertilisers, drugs and pharmaceuticals and non-electrical machinery were significant at 1 percent l.o.s. Non-electrical machinery experienced the highest backward vertical spillovers, followed by cosmetics and drugs and pharmaceuticals. Domestic firms in these industries are, thus, witnessing improvements in their production quality and human capital due to their relationships with foreign firms. Industries like plastic and rubber products and miscellaneous manufacturing, however, did not gain through backward linkages. This implies that foreign firms are not relying on local firms for their intermediate products in these industries. They might be either importing them or producing these products by themselves.

In the case of forward vertical spillovers, on the other hand, industries like plastic and rubber products, electrical machinery, automobiles and miscellaneous manufacturing received positive spillovers from FDI (at 1 percent l.o.s). Foreign firms as suppliers of intermediate products are, hence, catering to the needs of domestic firms in these

industries. Domestic firms are profiting from quality inputs and better customer services from MNEs. Nevertheless, it can be observed that industries experiencing negative spillovers from forward linkages are considerable in number. These comprise of paper products (5 percent l.o.s), cosmetics, chemicals and fertilizers, drugs and pharmaceuticals and non-electrical machinery (significant at 1 percent l.o.s). Inputs from foreign firms are, thus, not helping domestic firms from these industries to improve their TFP.

The evidence on spillovers at the industry level is, therefore, mixed. While some industries gained from spillovers, others did not. Out of the three spillover variables, industries gaining from backward vertical spillovers were more, followed by forward vertical spillovers and lastly horizontal spillovers. It can also be noticed that, in the industries where the variable for forward vertical spillovers was excluded, backward vertical spillovers were more pronounced than the horizontal spillovers. These include industries such as beverages and electronics. The coefficient for human capital was negative for majority of the industries. As pointed out in the literature, development of human capital is important to gain from spillovers through FDI (Anwar and Nguyen, 2010; Borensztein, Gregorio and Lee, 1995; Joseph, 2007; Smarzynska, 2002; Wang and Gu, 2006). The coefficient for research and development is also positive for very few industries. The absorptive capacity of the economy in form of human capital and research has to be increased in order to gain more from spillovers.

Lastly, a comparison between spillovers at the industry level and corresponding FDI inflows can be undertaken with the help of Table 4 and Table 5. Table 5 represents the percentage share of FDI inflows received by different manufacturing industries (top 25) from 2000 to 2010. It can be seen from the Table that, FDI inflows were relatively high in industries like miscellaneous manufacturing, automobiles, chemicals, drugs and pharmaceuticals, non-electrical machinery (earth moving machinery, industrial machinery, machine tools, miscellaneous mechanical and engineering, medical and surgical appliances and prime movers other than electrical), metallurgical industries (ferrous and non-ferrous metals), non-metallic mineral products (cement, gypsum and

ceramics) etc. These industries can, therefore, be characterised as those having considerable foreign presence.

If results from panel estimation (Table 4) are compared with FDI inflows in the corresponding industries, it can be seen that non-electrical machinery is the only industry receiving high FDI inflows and gaining substantially from horizontal and backward vertical spillovers. On the other hand, automobiles, electrical machinery, electronics, miscellaneous manufacturing and petroleum, who were leading recipients of FDI, did not experience spillovers in equivalent proportion. As indicated in Table 4, most of these industries did not gain through horizontal spillovers. Within the metallurgical industries, both ferrous and non-ferrous metals encountered insignificant results. Similarly, the results for food products and textiles were also found to be insignificant, irrespective of high amount of FDI inflows. It can, thus, be inferred that most of the industries falling within top 10 receivers of FDI inflows, did not benefit significantly through spillovers.

**Table 5:** FDI Inflows in Indian Manufacturing Sector (2000 to 2010)
(Percentage Share)

| RANK | INDUSTRY | SHARE | RANK | INDUSTRY | SHARE |
|---|---|---|---|---|---|
| 1 | Miscellaneous Industries | **16.89** | 14 | Industrial Machinery | **2.14** |
| 2 | Automobile Industry | **14.11** | 15 | Ceramics | **1.45** |
| 3 | Metallurgical Industries | **9.53** | 16 | Paper and Pulp Including Paper Product | **1.34** |
| 4 | Petroleum and Natural gas | **7.77** | 17 | Machine Tools | **1.15** |
| 5 | Electrical Equipments | **6.83** | 18 | Medical and Surgical Appliances | **1.05** |
| 6 | Chemicals (other than Fertilizers) | **6.63** | 19 | Rubber Goods | **0.87** |
| 7 | Drugs and Pharmaceuticals | **5.2** | 20 | Diamond and Gold Ornaments | **0.85** |
| 8 | Cement and Gypsum Products | **5.16** | 21 | Fertilizers | **0.62** |
| 9 | Food Processing Industries | **3.2** | 22 | Prime Movers other than Electrical | **0.55** |
| 10 | Electronics | **2.72** | 23 | Commercial, Office and Household Equipment | **0.53** |
| 11 | Fermentation Industries | **2.71** | 24 | Printing of Books | **0.52** |
| 12 | Textiles | **2.49** | 25 | Earth-Moving Machinery | **0.46** |
| 13 | Miscellaneous Mechanical and Engineering | **2.49** | -- | -- | **--** |

*Source*: Calculated from GOI (2012a)

## 6. Conclusions:

In the present study, efforts are made to assess productivity spillovers from FDI through horizontal and vertical spillovers in the manufacturing sector of India. It can be inferred from the analysis that, the Indian manufacturing sector as a whole, witnessed spillovers from vertical channels (backward and forward) for the period 2000 to 2010. Horizontal spillovers were, however, found to be negative. The empirical results are, therefore, in line with what is suggested in the literature. Negative horizontal spillovers imply that FDI is not helping domestic firms to upgrade their production techniques through demonstration effects in the same industries. The competition by foreign firms is, on the other hand, adversely affecting their TFP. Despite this, the linkages created by MNEs with the local suppliers of intermediate products are assisting local firms to improve their product quality. The inputs provided by foreign firms are also catering to productivity increase in domestic firms. Furthermore, results from classification based on RI also revealed that all the three industry groups benefitted from spillovers through backward vertical linkages than the horizontal ones. Therefore, rivalry effect from competition is dominating the knowledge spillover effect within the industries, irrespective of the research and development initiatives. The investigation at the industry level, however, presented mixed evidence. The estimation results pointed out that spillovers differed across different manufacturing industries. Spillover effects through backward vertical linkages were more pronounced, followed by forward vertical linkages and lastly horizontal ones. Industries like paper products and non-electrical machinery experienced significant spillovers from horizontal and backward vertical channels. However, industries like electrical machinery, automobiles and miscellaneous manufacturing did not gain through spillovers. Spillovers for non-ferrous metals and textiles were insignificant for all three variables. Most of the manufacturing sector industries, therefore, did not gain through spillovers from FDI.

In addition to this, it was found that most of the industries recipient to high amounts of FDI inflows did not benefit from spillovers in a similar manner. Therefore, though the manufacturing sector as a whole is benefitting from spillovers (mainly vertical

spillovers), industries dominating FDI inflows are adversely affected. One of the findings of the study was the negative contribution of human capital to TFP. The coefficient for research and development was also insignificant for most of the industries. Both the variables are of significant importance in realizing spillovers from FDI as they represent absorptive capacity of the host economy. It can, therefore, be implied that absorptive capacity of Indian manufacturing industry has to be increased in order to benefit from spillovers.

Furthermore, it can be stated that the present analysis considered spillovers explicitly through horizontal and vertical channels. Spillovers from FDI can be experienced through mediums like exports, labour turnover, licensing etc (Blomström and Kokko (1997), which the study did not cover. It would be, thus, helpful to consider these factors along with horizontal and vertical spillovers, to appraise the overall impact of FDI on domestic industry. Moreover, spillovers represent benefits from FDI to the recipient economy. Taking into account, the incentives provided by the host country governments to MNEs, it would be useful to evaluate costs from FDI along with the incoming benefits through spillovers. This would help to precisely estimate the role played by FDI in the host country.

**References:**


1. Aitken, B. J. and A. E. Harrison (1999), "Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela", *The American Economic Review*, Vol. 89, No. 3, pp. 605-618.

2. Anwar, S. and Nguyen, L.P. (2010), "Absorptive capacity, foreign direct investment-linked spillovers and economic growth in Vietnam", *Asian Business and Management*, Vol. 9, No. 4, pp.553-570.

3. Baltagi, B. (2005), "*Econometric Analysis of Panel Data*", 3rd Edition, John Wiley and Sons Limited, England.

4. Bitzer, J., I. Geishecker and H. Görg (2007), "*Productivity Spillovers through Vertical Linkages: Evidence from 17 OECD Countries*", The University of Nottingham, Research Paper 2007/26.

5. Blalock, G. and P. J. Gertler (2008), "Welfare gains from Foreign Direct Investment through Technology Transfer to Local Suppliers", *Journal of International Economics*, Vol. 74, No.2, pp. 402–421.

6. Blomström, M. (1986), "Foreign Investment and Productive Efficiency: The Case of Mexico", *The Journal of Industrial Economics*, Vol. 35, No. 1, pp. 97-110.

7. Blomström, M. and A. Kokko (1997), "The Impact of Foreign Investment on Host Countries: A Review of the Empirical Evidence", World Bank Policy Research, *Working Paper No*. 1745.

8. Blomström, M. and A. Kokko (1998), "Multinational Corporations and Spillovers", *Journal of Economic Surveys*, Vol. 12, No. 2, pp. 1-31.

9. Blomström, M. and F. Sjökholm (1999), "Foreign Direct Investment Technology Transfer and Spillovers: Does local participation with multinationals matter?", *European Economic Review*, Vol. 43, pp. 915-923.

10. Borensztein, E., J. De Gregorio and J. W. Lee (1995), "How does Foreign Direct Investment affect Economic Growth?", *NBER Working Paper No*. 5057.

11. Caves, R. E. (1974), "Multinational Firms, Competition, and Productivity in Host-Country Markets", *Economica*, Vol. 41, No. 162, pp. 176-193.

12. Clare, A. R. (1996), "Multinationals, Linkages and Economic Development", *The American Economic Review*, Vol. 86, No. 4, pp. 852-873.

13. Croissant, Y. and G. Millo (2008), "Panel Data Econometrics in R: The PLM Package", *Journal of Statistical Software*, Vol. 27, No. 2, pp. 1-43.

14. Damijan, J. P., M. Knell, B. Majcen and M. Rojec (2003), "Technology Transfer Through FDI in Top-10 Transition Countries: How Important are Direct Effects, Horizontal and Vertical Spillovers?", Institute for Economic Research, Ljubljana, *Working Paper No*. 17, 2003.

15. Filippo, R. and E. Sica (2007), "*Horizontal and Vertical Spillovers from FDI: Evidence from Panel Data for the Italian Manufacturing Sector*", Department of SEMS, University of Foggia, Italy.

16. Globerman, S. (1979), "Foreign Direct Investment and 'Spillover' Efficiency Benefits in Canadian Manufacturing Industries", *The Canadian Journal of Economics*, Vol. 12, No. 1, pp. 42-56.

17. Görg, H. and D. Greenaway (2001), "Foreign Direct Investment and Intra-industry Spillovers: A Review of the Literature", Centre for Research on Globalisation and Economic Policy, *Research Paper No*. 2001, 37.

18. Government of India (2012a), "*FDI Factsheets"*, Department of Industrial Policy and Promotion, Ministry of Commerce and Industry, New Delhi *(Various Issues).*

19. Government of India (2012b), "*Input-Output Transaction Table*", Ministry of Statistics and Programme Implementation, New Delhi (*Various Issues*).

20. Government of India (2012c), "*Wholesale Price Index*", Office of the Economic Advisor to Government of India, Ministry of Commerce and Industry, New Delhi.

21. Greene, W. (2003), "*Econometric Analysis*", 5th Edition, Pearson Education, New Delhi, India.

22. Hsiao, C. (2001), "*Panel Data Models*", A Companion to Theoretical Econometrics: Edited by Badi. H. Baltagi, Blackwell Companions to Contemporary Economics, Blackwell Publications.

23. Hsiao, C. (2005), "Why Panel Data?", *IEPR Working Paper* 05.33, Institute of Economic Policy Research, University of Southern California.

24. Hymer, S. (1976), "*The International Operations of the National Firms: A Study of Direct Foreign Investment*", The Massachusetts Institute of Technology Press.

25. Javorcik, B. S. (2004), "Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages", *American Economic Review*, Vol. 94, No. 3, pp. 605–627.

26. Joseph, T. J. (2007), "Spillovers from FDI and Absorptive Capacity of Firms: Evidence from Indian Manufacturing Industry after Liberalisation", *IIMB Management Review*, Vol. 19, No.2, pp. 119-130.

27. Kathuria, V. (2001), "Foreign Firms, Technology Transfer and Knowledge Spillovers to Indian Manufacturing Firms - A Stochastic Frontier Analysis", *Applied Economics*, Vol.33, No. 5, pp. 625-42.

28. Kathuria, V. (2010), "Does the Technology Gap Influence Spillovers? A Post-Liberalization Analysis of Indian Manufacturing Industries", *Oxford Development Studies*, Vol. 38, No. 2, pp.145-170.

29. Kohpaiboon, A. (2009), "Vertical and Horizontal FDI Technology Spillovers: Evidence from Thai Manufacturing", *Working Paper No*. d011, Economic Research Institute for ASEAN and East Asia.

30. Kokko, A. (1996), "Productivity Spillovers from Competition between Local Firms and Foreign Affiliates", *Journal of International Development*, Vol. 8, No. 4, pp. 517-530.

31. Kokko, A., R. Tansini and M. Zejan (1996), "Local Technological Capability and Productivity Spillovers from FDI in the Uruguayan Manufacturing Sector", *The Journal of Development Studies*, Vol. 32, No. 4, pp. 602-611.

32. Konings, J. (2001), "The Effect of FDI on the Domestic Firms: Evidence from Firm-Level Panel Data in Emerging Economies", *Economics of Transition*, Vol. 9, No. 3, pp. 619-633.

33. Kugler, M. (2006), "Spillovers from Foreign Direct Investment: Within or Between Industries?", *Journal of Development Economics*, Vol. 80, pp. 444– 477.

34. Liu, X. and C. Wang (2003), "Does foreign direct investment facilitate technological progress: Evidence from Chinese industries", *Research Policy*, Vol.32, No.6, pp. 945-953.

35. Liu, X., P. Siler, C. Wang and Y. Wei (2000), "Productivity Spillovers from Foreign Direct Investment: Evidence from UK Industry Level Panel Data", *Journal of International Business Studies*, Vol. 31, No. 3, pp. 407-425.

36. Liu, Z. (2008), "Foreign direct investment and technology spillovers: Theory and Evidence", *Journal of Development Economics*, Vol. 85, pp. 176-193.

37. Pradhan, J. P. (2004), "FDI Spillovers and Local Productivity Growth: Evidence from Indian Pharmaceutical Industry", Munich Personal RePEc Archive, *MPRA Paper No*. 17080.

38. Sasidharan, S. and A. Ramanathan (2007), "Foreign Direct Investment and Spillovers: Evidence from Indian Manufacturing", *International Journal of Trade and Global Markets*, Vol.1, No. 1, pp. 5-22.

39. Smarzynska, B. K. (2002), "*Spillovers from Foreign Direct Investment through Backward Linkages: Does Technology Gap Matter?*", World Bank, Washington D. C. Retrieved on 9th September, 2012 from: info.worldbank.org/etools/docs/voddocs/216/415/spillovers_draft.pdf

40. Stančík, J. (2009), "*Horizontal and Vertical FDI Spillovers: Recent Evidence from the Czech Republic*", Center for Economic Research and Graduate Education, Charles University, Prague, Czech Republic. Retrieved on 28th March, 2012 from: www.cerge-ei.cz/pdf/wp/Wp340.pdf

41. Todo, Y. and K. Miyamoto (2006), "Knowledge Spillovers from Foreign Direct Investment and the Role of Local R&D Activities: Evidence from Indonesia", *Economic Development and Cultural Change*, Vol. 55, No. 1, pp. 173-200.

42. Wang, Y. and W. Gu (2006), "*FDI, Absorptive Capacity, and Productivity Growth: The Role of Inter-Industry Linkages*", Retrieved on 24th September, 2012 from: papers.ssrn.com/sol3/papers.cfm?abstract_id=924771

43. Wang, Y. (2010), "FDI and Productivity Growth: The Role of Inter-Industry Linkages", *Canadian Journal of Economics*, Vol. 43, No.4, pp. 1243-1272.

44. Wooldridge, J. M. (2003), "*Econometric Analysis of Cross Section and Panel Data*", The MIT Press, Massachusetts.

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

## Appendix: A

**Table A1:** Industry-wise Number of Domestic and Foreign firms

| NIC Code | Industries | Total no. of Firms | Domestic Firms | Foreign Firms |
|---|---|---|---|---|
| 10 | Food Products | 368 | 348 | 20 |
| 11 | Beverages | 48 | 38 | 10 |
| 12 | Tobacco | 14 | 12 | 2 |
| 13 | Textiles | 412 | 399 | 13 |
| 15 | Leather | 29 | 28 | 1 |
| 17 | Paper Products | 92 | 83 | 9 |
| 18 | Books and Cards | 20 | 19 | 1 |
| 19 | Petroleum Products | 27 | 20 | 7 |
| 20 | Chemicals and Fertilisers | 256 | 229 | 27 |
| 20 | Cosmetics | 35 | 30 | 5 |
| 21 | Drugs and Pharmaceuticals | 216 | 187 | 29 |
| 22 | Plastic and Rubber Products | 187 | 170 | 17 |
| 22 | Tyres and tubes | 22 | 17 | 5 |
| 23 | Non-metallic Mineral Products | 189 | 169 | 20 |
| 24 | Ferrous Metals | 375 | 356 | 19 |
| 24 | Non-ferrous Metals | 40 | 38 | 2 |
| 26 | Electronics | 139 | 121 | 18 |
| 27 | Electrical Machinery | 151 | 127 | 24 |
| 28 | Non-electrical Machinery | 200 | 161 | 39 |
| 30 | Automobile Industry | 266 | 223 | 43 |
| 32 | Miscellaneous Manufacturing | 122 | 106 | 16 |
| | **Total** | **3208** | **2881** | **327** |

## Appendix: B

Construction of Backward Vertical Linkages and Forward Vertical Linkages

For the construction of backward vertical and forward vertical linkages, input-output tables for the years 1999-2000, 2003-04 and 2006-07 have been used (GOI, 2012b). The motive behind using different tables is to take in to account the associated technological change over several time periods. The input-output tables comprises of two main matrices, the Absorption Matrix (AM) and the Make Matrix (MM).

- **AM:** The rows of AM correspond to commodities used by various industries as inputs to produce their output. The dimension of this matrix is, thus, commodity × industry.

- **MM:** It represents production of different commodities by different industries. The dimension of MM is, therefore, industry × commodity one.

In the first step, the rows of the AM are divided by total output (gross value of output) in order to obtain a matrix of technical coefficients (B).

$$\frac{AM}{Y} = B \qquad \ldots\ldots\ldots\ldots (1)$$

In the next step, the rows of the MM are divided by the corresponding outputs. Let this matrix be D.

$$\frac{MM}{Y} = D \qquad \ldots\ldots\ldots\ldots (2)$$

In order to construct backward and forward linkages, an industry × industry matrix is to be calculated. In the final step, matrix B is multiplied by matrix D to derive at an industry × industry matrix (Z). Therefore, Z = BD.

$$BD = Z \qquad \ldots\ldots\ldots\ldots\ldots (3)$$

The rows of the Z matrix represent output of an industry used as inputs by others, while columns give the output of all industries used as input by one industry.