Firm Capabilities and Productivity Spillovers from FDI: Evidence from Indian Manufacturing Firms

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Abstract

Using a panel dataset on Indian manufacturing firms from 1994 to 2010, the present paper examines the productivity spillovers from the foreign direct investment (FDI) through various channels of horizontal and vertical linkages. In addition, the study also focuses on the influence of domestic firms' initial capabilities in absorbing FDI induced technological benefits. Firm productivity has been measured by using the semi-parametric Levinsohn-Petrin methodology. Using the fixed effect panel model, the initial results show that the productivity growth of Indian firms is adversely affected by various horizontal spillover channels while the vertical linkages are insignificant. Interestingly, the second part of the study reveals that only the domestic firms with some initial technological capabilities (Proxied by initial three years' R&D activities), low technology gap with the foreign firms in the initial periods and high complementary capabilities (proxied by initial three years' average firm size) gain productivity benefits from FDI spillover channels as compared to other firms within the industry. Essentially, the study brings out the importance of domestic firms' need to encourage internal R&D activities in absorbing technological benefits from foreign presence and their economic activities in the domestic market.

Key Words: FDI, TFP, Horizontal spillovers, Vertical spillovers, Technological Capability, Indian Manufacturing firm.

JEL codes: F21, F23, D24, O33

1. Introduction

Since the pioneering work of Caves (1974), a substantial amount of empirical literature has focused on identifying the *spillover* effects of foreign direct investment (FDI) on the host country firms. Studies have tried to identify the channels of spillovers and quantify it by

measuring FDI effects on productivity growth of the host country firms. The key argument of productivity spillovers[1] is that technology brought by the foreign firms diffuse to the domestic firms through various channels altering their production capacity or productivity of the domestic firms. The studies have highlighted two broad categories of FDI spillover channels, namely, horizontal and vertical. The horizontal spillovers occur due to the foreign investment and activities within an industry while vertical spillovers take place across the industries through buyer-supplier linkages among foreign and domestic firms. The most debated notions of FDI spillovers concern the issue of "channels of spillovers". However, it may be noted that the studies do not yield any clear conclusion about the most effective spillover channels.

These mixed outcomes have raised the importance of structural factors affecting occurrence of spillovers. Following the work of Melitz (2003) on the role of industry and firm specific heterogeneity in influencing local and international involvement of the firms, recent studies have tried to explain the difference in dynamic spillover effects of FDI (See Merlevede and Schoors, 2006). The factors include not only the host country and industry characteristics like competitive environment or openness of the industry but also firm characteristics such as technological complementary between foreign and domestic firms, financial stability etc. in capturing benefits from foreign activities within and across the industries (Crespo and Fontoura, 2007). Most of the studies have shown that the firm capabilities are the crucial determinants of the benefits from FDI. Very recently, Blalock and Simon (2009) have highlighted that it is the initial level[2]of firm capabilities[3] which help the domestic firms to compete with the foreign firms when they start investing in the host country and facilitate future benefits from foreign advanced technologies and business linkages.

In India, FDI was encouraged in the manufacturing sector to boost internal competition, to gain technological knowledge from foreign technological activities and to build human

[1]In this study, the productivity spillover and technology spillover terms have been used interchangeably. In this context, it is necessary to distinguish between technology or productivity spillovers from technology transfer from foreign to domestic firms. In the case of technology spillover, domestic firms acquire foreign technology without fully compensating the foreign firms or not through the market transactions. When the technology flows from foreign to domestic firms through proper market transactions, we can call it technology transfer.

[2] Initial level relates to the initial periods of foreign investment. Following Blalock and Simon (2009), the present study defines initial period as the period of three years prior to the foreign intervention period.

[3] Firm capabilities are, initial absorptive capability, initial production capability and initial complementary capability. Initial absorptive capability indicates the initial level of R&D activities of the domestic firms, initial production capability measures the initial difference between foreign and domestic firms' productivity and complementary capability is the initial average size of the domestic firms.

capital through foreign contacts[4]. In view of the significant FDI inflows into the manufacturing sector since the economic liberalisation in 1991, numerous studies have attempted to disentangle the spillover channels that influence the diffusion of technology via a change in the productivity of the domestic firms (For example, Kathuria, 2000; Basant and Fikkert, 1996; Sasidharan and Ramanathan, 2007). The studies on India have broadly focused mainly on the horizontal spillovers occurring through the foreign presence and interactions in the domestic market only (Kathuria, 2002; Behera et al., 2012). Only a handful of the studies have focused on the issue of vertical (See, Sasidharan and Ramanathan, 2007; Malik, 2014) and R&D spillovers from FDI (Basant and Fikkert, 1996). According to Balsvik (2011), different proxy measures may be considered as different technology spillover channels as each of the measures indicate a different economic activity and different level of interactions with the domestic firms.

Therefore, in this study we take the literature forward in two ways. First, new data and methods of measurements are used to integrate channels of horizontal (competition, labour turnover and imitation) and vertical spillovers (backward and forward industry linkages) into a single econometric model. Second, we also focus on the role of the firm level initial conditions (defined as firm capabilities) in determining the impact of horizontal and vertical technology spillovers. Here, we move away from the conventional method of measuring firm level capabilities by current internal R&D activities of the domestic firms (Kathuria, 2000,2002) or by the technology gap between foreign and domestic firms (Behera et al., 2010). Following Blalock and Simon (2009), we measure three initial firm level capabilities, namely, absorptive capability (measured by the initial three years' average R&D activities of the domestic firms prior to the foreign intervention), production capability (measured by the average productivity gap during the initial three years) and complementary capability (measured by the average size of the domestic firms during initial three years).

[4] Since liberalization, India has been experiencing an increasing amount of inflow of actual FDI through various channels. The total FDI inflow has gone up to 34 billion in 2010 from merely 2 billion in 1991-92. It has to be noted that during this period of post 2004, the policy has allowed the investors to choose automatic route in manufacturing and service sectors. This may be one of the factors explaining this considerable jump in FDI inflows. This upward trend was maintained until 2007-08 thereafter a deceleration due to economic recession. During the last 5 years of the study period, (2006-2010), the inflow of foreign direct investment has changed its direction from services sector to the manufacturing sector. the share of FDI in services (including all service activities) has declined over the years from almost 57 per cent in 2006-07 to about 30 per cent in 2010-11, while the shares of manufacturing, and 'others' largely comprising 'electricity and other power generation' has increased over the same period. For instance, the share of manufacturing sector has gone up from 18 percent during 2006 to 32 percent in 2010. This suggests the growing importance of FDI in the organised manufacturing sector in recent years.

Our study brings out that Indian firms' productivity growth is adversely affected by foreign presence within an industry. Competition from the foreign firms in the domestic market seems to have the most adverse impact on a firm's productivity growth. The study also indicates that the low R&D activities of the domestic firms impede imitation spillovers from foreign firms. In fact, the other horizontal channels also show negative impact on domestic firms' productivity growth. On the other hand, both the vertical spillover channels are found to have no impact on the productivity growth of domestic firms. The second part of the study shows that technology spillovers from FDI are highly conditional upon the initial firm capabilities. Domestic firms with high absorptive capability, low technology gap and high average size are able to gain from foreign competition in extracting benefits from foreign activities within and across industries.

The rest of the paper is organised as follows. Section 2 provides a brief review of the theoretical and empirical literature. The methodology and construction of the variables is illustrated in section 3. Section 4 is devoted to the analyses of the productivity spillovers from FDI and the last section concludes the paper.

2. Review of Literature

2.1 Theoretical Aspects: Channels of Productivity Spillovers

It has been widely acknowledged that transnational corporations (TNCs) are in general, more technologically advanced and invest significantly on R&D activities as compared to pure domestic firms (Marin, 2007). Along with the major share of world R&D stocks, TNCs also possess superior managerial and organisational skills than firms belonging to the developing countries. Thus, developing countries perceive FDI from the TNCs as one of the most attractive sources of technology and skills over any other sources (for example, licensing) of acquiring technology. Developing countries offer several favourable terms and conditions (tax holidays, import duty exemptions etc.) to attract FDI flows[5]. Similarly, TNCs with proprietary assets like, knowledge, technology, organisational skills together with their ability to exploit economies of scale, also find it profitable to invest in those developing countries where they can compete over the incumbent firms in the host country domestic market (Blomstrom and Sjoholm, 1999). However, weak intellectual property rights (IPRs) in the

[5] East European countries have undertaken a policy of internalisation and rapid privatisation to attract FDI. On the other hand, most of the Asian countries generally plan for favourable foreign investment policies (Pant and Srivastava, 2015).

developing countries and intangible nature of the technological knowledge leads to spillovers of technology to the domestic firms. The literature indicates several channels through which spillovers may take place among the host country firms (for details, see, Gorg and Greenaway, 2004; Smeets, 2008). The channels are broadly categorised into horizontal and vertical spillover channels.

The most significant channels for horizontal spillovers are demonstration effects, labour turnover and competition effects. First, in *Demonstration effects*, domestic firms imitate the technology or R&D activities undertaken by the foreign firms within the industry and can upgrade their production technology (Barrios and Strobl, 2002; Wang and Blomstrom, 1992). However, the imitation depends on the complexity of technology or R&D activities undertaken by the foreign firms. Second, human embodied technology is diffused to the domestic firms through *labour turnover*. The skills and embodied technology diffuse to the local organisations when workers trained in the foreign entities are hired by the domestic firms or they establish new firms in the local market (Fosfuri et al., 2007). Third, *Competition* from the foreign firms improves the productivity and efficiency of the domestic firms by reallocating resources to the appropriate production sector (Caves, 1974) and by forcing the domestic firms to improve their production process by upgrading technological capability (Wang and Blomstrom, 1992). Even if the indigenous firms are unable to imitate technology from the foreign enterprises, competitive pressure from the foreign firms force the domestic firms to use existing technology more efficiently by yielding productivity growth. Reduction in X-inefficiency[6] pushes the production cost down along the cost curve[7].

However, Aitken and Harrison (1999) have shown that entrance of the foreign firms in the market may reduce the productivity of the domestic firms by reducing their domestic market share, at least in the short run. Similarly, Globerman (1979) has pointed out that foreign firms hire most of the available skilled workers from the domestic market causing a skill gap between foreign and domestic firms. Foreign firms would clearly try to minimise the diffusion of technology to its domestic competitors within industry by means like, paying higher wages to their employees (to reduce labour turnover) or by patenting their technology etc. These considerations led to the doubt of existence of positive horizontal spillover effects from FDI. In contrast, researchers argue in favour of the vertical spillovers where the FDI

[6] X-inefficiency is the difference between the potential and observed behaviour of the firm. It occurs when potential productive efficiency is not reached due to lack of competitive pressure within the industry.

[7] Most of the studies showed that direct competition from the foreign firms are the determining factor for horizontal productivity spillover to the domestic firms (Haddad and Harrison, 1993; Aitken and Harrison. 1999).

firms are not in direct competition with the domestic firms but have a supplier-buyer linkage so that productivity gains are mutually beneficial. .

The vertical spillovers can be either backward or forward. The *Backward technology or productivity spillover* takes place when the foreign producers buy inputs from the upstream domestic suppliers. To maintain the international quality and standards, foreign firms generally provide necessary technological assistance to the domestic input suppliers and provide training to the local employees to improve their management and organisational skills (Blalock and Gertler, 2005). Moreover, attractive business opportunities with the foreign firms induce greater competition among the upstream local firms leading to technological improvement and exploitation of economies of scale (Marin, 2007). Entry of the new domestic firms in the upstream sector leads to reduction of costs even more. On the other hand, foreign firms supply high quality and technology intensive intermediate inputs to the domestic final good producers through *forward linkage* that induces higher productivity. However, if the domestic firms have low bargaining power, which is the most common feature of the domestic firms in the developing countries, foreign firms may exploit the domestic firms. Moreover, if the foreign firms demand inputs with low technological content or source from abroad or "cherry-pick" the most productive domestic firm as the supplier, domestic firms may not be benefitted from the foreign technology (Schoors and Tol. 2002).

2.2 Empirical Evidence

Earlier empirical studies were mainly cross industry (Globerman, 1979; Caves, 1973; Blomstrom and Wolff, 1994) and indicated positive horizontal productivity spillovers. Kugler (2006) indicated that cross sectional studies suffer from endogeneity and simultaneity biases and merely provide contemporaneous results. Haddad and Harrison (1993) for Morocco and Aitken and Harrison (1999) for Venezuela first showed that the positive spillover effects disappear when firm level panel data are considered for examining FDI spillover effects. According to the studies, market-stealing effects offset any positive externalities that occur from technology diffusion. In similar studies, Konnings (2001) for a number of transition countries, Barrios and Strobl (2001) for Spain and Kosova (2010) for Czech Republic either did not find any spillover effects or negative spillover effects on domestic firms' productivity. All these studies have mainly focused on the horizontal spillover effects arising from FDI. Interestingly, a study on 40 developed and developing countries by Xu (2000) has shown that

mostly developed countries are positively influenced by foreign direct investment within industry.

In the case of empirical studies on vertical spillovers, Javorcik (2004) for Luthiania, Blalock and Gertler (2008) and Jabbour and Mucchielli (2007) for Spain found positive spillover effects for vertically integrated domestic firms through backward linkages. There is evidence of positive spillover through forward linkages as well (Schoors and Tol, 2002; Du et al., 2012). However, Havranek and Irsova (2011) in a meta analysis showed that backward linkages are relatively more likely than forward linkages.

2.3 Firm Capabilities and Spillovers[8]

The ambiguity of the numerous empirical results has raised the concerns about the ability of domestic firms to learn from foreign firms. Cohen and Levinthal (1990) has argued that while outside source of technological knowledge is critical to the internal innovation process, it is also important to have the internal capability to exploit this knowledge. The study showed that prior accumulated knowledge increases the ability to assimilate new knowledge. Prior knowledge, current R&D and innovative activities develop a firm's ability to absorb technology continually. A large number of studies have shown that horizontal and vertical spillover effects are highly conditioned upon the initial and current R&D activities of the domestic firms (for example, Blalock and Simon, 2009; Damijan et al., 2003). In contrast to the view of higher technological capabilities to absorb foreign technology, Findlay (1978) proposed that the greater the distance between the foreign and domestic technology frontiers the higher would be the possibility of technology spillovers. However, mostly studies found the opposite results (Wang and Blomstrom, 1992). Recently, Blalock and Gertler (2009) have shown that initial technological distance between the foreign and domestic firms in the form of productive capability induces higher spillovers. Among other factors, firm size is considered to be a complementary capability of the firm as it provides competitive advantage, advanced technological mastery due to financial stability, greater distribution and logistics facilities, better network of suppliers, and marketing capabilities (Blalock and Simon, 2009).

[8] Several studies have indicated the importance of various firm and industry characteristics that facilitate the productivity spillover effects through technology diffusion from foreign firms (Smeets, 2008). Irsova and Havranek (2013) in a meta-analysis of 45 countries, showed that unless firm and economy specific characteristics such as human development, high technology competence, competition of the industry and openness are controlled, the evidence of horizontal spillovers are negligible. Many studies has shown the importance of competitive environment of the industry (Sjoholm, 1999; Javorcik and Spatareanu, 2008), openness (Tong and Hu, 2003), geographical proximity (Girma and Wakelin, 2001) and FDI characteristics (Dimelis and Louri, 2002) in capturing benefits from foreign investment.

Barrios and Strobl (2003) have shown that larger domestic firms have a higher probability of survival against foreign competition as compared to other domestic firms.

2.4 Productivity Spillovers from FDI in Indian manufacturing Sector: A Brief Review

Most of the disaggregated studies on Indian manufacturing firms have shown that FDI could not be a productivity enhancing factor (see Kathuria, 2000, 2001, 2002, 2010; Patibandla and Sanyal, 2005; Sasidharan and Ramanathan, 2007; Marin and Sasidharan, 2010). In contrast, Siddharthan and Lal, (2004), Behera *et al*. (2012) found evidence of positive technology vis-a-vis productivity spillover effects of FDI on Indian manufacturing firms. In what follows, we briefly discuss some of these studies.

Kathuria (2002) showed that foreign presence decreases the efficiency of the domestic firms. However, internal R&D activities were found to have a strong learning effect confirming the complementary effects between foreign spillovers and absorptive capacity. In another study, Kathuria (2010) could not find any systematic spillover effects of foreign presence on the productivity or productivity growth due to the lower level of technology brought by the foreign firms during 1995-2005. Patibandla and Sanyal (2005) supported Kathuria's results and showed that R&D activity is a productivity enhancing factor for the firms with low foreign ownership and low sectoral foreign presence. They argue that firms with higher foreign presence carry out their advanced innovation activity in the parent firms. These results follow the earlier result by Basant and Fikkert (1996) where they found that foreign R&D activity does not generate any positive spillover to the domestic firms if the domestic firms are not technologically advanced and undertaking some R&D activity.

In a study on Indian manufacturing firms, Marin and Sasidharan (2010) showed that technology spillovers depend highly on the heterogeneity of FDI subsidiaries rather than the simple pipeline effects. The study found that competence creating subsidiaries have a positive spillover effect on the host economy irrespective of the level of absorptive capability of the local firms. On the other hand, competence exploiting subsidiaries generate negative spillover effect only for the more advanced domestic firms while passive firms do not show any effect on the host country firms. Sasidharan and Ramanathan (2007) also did not find any evidence of horizontal and vertical productivity spillovers (backward linkage effect) during 1994 - 2002 as foreign firms mostly rely on imported technology rather than sourcing domestically.

Contradicting the above studies, Goldar et al. (2003) and Behera *et al*. (2012) noted that competition from foreign presence in the industry enhances the domestic firms' capability and productivity. Both of these studies focused on relatively recent periods. For instance, Behera *et al*. (2012) covered the study period of 1990-2007. Siddharthan and Lal (2004) have argued that increasing capability since liberalisation has helped domestic firms to gain from foreign presence in the market.

3. Empirical Methodology and Data Sources

3. 1 Econometric Methodology

The econometric analysis consists of two steps. In the first step, we estimate the production function to obtain the firm specific productivity growth. In the second step, we formulate and estimate the "spillover" model by regressing productivity growth of the firms on a number of independent variables including various measures of FDI spillovers.

3.1.1 Measurement of Productivity

In this study, productivity or total factor productivity (TFP) is measured directly through an econometric estimation of production function. The two important measurement issues related to the estimation of production function are endogeneity of input choices or simultaneity bias and the selection bias (Beveren, 2012). Simultaneity bias arises because the input decision of the firms is often determined by the characteristics of the firm or its productivity performance. This means that input choice in the production process are not exogenous but simultaneously arises from the correlation between the input mix and unobserved productivity shocks (De Loecker, 2007). The issue of selection bias arises when firm's decision to stay in the market highly depends on its productivity and expected future profitability. Thus, in the presence of endogeneity, OLS does not produce unbiased estimates.

The semi-parametric productivity measures, proposed by Olley & Pakes (1996) and Levinsohn & Petrin (2003) incorporate the unobservable effects on productivity from inputs and produces reliable input coefficients. To solve the endogeneity problem, both methodologies use a proxy variable which is assumed to have a monotonic relationship with the firm specific unobserved productivity differences. Inverting such a function provides the unobserved component of the productivity as a function of the observed variables. The Levinsohn and Petrin (or LP) uses intermediate inputs as the proxy variable (raw material or

energy inputs) for productivity shocks whereas Olley and Pakes uses firms investments, which are often non-reported. We follow the LP methodology to estimate the production function of the firms of Indian manufacturing sector during 1994-2010. The productivity estimates we obtain from the estimation are used for the spillover analyses in the second step.

We assume a Cobb-Douglas production function where output is a function of capital as the endogenous input variable, labour and raw material as the free input variables and, power and fuel (energy) as the proxy variable. The production function can be expressed as:

$$Y_{it} = A_{it} K_{it}^{\beta_k} L_{it}^{\beta_l} M_{it}^{\beta_m} E_{it}^{\beta_e} ----(1)$$

Where, Y_{it}represents the output of the firm *i* at period *t*. $A_{it}$is the productivity level of the firm *i* at period *t*. K_{it}, L_{it}, M_{it}, E_{it} respectively represents the state variable capital, free variable labour and raw material, and the proxy variable for intermediate input, energy which is correlated with unobserved productivity respectively. Taking natural log in the equation (1), the production function can be written as:

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \beta_e e_{it} + \omega_{it} + \varepsilon_{it} ----- (2)$$

$y_{it}, k_{it}, l_{it}, m_{it}, e_{it}$ denote the log of output, capital stock, labour, raw material and energy variable. $(\omega_{it} + \varepsilon_{it})$ represents the error term of the estimation.

$\ln(A_{it}) = \beta_0 + \omega_{it} + \varepsilon_{it}$, where $\beta_0$measures mean productivity level across the firms at time t, ω_{it} denotes the firm specific productivity difference not captured by explanatory variables and ε_{it} stands for the measurement error uncorrelated to the input choices. The major difference between ω_{it} and ε_{it} is that the former is a state variable[9], which is observable to the firm only, and hence influences firms input demand choices.

As we have considered energy (e_{it}) as a proxy to take care of endogeneity bias, by assumption of LP methodology, the demand function of energy variable would be monotonically increasing function in its unobserved productivity, conditional on the state variable k_{it}. Therefore, the demand function of e_{it} can be expressed as: $e_{it} = e_t(\omega_{it}, k_{it})$. By the assumption of monotonicity, we can invert this function as $\omega_{it} = \omega_t(e_{it}, k_{it})$. Thus, the

[9] State variables are fixed factors which are affected by the distribution of ω_{it}, conditional on the information set available at (t-1) period and past values of ω_{it}. In the case of free variables, the input choices by the firms depend upon the current values of ω_{it} (Ollay and Pakes, 1996).

unobserved productivity term (ω_{it}) becomes the function of two observed inputs $e_{it}\ and\ k_{it}$. Rewriting the previous equation, we get:

$$y_{it} = \beta_l l_{it} + \beta_m m_{it} + \theta_t(e_{it}, k_{it}) + \delta_{it} - - - - - (3)$$

Where, $\theta_t(e_{it}, k_{it}) = \beta_0 + \beta_k k_{it} + \beta_e e_{it} + \omega_t(e_{it}, k_{it})$ and δ_{it} is not correlated with the inputs. The estimation of production function takes place at two stages[10].

In the first stage of the estimation, the conditional moments $E(y_{it}|e_{it}, k_{it})$, $E(l_{it}|e_{it}, k_{it})$, $E(m_{it}|e_{it}, k_{it})$ are estimated by regressing the respective variables on $e_{it}\ and\ k_{it}$ using third order polynomial regression with full set of interactions. Subtracting the expectation of the equation (3) conditional on $e_{it}\ and\ k_{it}$ from the equation (3) we get the following equation:

$$y_{it} - E(y_{it}|e_{it}, k_{it}) = \beta_l\big(l_{it} - E(l_{it}|e_{it}, k_{it})\big) + \beta_m\big(m_{it} - E(m_{it}|e_{it}, k_{it})\big) + \delta_{it} - - - - - (4)$$

We use the no intercept OLS on the equation (4) to estimate the parameters $\widehat{\beta_l}$ and $\widehat{\beta_m}$.

In the second stage, we use two moment conditions to identify the parameters β_k and β_e. The second stage of the LP method assumes two population moment conditions, $E[(\gamma_{it} + \delta itkit{=}E\gamma itkit{=}0$ and $E\gamma it{+}\delta iteit{=}E\gamma iteit{-}1{=}0$ for the estimation process. The first condition states that the capital does not respond to the innovation in productivity γ_{it}, while the second moment condition reflects that previous period's choice of intermediate input is not related to the current period innovation in productivity.

Using the estimated coefficients of the production function, we can calculate the productivity of Indian manufacturing firms as follows

$$\ln TFP_{ijt} = y_{ijt} - \widehat{\beta_l} l_{ijt} - \widehat{\beta_k} k_{ijt} - \widehat{\beta_m} m_{ijt} - \widehat{\beta_e} e_{ijt} - - - - - (5)$$

3.1.2 Productivity Spillovers: econometric model

After we estimate the productivity of the firms, we investigate the FDI spillover effects on productivity growth of the Indian manufacturing firms. In the model, we basically use the growth rate of TFP of the domestic firms as the dependent variable$\big(i.e, TFPG_{ijt} =$

[10] The detailed estimation process is given in Levinsohn and Petrin (2003).

$\Delta \ln TFP_{ijt}$). The explanatory variables include spillover variables, sectoral variables and firm level control variables. We use lagged values of the explanatory variables to capture the time-lag effects on productivity growth of the domestic firms. The basic model therefore can be expressed as:

$$TFPG_{ijt} = \beta_0 + \beta_1 Expint_{ijt-1} + \beta_2 RDint_{ijt-1} + \beta_3 DTint_{ijt-1} + \beta_4 ETint_{ijt-1} + \beta_5 Size_{ijt} + \beta_6 HHI_{jt} + \beta_7 Openness_{jt-1} + \beta_8 SP_{it-1} + T + \mu_i + \epsilon_{ijt} ----(6)$$

Where, SP_{it-1} variable represents the lagged values of spillover variables. . The five spillover variables are competition spillover (*Comp*), imitation spillover (*IMITATION*), skill spillover (*SKILL*), Backward spillover (*Backward*) and forward spillover (*Forward*). First three spillover variables represent the foreign economic activities within industry (horizontal spillover channels) and the last two represent the foreign activities across industries (vertical channels). We use these spillover variables[11] in five separate regression models. Apart from the spillover variables, TFPG of the domestic firms is also considered as function of sectoral variables, concentration (*HHI*) and openness of the industry (*Openness*), and firm level variables, export intensity (*Expint*), R&D intensity (*RDint*), Disembodied and embodied technology import intensity (*DTint* and *ETint* respectively) and size (*Size*) . Variables with (*t-1*) represent the lagged values. *T* represents the time fixed effects, μ_i represents the firm fixed effects and ϵ_{ijt} stands for the random error associated with the models[12].

Subsequently, to investigate the influence of initial firm capabilities on FDI spillover channels in gaining productivity of the domestic firms we use separate econometric model. The model consists interaction terms of firm capability variables and spillover variables along with the similar firm and sector specific variables as before. The model is represented as:

$$TFPG_{ijt} = \beta_0 + \beta_1 Expint_{ijt-1} + \beta_2 RDint_{ijt-1} + \beta_3 DTint_{ijt-1} + \beta_4 ETint_{ijt-1} + \beta_5 Size_{ijt} + \beta_6 HHI_{jt} + \beta_7 Openness_{jt-1} + \beta_8 SP_{jt-1} + \beta_9 FC_{ij} \times SP_{jt-1} + T + \mu_i + \varepsilon_{ijt} ----(7)$$

Among the explanatory variables, we focus on the two variables; spillover variables, (SP_{jt-1}) and interaction terms between firm capabilities and spillover variables($FC_{ij} \times SP_{jt-1}$). FC_{ij} represents the firm capability variables.

[11] Since spillover variables are highly correlated, we cannot use them in a single model.

[12] General argument about quantifying the FDI spillover is the endogeneity of the spillover variables. The spillover variables are measured at the two digit industries, reducing the possibility of endogeneity of FDI to be attracted to the industries with high productivity.

We have used three firm capability (*FC*) measures, initial absorptive capability (*RD*), initial production capability (*TECH*) and initial complementary capability (*SIZE*). The interaction terms between each of the spillover variables and firm capabilities are presented by ($FC_{ij} \times SPjt-1$), for instance, interaction between absorptive capability and competition spillover as *RDComp*, interaction between production capability and competition spillover as *TECHComp* and interaction between complementary capability and competition spillover is represented by *SIZEComp*. Likewise, interactions of the imitation spillover variable with firm capabilities are represented as *RDIMITATION, TECHIMITATION, and SIZEIMITATION*, and, Interaction variables of firm capabilities and skill spillovers are *RDSKILL, TECHSKILL and SIZESKILL*. These interaction terms indicate the influence of initial firm capabilities in accruing benefits from foreign activities within industry. Similarly, we use interaction terms between the firm capabilities and backward spillover, specifically, *RDBACK, TECHBACK and SIZEBACK* in the model to capture the benefits of backward linkages accrued through firm capabilities. *RDFOR, TECHFOR and SIZEFOR* represent the interaction terms between firm capabilities and forward linkage variables.

We use fixed effects panel data model for the purpose of econometric analysis. Firm fixed effects would control for the unobserved time-invariant firm characteristics. Firm capability measures are also time invariant, and thus the main effects are dropped from the fixed effects specification (Blalock and Gertler, 2009). The effects of firm capabilities enter in the model only through the interaction between spillover and firm capabilities. Moreover, we have included time fixed effects (*T*) to control time variant effects on productivity growth of domestic firms.

3.2 Data Sources and Variable Construction

The study is primarily based on the firm level data collected from PROWESS for 1994-2010. First, we checked the growth rate of the output for each firm and if the output growth rate for any year is found to be less than -60% or higher than 250% we have dropped those observations (Parameswaran, 2009). We have followed the same procedure for capital and labour as well. After this, we dropped all those firms with only one year observation. In the last stage, we checked whether each firm has at least three years of continuous output data at the beginning of each firm sample. We dropped all the firms of the 2-digit industries (NIC16

and NIC31) from the sample where no foreign firms[13] are present over the study period. After this process, we are left with an unbalanced panel sample consists of 5923 firms with 61666 observations, where 5661 firms are domestic and 262 firms are foreign firms. The construction of variables is discussed in the following sub-section.

3.2.1 Selection of variables

(a) Horizontal Spillover channels

(i) Competition Spillover (*CompSpill*): Competition spillover occurs from the foreign presence and its production in the domestic market. We measure it as the ratio of total foreign sales to the total industrial sales at a particular time period. We measure the *CompSpill* variable at a particular period by following the equation,

$$CompSpill_{jt} = \frac{\sum FSales_{ijt}}{\sum Sales_{jt}} \times 100 \quad -----(8)$$

Where, $FSales_{ijt}$ represents i^{th} foreign firm's domestic market sale in the industry j at the time period t. $Sales_{jt}$ is the total sale of the j^{th} industry at the time period t.

(ii) Imitation Spillover (*IMITATION*): Imitation spillover is measured as the ratio of foreign R&D and technology import to total industrial R&D activity and technology import at a particular year (measured as expenditure in nominal values). We measure imitation spillover as,

$$Immitation_{jt} = \frac{\sum FRDTech_{ijt}}{\sum RDTech_{jt}} \times 100 \quad -----(9)$$

Where, $FRDTech_{ijt}$ represents i^{th} foreign firm's total technological activities in the industry j at the time period t. $RDTech_{jt}$ is the overall technological activities of the j^{th} industry at the time period t.

(iii) Skill Spillover (*SkillSpill*):. Following Franco and Sasidharan (2009), we proxy the skill spillover variable using the wage bill of foreign firms, which is an indicator of knowledge spillover associated with foreign labours. The measurement of *SkillSpill* variable is represented as

[13] Following the definition of IMF, we define the foreign firms as the firm with more than or equal to 10% of foreign promoters' share holding.

$$SkillSpill_{jt} = \frac{\sum FWAGE_{ijt}}{\sum WAGE_{jt}} \times 100 \quad -----(10)$$

Where, $FWAGE_{ijt}$ represents i^{th} foreign firm's wage bill in the industry *j* at the time period *t*. $WAGE_{jt}$ is the total wage bill of the j^{th} industry at the time period *t*.

(iv) Backward Spillover (*Backward*): Backward linkage between the foreign and domestic firms occurs when the foreign firms in the downstream sector purchase from the upstream domestic firms. Thus, the *Backward* variable is measured as

$$Backward_{jt} = \sum_{k} \alpha_{jkt} FDI_{kt} ----(11), where, j \neq k$$

Where, α_{jkt} is the proportion of the industry *j*'s output used by the industry *k* at time *t*[14]. FDI_{kt}[15] represents the share of the foreign output in the total output in industry *k* .

(v) Forward Spillover *(Forward)***:** In this case, spillover occurs when the foreign firms supply advanced intermediate inputs or final products to the downstream domestic buyers. The variable is measured as:

$$Forward_{jt} = \sum_{k} \beta_{kjt} FDI_{kt} ----(12), where, k \neq j$$

β_{kjt} represents the proportion of the industry *k*'s output going to the industry *j* at time *t*. Similar as before,FDI_{kt} represents the share of the foreign output in the total output in industry *k*.

(b) Firm Capability Variables

Production Capability (Relative Technology Gap): Following Blalock and Gertler (2009), we measure production capability as the distance of the domestic firms' initial technical competency levels to that of the foreign firms. To measure it, the whole sample is divided

[14] The proportions are calculated using the input-output tables available in the CSO. The detailed construction process of ($Industry \times Industry$) input-output matrix is provided in the appendix A1.

[15] To measure vertical spillover variables, the FDI variable or the foreign presence within industry is measured by the foreign output share in total industry output (not domestic sales as discussed before). Output considers total domestic sales and export of the firms.

into two parts, pre-sample period which is the first three years of each sample firms and another including rest of the observation. Initial baseline productivity of the domestic firm is measured by the average productivity of the initial three years of each domestic firm. The distance of average TFP of the domestic firms from the median foreign productivity of the 2-digit industry over these initial 3 years was taken as the gap between foreign and domestic firms in the initial period. Then, we divide the gap by the average productivity of the foreign firms for initial 3 years to get production capability or relative technology gap between domestic and foreign firms[16]. For instance, a relative technology gap of 0.23 indicates that domestic firm's TFP is 23% lower than that of the average foreign TFP in the initial periods or we say that this domestic firm has lower production capability compared to the foreign firm. There are five interaction terms used (separately[17]) in the model to analyse the effects of initial production capability of the domestic firms in facilitating spillovers from foreign presence.

Absorptive Capability: The absorptive capacity of the domestic firms is measured using the initial R&D intensity. We take average R&D intensity[18] of the domestic firms of the initial three years to capture absorptive capacity of the domestic firms on the premise that increasing R&D expenditure in every year due to change in production capacity is not easy or costless (Blalock and Simon, 2009). The initial R&D capability of the firms is used for rest of the study years. Similar to production capability, we use five interaction terms between firm absorptive capability and spillover channels in the models separately. We expect that higher the initial absorptive capacity of the domestic firms, higher would be the possibility of productivity spillover to the domestic firms.

[16]For the analysis, we drop first three years for each firm as this is considered as the production capability of the firms in the pre-sample period. Due to the endogeneity of the production capability measure, the whole sample years were divided into pre-sample period and current period. The endogeneity problem arises because the production capability and the current productivity are jointly determined (Blalock and Simon, 2009).As was argued by Blalock and Simon (2009), to avoid the prior production capabilities acquired from FDI. It is possible that low productive firms gain immediately and heavily at the initial period of foreign entrance. High productivity of the later years would outweigh the initial low productivity and laggard firms would emerge as highly productive firms which is not true. Therefore, the measurement of the production capability does not consider the entire period. By separating the panel, prior technology competency of pre-sample period is calculated.

[17] The interaction terms are found to be highly correlated with each other because of the correlation among the spillover variables. Therefore, we use separate models representing the firm capabilities and their interactions with spillover variables.

[18] Average R&D intensity is measured as the ratio of average R&D expenditure of the domestic firms in the initial three years to average sales of the domestic firm.

Complementary Capability: The complementary capability is measured by the initial average size of the firms. Due to unavailability of the employment data at the firm level, we use the ratio of output of the each domestic firm to the median output of the respective 2-digit industry in pre-sample period as the measure of initial size of the firms. Similar to the other firm capabilities, we use this initial size of the firms for rest of the years and thus this variable also becomes time-invariant like production capability or absorptive capability. We add interaction terms between size and foreign presence. We expect that higher the initial size, higher would be the productivity spillover from foreign activities in the domestic market.

(c) Sectoral Variables[19]

We use two sectoral variables to capture the *industry* effects on domestic firm's productivity.

(i) Concentration (*HHI*): This variable inversely captures the effects of competition on the productivity of the domestic firms and is measured by Herfindahl-Hirschman Index (HHI).

(ii) Openness (*Openness*): Openness is measured by import penetration of the industry. We expect that firms belonging to an open industry would acquire quick information about the international technology, skills and prevailing product quality in abroad, expanding firms R&D activity and technology use, and thus improve productivity (Hejazi and Safarian, 1999).

(d) Firm Specific variables

Export Intensity (*Expint*): This measures the outward orientation of the firms. Generally, export facilitates the interaction of the domestic firms with the foreign buyers and producers and consequently learning helps improve the production process, and skills. Moreover, exposure to the international competition leads to higher efficiency in production and scale economies by huge production potential for larger market (Chuang, 1998).

R&D intensity (RDint): The internal R&D activity increases firms' adaptability of the new technology as well as the innovation capability. Improvement of the existing production process reduces cost of production and raises profit (Wei and Liu, 2006). Moreover, firms with R&D activity are able to face competition from the foreign firms more strongly by introducing new and diversified products or through imitating foreign production technology (Kathuria, 2008).

[19] Measurements are provided in the appendix A2.

Import of Technology (*Tech*): In the present study, we use disembodied technology import intensity (*DTint*) and embodied technology import intensity (*ETint*) to represent the importance of imported technology on productivity of the domestic firms.

Size of the firm (*Size*): We measure the size of the firm as the ratio of firm output to the median output of the 2-digit NIC industry.

4. Empirical Results

4.1 FDI Spillover effects on Productivity growth of Domestic firms (1994-2010)

The table 1 presents the factors influencing FDI induced productivity growth of the domestic firms. The negative coefficients of most of the spillover variables suggest that Indian firms are in general adversely affected from foreign presence and their activities. The negative effects become significantly high when the foreign firms operate within same sector of the domestic firms. The significantly negative coefficient of the *CompSpill* variable indicates that Indian firms are not able to deal with foreign competition. As already pointed out by Aitken and Harrison (1999), in most of the developing countries, foreign firms generally reduce the market share of domestic firms by drawing demand away from them. Thus, increasing average cost of production offsetting the positive spillover benefits (if any) from technology diffusion or resource reallocation, resulting productivity loss of the domestic firms (Konings, 2001).

Table: 1

Productivity Spillover from FDI through Horizontal and Vertical channels during 1994-2010 (Domestic Firms): Dependent Variable (TFPG)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
$Constant\ (\beta_0)$	0.5936 (0.0446)***	0.6728 (0.0412)***	0.6478 (0.0429)***	0.6620 (0.0416)***	0.6709 (0.0418)***
$expint_{-1}\ (\beta_1)$	0.0143 (0.0017)***	0.0144 (0.0017)***	0.0144 (0.0017)***	0.0144 (0.0017)***	0.0145 (0.0017)***
$RDint_{-1}\ (\beta_2)$	0.0114 (0.0015)***	0.0113 (0.0015)***	0.0114 (0.0015)***	0.0113 (0.0015)***	0.0113 (0.0015)***
$DTint_{-1}\ (\beta_3)$	0.0043 (0.0014)**	0.0043 (0.0014)**	0.0044 (0.0014)**	0.0043 (0.0014)**	0.0043 (0.0014)**

$ETint_{-1}$ (β_4)		0.0138 (0.0012)***	0.0137 (0.0012)***	0.0138 (0.0012)***	0.0138 (0.0012)***	0.0138 (0.0012)***
$Size$ (β_5)		0.0001 (0.00006)*	0.0001 (0.00006)*	0.0001 (0.00006)*	0.0001 (0.00006)*	0.0001 (0.00006)*
HHI (β_6)		-0.3451 (0.2380)	-0.3310 (0.2350)	-0.3920 (0.2353)	-0.3242 (0.2349)	-0.3269 (0.2349)
$Openness_{-1}$ (β_7)		-0.0120 (0.0087)	-0.0122 (0.0109)	-0.0151 (0.0096)	-0.0165 (0.0105)	-0.0164 (0.0105)
$CompSpill_{-1}$ (β_8)		-0.7321 (0.1314)***				
$IMITATION_{-1}$ (β_8)			-0.3253 (0.1316)**			
$SKILLSPill_{-1}$ (β_8)				-0.2209 (0.1104)**		
$Backward_{-1}$ (β_8)					0.2377 (0.1545)	
$Forward_{-1}$ (β_8)						-0.3872 (0.2587)
R-Squared	*Within*	0.3278	0.3279	0.3194	0.3226	0.3126
	Between	0.2164	0.2166	0.2145	0.2177	0.2157
	Overall	0.2338	0.2331	0.2278	0.2286	0.2266
F-Statistics		160.85***	162.73***	159.56***	161.69***	156.69***
No of Observation		49434	49434	49434	49434	49434
No of Firm		5661	5661	5661	5661	5661

*,**,*** represents 10%, 5% and 1% level of significance. The values in the parentheses are robust standard errors.

Indian industries are mainly dominated by low technology intensive small and medium sized firms and therefore, mostly lack ability to absorb foreign competition. Our results follow the works of Kathuria (2000, 2001, and 2002), and, Sasidharan and Ramanathan (2007) who also found negative spillover effects from foreign output share in the domestic market.

Similar to the study of Feinberg and Majumdar (2001), we also do not find any evidence of imitation spillover on the productivity growth of the domestic firms. According to Feinberg and Majumdar (2001), the possibility of R&D spillovers highly depends on the prevailing

policy environment of the domestic market. Indian policy does not compel foreign firms to commence R&D activities in the domestic market. Moreover, lack of firm capabilities to absorb foreign technology reduces the possibility of the imitation spillover (Cantwell and Piscitello, 2002).

Like other horizontal spillover channels, *SKILLSpill* also show negative effects on productivity growth of the domestic firms. Generally, higher wage paid by the foreign firms limit the possibility of labour turnover to the domestic counterpart. Therefore, domestic firms have higher possibility of losing skilled workers (labour turnover) to the high paying foreign firms. Thus, a gap is generated between foreign and domestic human capital. Moreover, hiring highly skilled and experienced workers from the TNCs increases the overall learning cost by increasing the wage of existing labour in the domestic firms limiting the possibility of any externalities through labour turnover.

Now we move to the spillover effects from vertical linkages between foreign and domestic firms. The coefficient of the backward spillover variable (*Backward*) is found to be positive but insignificant. Lack of statistical significance may indicate that foreign firm may source less technology intensive intermediate inputs from the local firms or probably rely on the imported inputs or on other foreign subsidiaries in the upstream market for technologically advanced inputs[20].Similar to the *backward* variable, we do not find any statistically significant impact of *forward* linkage on productivity growth of the domestic firms.

Sectoral Variables

The general anticipation about the effects of openness (*Openness*) on productivity growth of domestic firms does not hold among Indian manufacturing firms. The insignificant negative coefficient of the *openness* variable shows that import penetration does not influence productivity growth of the domestic firms. Similarly, the other sector specific variable, concentration (*HHI*) shows insignificant negative coefficients in the estimated models

Firm Specific variables

We find the expected results of the technology variables (*RDint*, *ETint* and *DTint*) on productivity growth. All these variables are positive and significant confirming the

[20] However, our finding contradicts the study by Lall (1978) which found significant positive impact of FDI backward linkage on the productivity of the Truck industry in India.

importance of firm's technological capability in enhancing productivity of the domestic firms. It can be seen that the imported disembodied technology has the lowest impact on the productivity growth of the Indian firms as compared to the imported embodied technology. Kathuria (2000) has also found that import of capital goods has reduced dispersion of firm level efficiency from highest efficient firms in the sector while disembodied technology had negative effects.

Our analysis contradicts Kathuria (2000, 2002) as we find that exposure to the foreign market (*expint*) enhances productivity of the domestic firms. *Size* of the firms shows positive impact on the productivity growth of the Indian manufacturing firms. The usual notion that firms with higher size are able to handle competition and hedge risk of production clearly holds in the case of Indian manufacturing firms. In all specifications of regression, R&D activity (*RDint*), import of technology (*DTint, ETint*), export activity (*expint*) and *size* of the firms are found to be important factors for productivity.

4.2.2 Firm Capabilities and Productivity Spillovers from FDI: Manufacturing Sector (1994-2010)

Horizontal Spillover

In table 2, we report the results based on the interactions between firm capabilities and spillover variables in all manufacturing firms[21]. Models 1-9 of table 2 show the effects of domestic firm capabilities on the firm's propensity to grow from horizontal spillovers. Model 1 – Model 3 of table 2 focuses on the competition spillover effects and the interaction between capabilities and competition spillover variable. Similarly, Model 4 - Model 6 represent the Imitation spillover and Model 7 – Model 9 present the skill spillover effects. For simplicity, we discuss various firm capability variables separately.

Absorptive Capability (RD): As expected, the interaction terms, *RDComp* (Model 1), *RDIMITATION* (Model 4) and *RDSKILL* (Model 7) show significant positive coefficients. Thus, we say that initial internal R&D activity of the domestic firms is an important component in penetrating advantages from foreign competition, foreign technological activities and foreign skills within the industry. Initial R&D firms are more innovative and could diversify products rapidly as compared to non-R&D firms in face of the competition

[21] For the convenience, we have reported only the spillover variables and the interaction terms in the text.

from foreign firms. In fact, the result shows that by quickly realising the relevance of the technologies, initial R&D domestic firms were more capable of absorbing technological advancement of the foreign firms and utilise existing resources more efficiently without incurring much extra cost and therefore, inducing higher productivity growth. For instance, given foreign presence in the industry, initial R&D firms enjoy 0.75% higher productivity growth from foreign competition in the market than the non-R&D firms. Besides, the domestic firms can internalise foreign skills if they undertake higher R&D activity. Labour, skilled and trained in the foreign firms are better equipped with the knowledge and technology of the international level. Therefore, we find a complementary relationship between foreign competition, foreign R&D activity and foreign skills with initial internal R&D activities of the Indian firms.

Production Capability (TECH): In contrast to the technology gap hypothesis, we find that that higher initial technology gap would hinder the productivity growth through horizontal spillover channels. The estimates of the coefficients of *TECHComp* (Model 2), *TECHIMITATION* (Model 5) *and TECHSKILL* (Model 8) variables are negative and significant for *TECHIMITATION* and *TECHSKILL*. The insignificant and negative coefficient of the *TECHComp* variable reveals that the higher the productivity gap, lower would be the benefit from foreign competition. Firms with large initial technology gap cannot compete in the market due to lack of technological and production capability. Similarly, firms with higher initial technical proficiency could easily imitate and employ advanced technology (*TECHIMITATION*) brought by the foreign firms and reduce the negative effects of foreign R&D activity on domestic TFP growth[22]. The significant negative coefficient of the *TECHSKILL* variable indicates that domestic firms benefit from skill spillovers with a small technology gap from foreign firms.

[22] The coefficient of the IMITATION variable in Model 5 is insignificant although carries a negative sign. The estimates of model 2 showed that without the interaction terms, *Comp, IMITATION and SKILL* variables had significant negative impact on the productivity growth of the domestic firms. Due to the inclusion of the interaction terms in the models, these variables become insignificant. This reflects that the negative impacts of the foreign activities within sector would reduce if the domestic firms possess particular firm specific capabilities. Or, in other words, firms with higher R&D activity, low technology gap and larger size are capable of extracting benefits from intra-industry foreign activities.

Table 2
Firm Capability and Intra-Industry Productivity Spillovers from FDI on Indian manufacturing firms (1994-2010)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
$Comp_{-1}$ (β_9)	-0.1878 (0.1093)	-0.1984 (0.1093)*	-0.1627 (0.1090)						
$IMITATION_{-1}$ (β_9)				-0.1067 (0.0561)*	-0.0518 (0.0338)	-0.1072 (0.1090)			
$SKILL_{-1}$ (β_9)							-0.1350 (0.1236)	-0.1827 (0.1231)	-0.1734 (0.1090)
$RDComp_{-1}$ (β_{10})	0.0751 (0.0102)***								
$TECHComp_{-1}$ (β_{10})		-0.0672 (0.0586)							
$SIZEComp_{-1}$ (β_{10})			0.0291 (0.0016)***						
$RDIMITATION_{-1}$ (β_{10})				0.0552 (0.0060)***					
$TECHIMITATION_{-1}$ (β_{10})					-0.0527 (0.0286)*				
$SIZEIMITATION_{-1}$ (β_{10})						0.0091 (0.0056)			

$RDSKILL_{-1}$ (β_{10})								0.0679 (0.0091)***		
$TECHSKILL_{-1}$ (β_{10})									-0.0002 (0.0001)**	
$SIZESKILL_{-1}$ (β_{10})										0.0036 (0.0026)
R^2	*Within*	0.1421	0.1422	0.1423	0.1415	0.1423	0.1422	0.1422	0.1423	0.1424
	Between	0.0721	0.0719	0.0719	0.0722	0.072	0.0723	0.0728	0.072	0.0716
	Overall	0.1051	0.1048	0.1034	0.1052	0.1047	0.1046	0.1055	0.1035	0.1046
F-Statistics		68.13***	64.96***	64.98***	68.21***	64.93***	67.73***	67.85***	64.62***	65.66***
No of Observation		42607	42607	42607	42607	42607	42607	42607	42607	42607
No of Firm		5620	5620	5620	5620	5620	5620	5620	5620	5620

Note: *** , **, * signify 1%, 5% and 10% level of significance respectively. Values in the parenthesis are the heteroscedasticity corrected standard errors.

Complementary Capability (Size): Similar to the other firm capabilities, domestic firm with initial larger size enjoys productivity gains from the foreign competition in the industry (*SIZEComp*). Our result shows that if foreign presence in the industry increases from 0 to nearly 1 (almost 100% foreign presence in the market), then an initial larger firm accrues almost 2.9 percentage point higher productivity growth relative to other firms, due to increase in foreign competition. However, the other two interaction terms with horizontal spillover channels (*SIZEIMITATION and SIZESKILL*) are insignificant with positive signs.

Vertical Spillovers

Table 3 summarises the estimation results of equation (10) focusing on the vertical spillover channels (Backward and Forward). The model 1-3 presents the results of backward spillover channel and the interactions between backward linkage and firm capabilities. The model 4–6 presents the results of forward spillover variables.

Absorptive Capability (RD): Model 1 and Model 4 of the table 3 show the effects of initial R&D activity of the domestic firms on the propensity of domestic firm's productivity growth from backward and forward linkages between foreign and domestic organisations. As expected, domestic firms with high R&D intensity would achieve higher productivity gains from both backward (*RDBACK*) and forward (*RDFOR*) linkages. Coefficients of both the interaction terms are positive and highly significant. Domestic firms with initial R&D activity are able to exploit technology, supplied by the downstream foreign firms more efficiently compared to other domestic firms in the upstream sector. Moreover, foreign firms prefer to build linkages with domestic firms which have R&D activity as they want to maintain the international standard of intermediate products. Direct supply of technology to the upstream domestic firms reduces the cost of technology acquisition, resulting higher productivity growth. We find that if the R&D domestic firms in the upstream sector increase R&D activity by 10%, the productivity benefit from backward linkage increases by almost 1.4% points relative to other firms that do not. Similarly, initial domestic R&D firms in the downstream sector can appropriately utilise technologically advanced intermediate inputs supplied by the foreign firms in the production process and thus appropriate higher productivity growth as compared to other domestic firms.

Table 3
Firm Capability and Inter-Industry Productivity Spillovers from FDI on Indian Manufacturing Firms (1994-2010)

Variables		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
$Backward_{-1}$ (β_9)		-0.1958 (0.1695)	-0.2243 (0.1648)	-0.2653 (0.1672)			
$Forward_{-1}$ (β_9)					0.4927 (0.2950)*	0.2763 (0.2228)	0.2658 (0.2717)
$RDBACK_{-1}$ (β_{10})		0.1429 (0.0220)***					
$TECHBACK_{-1}$ (β_{10})			-0.1596 (0.0316)***				
$SIZEBACK_{-1}$ (β_{10})				0.0822 (0.0452)*			
$RDFOR_{-1}$ (β_{10})					0.1494 (0.0432)***		
$TECHFOR_{-1}$ (β_{10})						0.2218 (0.1198)*	
$SIZEFOR_{-1}$ (β_{10})							0.0204 (0.0100)**
R^2	*Within*	0.1417	0.1422	0.1422	0.1416	0.1421	0.1422
	Between	0.0722	0.0720	0.0721	0.0724	0.0719	0.0722
	Overall	0.1052	0.1049	0.1049	0.1055	0.1031	0.1035
F-Statistics		67.93***	64.59***	64.70***	67.64***	64.69***	64.68***
No of Observation		42607	42607	42607	42607	42607	42607
No of Firm		5620	5620	5620	5620	5620	5620

Note: *** , **, * signify 1%, 5% and 10% level of significance respectively. Values in the parenthesis are the heteroscedasticity corrected standard errors.

Production Capability (TECH): The coefficient of the interaction term *TECHBACK* (Model 2) is negative and highly significant implying that high initial technology gap hurts the upstream domestic firms. We know that technologically backward domestic firms need to invest on skill development and R&D activity if they want to absorb foreign technology. Interestingly, the other interaction variable (*TECHFOR*) shows a positive sign (Model 5) with marginal significance. This implies that domestic firms with large initial technology gap benefits from upstream foreign linkage. The reason may be that foreign firms mainly use

downstream local firms for their assembly works rather than production work. Thus, foreign firms supplied their products to the low technology and low skill intensive domestic firms which benefited from foreign contract and financial support rather than technological advancement.

Complimentary Capability (SIZE): Similar to the previous results, we find that the larger firms, with higher complimentary capabilities, benefit more from foreign vertical linkages. If we compare the coefficients of both interaction terms (*SIZEBACK and SIZEFOR*), it is evident that larger domestic firms can reap higher benefits from backward spillover (*SIZEBACK*) compared to the forward linkage (*SIZEFOR*). Chung *et al*. (2003) shows that larger domestic firms in the upstream sector attract higher association from the foreign firms. Therefore, inflow of technology and knowledge from the foreign to local supplying firms would naturally lead to higher productivity benefits.

Thus, it is evident that firm capabilities are an important factor for accommodating intra and inter industry benefits from foreign activities. Most of the interaction terms turn out to be significant and show signs as expected. However, comparing the coefficients of the interaction terms between horizontal and vertical spillover channels with initial absorptive capacity and technology gap variables, we can say that firms with initial absorptive capacity and technological capabilities gain higher productivity from vertical spillover channels as compared to the intra-industry spillover channels. Upstream and downstream domestic firms obtain advanced technology, financial support, labour training etc. directly from the foreign firms related through the vertical linkages. R&D activity, larger size and low technology gap of the domestic firms are added advantages for the domestic firms in upstream and downstream sectors for gaining more productivity compared to other firms. On the other hand, industries where foreign and domestic firms act as competitors, foreign firms attempt to reduce the leakage of knowledge to the domestic firms in different ways. Thus, to gain benefits from foreign activities within industry, domestic firms need to be highly technologically proficient. Moreover, the cost of learning is also high in the case of horizontal spillovers. Therefore, it is apparent that any firm capability would be highly beneficial for the firms in upstream and downstream sectors compared to competing sector.

Other firm and sectoral variables do not change their signs or significance much with the introduction of the interactive variables in the regression models. Therefore, we do not discuss about those variables separately in this section again.

5. Summary and Conclusion

In the present paper, we examined the impact of FDI spillovers on the productivity growth of Indian manufacturing firms during 1994-2010. In contrast to the earlier studies, we have focused on different channels and aspects of the FDI spillover effects. For the empirical analysis, we identified three firm capabilities, namely, absorptive capability (initial R&D capability), production capability (relative productivity gap between domestic firms and average foreign firm in the initial periods) and complementary capability (initial size of the domestic firms). In contrast to the existing studies, the present study has looked at the initial levels of the firm capabilities in facilitating benefits from foreign economic activities within industries.

Based on the theoretical literature, we incorporated five different forms of FDI induced spillover channels, i.e., competition, imitation, skill, backward and forward spillovers. Further, we also incorporated the interaction between each firm level capability and the five spillover variables, mentioned above. To measure productivity, we followed the semi-parametric estimation algorithm of Levinsohn and Petrin (2003). In the second stage of the estimation process, we carried out fixed effect panel regression considering TFPG as the dependant variable. Apart from the spillover variables, we incorporated various sectoral and firm specific control variables, which are often considered as some of the major determinant factors of productivity growth at the firm level.

Our primary findings show that productivity growth is highly influenced by the export intensity of the domestic firms. External competition, knowledge of advanced technology and increased market demand associated with export activity induce higher productivity growth among the export oriented domestic firms. We also find that the technology indicator such as R&D activity, import of disembodied and embodied technology facilitates productivity growth of the domestic firms. The R&D activity induces higher innovation activity and import of technology (embodied and disembodied) increases technological capability of the domestic firms. Innovation activities and advanced technology base improves the production process and thus enhances productivity of the domestic firms. The size of the domestic firms is also found to be a marginally important in enhancing productivity. Based on *HHI* indices, in general we did not find any significant impact of concentration on productivity growth of the domestic firms.

In the case of spillover variables we find that foreign presence and its activities within and across industries do not facilitate productivity growth of the domestic firms in aggregate manufacturing sector. It was argued in previous literature that the market stealing effects might outweigh the technology benefit from foreign presence inducing negative productivity spillover effects. Disentangling all possible channels of spillover effects we found that foreign competition reduces productivity growth. Similarly, we do not find any evidence of R&D spillover and skill spillover from foreign firms on Indian manufacturing firms. Foreign firms can afford skilled labour and undertake advanced innovation process compared to the domestic firms and, thus are able to produce at a lower cost. Introduction of cheap products by foreign firms force domestic firms reduce production and to produce at a higher average cost. Similar to this, domestic firms, with relatively low R&D capability and semi-skilled workers are not able to absorb the benefits of advanced technology and skills introduced in the market. As in the case of India, we find that foreign firms are not much R&D intensive and mostly rely on imported technology, thus it is not unexpected that domestic firms will not gain from foreign R&D activity. Indian firms also do not indicate any vertical productivity spillover effects from backward or forward linkages.

Interestingly, when we estimate the models controlling initial firm capabilities, we find positive productivity spillovers for the firms with initial high level of capabilities. The econometric result of the panel data revealed that domestic firms are largely benefitted from the initial level of absorptive capability, low technology gap and complementary capability. High initial R&D capacity of the domestic firms allows them to compete with the foreign firms within industry by upgrading their technology, and, innovating and diversifying their products. Moreover, firms with higher initial R&D can imitate foreign technology rapidly and are able to use the knowledge embodied in foreign labour efficiently as compared to non-R&D firms. Similarly, domestic firms with an initial low technology gap benefit more from foreign technology and knowledge spillover generated from horizontal and vertical FDI presence. Initial size of the domestic firms is found to be an important factor to capture higher benefits only from the competitive pressure from foreign firms. Hence, these results reflect that in aggregate manufacturing sector, domestic firms could actually gain higher productivity if initially the firms possess internal capabilities – absorptive capability, low technology gap and higher complementary capability.

From the above analysis, it is very clear that productivity growth from FDI is largely conditioned upon the technological competency of the domestic firms. There is a need to create synergy between internal technological capability and foreign activities. In this context, Indian government needs to take steps to create high quality R&D base and skill development by building efficient scientific infrastructure. This would also encourage foreign firms to take R&D activities within the industry. Moreover, Government needs to focus on building human capital by improving research based educational facilities and advanced training. In short, Indian Government needs to improve and build internal capabilities for generating long term development.

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Appendix

A1: Construction of *industry* × *industry* coefficient Matrix

For our study, we need to construct an *industry* × *industry* coefficient matrix using the Input-output transaction Table of India of years 1998-99, 2003-04, 2006-07 are published by the Central Statistical Organization (CSO). The Input-output transaction Tables consists of two matrices: absorption matrix (commodity-industry) and make matrix (industry-commodity). The former records the values of purchases of commodities by industries and the later records the value of commodities produced by industries. There are two basic assumptions which combine information of the make and absorption matrices to estimate a 'pure' table of *industry* × *industry* or *commodity* × *commodity* (Input-Output Tables and Analysis, 1973) matrices. They are generally referred to as the commodity technology and industry technology assumptions. The former assumes that a commodity has the same input structure in whichever industry it is produced. The industry technology assumption, on the other hand, assumes that all commodities produced by an industry are produced with same input structure and thus commodities will have different input structures depending on the industry in which they are produced.

As mentioned above our purpose is to construct an *industry* x *industry* matrix. As a first step, we need to aggregate the input-output table for the manufacturing sector to two digit level. For this we have used three I-O tables (1998-99, 2003-04 and 2006-07). We found that the

last two I-O tables have similar classification of products while the 1998-99 classification has different listing of products. For instance, in 1998-99, 115 products were listed whereas in the last two I-O tables there are 130 products. This made us to build correspondence table between 1998-99 and 2003-04 (2006-07). The concordance was prepared using the aggregate sector classification for input output transactions reported in the Appendix 4 table in each of the I-O tables reported by CSO. The concordance is provided in table A4.7 in the appendix. We can see that finally we have 132 products.

Secondly, a matrix of coefficient (we call it matrix X) has been created by dividing each row of the absorption matrix by the total output of the commodity. We create another matrix Y (using the make matrix) by dividing the each row by the total output produced by the respective industry. As a final step, we create a new matrix Z=YX. The new matrix Z is nothing but an *industry* x *industry* matrix. Each row of the matrix Z represents the total industry output delivered to different industries in the economy (Sasidharan and Ramanathan, 2007).

Table A2: Definition of the explanatory variables with expected signs

Variables	Symbol	Definition	**Expected Sign**
Export Intensity	*expint*	Ratio of FOB value of export and output of the firm	+
R&D Intensity	*RDint*	Expenditure on R&D divided by output of the firm.	+
Disembodied Technology Import Intensity	*Dtint*	Royalty and technical Fee payment made abroad divided by output of the firm	+
Embodied technology import intensity	*Etint*	Import of capital goods to output of the firm	+
Size	*Size*	Ratio of the firm output to the median output of the industry	+/-
Distance between the domestic firms	*GAP*	The Difference between the productivity of most productive domestic firms to the own productivity of the domestic firm	+/-
Concentration of the Industry	*HHI*	$HHI_{jt} = \sum_{i=1}^{n} \left(\frac{y_{ijt}}{y_{jt}}\right)^2$ (Herfindahl-Hirschman Index)	–
Trade Openness	*Openness*	Measured by import penetration of the industry ($Openness_{jt} = \frac{import_{jt}}{output_{jt}+import_{jt}-export_{jt}}$)	+
Competition Spillover	*CompSpill*	Share of foreign output to total output in an industry	+/-
Demonstration Spillover	*IMITATION*	Share of the MNE's total R&D and technology import expenditure to total R&D and technology import expenditure of the industry	+
Skill Spillover	*SKILL*	Share of the MNES' expenditure on wages and salaries on total expenditure on wages and salaries of the sector	+
Backward Spillover	*Backward*	$Backward_{jt} = \sum_{k} \alpha_{jkt} FDI_{kt}$	+
Forward Spillover	*Forward*	$Forward_{jt} = \sum_{k} \beta_{kjt} FDI_{kt}$	+