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# Abstract

The paper examines the spillover and linkage effects from the presence of foreign firms in the Indian pharmaceutical industry. A comprehensive panel data consisting of nearly 200 firms from 1989 to 2000 was used in the current study. The recent semi-parametric estimation methods as suggested by Olley and Pakes (1996) and Levinsohn and Petrin (2003) were adopted to account for the endogeneity in the input demand. Our results suggest the existence of positive and significant spillover from the foreign equity ownership in the Indian pharmaceutical industry. However, we also found negative and significant spillovers from the backward linkages with foreign firms. The negative spillovers from the backward linkages suggest the possibility of large technology and efficiency gap between local and foreign firms. The results also suggest that institutional arrangements that protect intellectual property rights such as product patents as opposed to process patents will be important for establishing positive linkages and spillovers between local and foreign firms in the Indian pharmaceutical industry.



Keywords: FDI, Backward and Horizontal Linkages, Olley-Pakes, Levinsohn-Petrin

JEL classification: F23 C23 O3

# 1. Introduction

Recent evidence suggests that India is increasingly becoming an important destination for FDI in Asia, where India's share in world FDI has been steadily increasing from 0.17% in 2000 to 0.53% in 2002, in line with the progressive liberalization in the FDI policy by the Indian government (World Investment Report, 2003). In fact, the progressive liberalization that was undertaken since 1990 has strengthened investor confidence and increased the FDI flows into various new sectors like integrated townships, defense, telecommunications, pharmaceutical etc. These reforms and deregulation in key sectors to foreign competition and ownership is expected to create strong economic benefits and externalities to the Indian economy through spillovers from multinational activities, thereby resulting in domestic firms becoming more productive and competitive.

With the growing importance of FDI, most host countries including India are not only seeking more of foreign investments, but are also interested in the technology and distributional networks of the multinational companies, which are the key propriety assets of the foreign firms. Although it is expected that the multinational firms will internalize the returns of these propriety assets, the activities of the foreign affiliates in the domestic economy has certain public good qualities that cannot be internalized. Multinational activities could create externalities and spillovers onto the domestic economy through ownership structures, enhancing domestic competition, transfer technology through imitation or reverse engineering, training of local entrepreneurs and workers, and establishing production and distributional linkages in the domestic economy (Dimelis and Louri, 2002; Gorg and Greenaway, 2002).

However, it not always the case that the domestic firms benefits from the activities of foreign firms, as the relative backwardness of the industrial structure and the institutional characteristics of the domestic economy significantly determines the relative size and extent of the spillovers (Glass and Saggi, 1998; Grima et al, 2001). In this paper, we examine if such linkages and spillovers exist from the multinational activities on the domestic firms in the Indian pharmaceutical industry.

One way to understand the complimentary benefits between multinational activities and local industrial capabilities is to examine the production linkages of foreign and domestic firms. Backward linkages occur when foreign affiliates acquire goods or services from domestic firms, and conversely, the forward linkages are formed when foreign affiliates sell their goods and services to domestic firms. By generating markets for indigenous firms through upstream and downstream linkages, foreign firms are able to develop products more successfully in the same or related industrial sector.

Foreign affiliates like any other firm have three options in obtaining inputs in a host country: imports, local in-house production, or procure them from a local or foreign supplier. The extent to which foreign affiliate forges linkages with domestic suppliers is determined by balance of costs and benefits, which is determined by the availability of efficient local suppliers. The lack of efficient domestic suppliers is often the key obstacle to the creation of local linkages. In order to sustain the quality standards in their production, multinational firms actively encourage foreign suppliers to establish local facilities or prefer to produce the required inputs in house.

There is a vast empirical literature that investigates if there are any spillovers from foreign affiliates to the host economy or if they operate in “enclave sectors” with no links to

the domestic economy (sees the surveys by Blomstrom et. al, 2000; Gorg and Greenaway, 2002). Most empirical studies tend to use labour productivity or total factor productivity of domestic firms as an independent variable and regress on a range of dependent variables. The proxies for "intra-sectoral" spillovers such as the share of foreign affiliates' employment or sales to total industrial activities were used as dependent variable to capture the activities of the MNCs in the domestic economy.

There is no general conclusion as to the effect or the extent of the spillovers from the activities of the foreign firms to the domestic firms or economy. Although, several empirical studies based on cross-sectional and industry level study suggest positive linkage and spillover effects from multinational activity in the host economy, more recent firm level evidence suggests negative spillovers from the presence of the foreign firms (Aitken and Harrison, 1999; Djankov and Hockman, 2000). In fact, these empirical evidences mostly suggest that the host country's industrial structure and the type of multinational activities affect the effectiveness of the backward linkages in the host country (Girma, Greenaway, and Wakelin, 2001; Kokko et al. 1996).

There are several recent empirical studies at the firm level that directly deal with backward linkages and multinational activities. Using firm level data for Venezuela, Aitken and Harrison (1999) failed to find any spillovers from multinational activities on domestic firms in the same region, although they found negative spillovers from multinationals located in the same sector. Girma and Wakelin (2000) found evidence of positive spillovers from multinational activities to domestic firms in the same sector in UK industries. Görg and Strobl (2002) in a study of the manufacturing industries of Ireland show a rather large effect of multinational activity in downstream sectors on entry of Irish firms in upstream sectors

and across a variety of industries. However, they also conclude that other indicators such as employment effects in upstream sectors are necessary in order to render stronger conclusions about the linkage effects of multinational firms in the Irish economy. In a recent study, Smarzynska (2002) estimates the backward linkages for a variety of Lithuanian industries and show that there are positive spillovers from the multinational activities to domestic firms in sectors downstream, but not with the presence of multinationals in the same sector. Furthermore, the study on Lithuania reveals that linkages appear stronger in a localized perspective, e.g. proximity between users and producers do matter to the externality effect. This study also shows that local market-seekers may have stronger linkage effects than the more export oriented multinational firms.

The purpose of this study is to examine the presence of spillovers and linkages stemming from the activities of foreign firms in the Indian pharmaceutical industry. The Indian pharmaceutical industry stands out of all other industries to examine industrial structure and the impact of foreign activities on the domestic economy. The pharmaceutical industry is one of the key industries that are affected by the current liberalization of the Indian economy. In 1970s, the government enacted the Foreign Exchange Regulation Act (FERA) to reduce the foreign ownership in domestic industries, which required domestic firms to reduce their foreign equity ownership to less than 40% so as to quality for the economic incentives as domestic firms. This led to a drastic reduction in the share of foreign collaborations and multinational activities in the pharmaceutical industry (Keayla, 1998). In 1994, under the economic liberalization, the Indian government allowed the foreign equity ownership to increase to 51% of the domestic companies. During the same year, under open general licence, the government also announced the removal of the restrictions on the imports

of almost all foreign drugs into the domestic economy. Both these initiatives let many firms to increase their foreign equity ownership in the pharmaceutical industry (GOI Annual Report 1997-98).

However, the full impact of the economic liberalization through the flow of FDI is not felt directly by the Indian pharmaceutical industry, since there is a large pharmaceutical industry in India that is largely based on reverse engineering on existing drugs, which directly affects the production relationship between domestic and foreign firms. This will allow us to address the institutional framework such as intellectual property rights that could directly affect the types of activities multinational companies will undertake in the domestic economy. Given that the Indian government only provides patent protection for pharmaceutical processes and not on products, there is a large industry that is based on reverse engineering on the existing or newly introduced drugs (Kremer, 2002). This lack of protection not only dampens FDI flow into the industry, but also hampers any R&D activities undertaken by existing foreign firms in the host country. Nicholas, Merind, Roche and Searle (GOI Annual Report 1993-94) highlights that the pricing system, lack of patents, and disadvantages in entering into licensing with local firms are the key reasons for the disinvestments in the Indian pharmaceutical sector.

Using a panel of nearly 200 firms from 1989 to 2000, the paper examines the impact of multinational activities on the Indian pharmaceutical industry. Recent studies highlights the biasness of industry and cross-sectional studies as they do not control for time-specific productivity differences across industries and sectors, which might be correlated with factors other than that of the foreign affiliate activities (see Gorg and Greenaway, 2002). The panel data estimation, on the other hand, allows us to control for unobservable firms effects that

enable us to identify the spillover effects from multinational activities. The semi-parametric estimation methodologies as suggested by Olley and Pakes (1996) and Levinsohn and Petrin (2003) that accounts for endogeneity of input demand are employed in the current study. More specifically, we control for unobserved firm heterogeneity and also account for the endogeneity in the input selection with respect to productivity, which allows for consistent estimates of the production function[2].

Our results suggest the existence of positive and significant spillover from foreign equity ownership in the Indian pharmaceutical industry. However, we found negative spillovers from the backward linkages between foreign and domestic firms. This suggests that full foreign ownership results in negative externalities to domestic firms in downstream sectors in the pharmaceutical industry. The negative spillovers from the backward linkages suggest the possibility of large technology and efficiency gap between local and foreign firms in the Indian pharmaceutical industry.

The structure of the paper is as follows. The sources of the data and estimation methodologies are given in section 2 and 3 respectively. In Section 4, we report the results. Section 5 concludes the paper.

## 2. Data

The data set used in the present study is from the Center for monitoring Indian economy (CMIE) database. The firm level data constitute an unbalanced panel from 1989-2000. The sample consists of a total of 192 firms that includes 176 domestic and 16 foreign affiliated firms. Foreign firms are distinguished from their domestic counterpart on the basis of its share of ownership of the firm, where ownership share of more than 25 percent is

[2] Griliches and Maireses (1998) have argued that inputs should be considered endogenous since they are chosen by a firm based on its productivity, which is observed by the producer but not by the econometrician. Not taking into account the endogeneity of input choices biases the estimated production function coefficients.

considered as foreign affiliated firms. All the variables used in the estimation are measured at constant 1990-91 prices.

The total value of output is taken to be the output variable in this study. The total raw materials consumed by the firms are deflated by the weighted input price index. The material price index is a weighted index of wholesale prices of major input groups, where the weights were calculated from the matrix of Input-Output Tables published by Central Statistical Organization (CSO). The value of the output and material input is taken from Annual Survey of Industry (ASI), various issues. The input-output transaction matrix (1978-79 and 1983-84) is used to construct the price deflators. The capital stock is defined by the value of tangible fixed assets and it is deflated using the capital stock deflator. The series on the number of workers is constructed using data from ASI using the data on total wages and salaries of the firms.

The key variables in our study are the horizontal (HRZ) and backward (BACK) linkages from the presence of foreign firms. The horizontal linkage (HORZ) variable captures the impact of foreign equity ownership and the benefits it delivers to local firms. The HORZ is defined as foreign equity participation averaged over all firms in the sector, weighted by each firm's share in sectoral output[3]. It is given as:

$$\boldsymbol{Horz_{it}} = \frac{\sum_i \boldsymbol{FS_{it}} * \boldsymbol{Y_{it}}}{\sum_i \boldsymbol{Y_{it}}} \qquad (1),$$

where $\boldsymbol{FS_{it}}$ is defined as the share of foreign equity in firm $i$ at time t and $\boldsymbol{Y_{it}}$ represents share of output in firm $i$ at time t. The *HORZ* variable is positively related to the output of the foreign firms and with the share of foreign capital in the domestic firms. We could

[3] The above definition is similar to Smarzynska (2000), which uses output as weights. In contrast, employment was used as weights by Aitken and Harrison (1999).

interpret the *HORZ* the degree of quality control and screening that foreign firms impose on the domestic firms through their equity ownership. In contrast, the backward linkage (Back) variable intends to capture the level of interactions between domestic suppliers and multinationals. It is defined as the share of local raw material expenditures by local firms to total raw material expenditures of foreign firms weighted by the sales ratio of the respective firm. It is given as:

$$Back_{it} = \frac{LRAWM_{it}}{\sum_j FRAWM_{jt}} * \frac{sales_{it}}{\sum_i sales_{it}} \qquad (2),$$

where $LRAWM_{it}$ denotes expenditures incurred on local raw material by local firm *i* at time *t* and $\sum_j FRAWM_{jt}$ denotes the total raw materials expenditures of all foreign firms. The backward linkage variable indicates the degree of linkage and spillovers that exist from the procurement activities undertaken by the foreign firms, as *BACK* increases with the procurement of local raw materials by the foreign firms. The backward linkage variable also reflects the domestic capacity and efficiency of local firms, where inefficient local suppliers could possibly lower the local procurement of raw materials by the foreign firms. In this case, foreign firms will create less backward linkage and increase their dependence on external market for their raw materials.

We summarize the key activities of domestic and foreign firms in Table 1. The average R&D expenditure in the Indian pharmaceutical industry is found to be very low, which is hardly one percent of the total sales of the whole industry. In fact, it is quite clear that most of the R&D activities are driven by foreign firms and the average R&D intensity of the foreign firms is much higher than the local firms, where the average R&D intensity of foreign firms is nearly 0.35 as compared to 0.30 for the domestic firms in 1990-2000. In fact,

the increase in R&D intensity for the local firms is only observed after the relaxation of foreign equity share to 51 percent in 1994. Recent trends suggest that the R&D intensity is increasing for local firms as they start to build-up their own research capabilities to compete with foreign firms.

**Table 1: The Trend of the Key Variables for the Foreign and Domestic Firms in Indian Pharmaceutical Industry, 1990-2000.**

| | (W/S)*100 | | Export-Intensity | | Tech. Import Intensity | | R&D intensity | |
|---|---|---|---|---|---|---|---|---|
| Year | Foreign | Domestic | Foreign | Domestic | Foreign | Domestic | Foreign | Domestic |
| 1990-1993 | 11.40 | 11.41 | 5.00 | 8.80 | 0.22 | 0.49 | 0.23 | 0.11 |
| 1994-1996 | 10.35 | 9.13 | 6.11 | 11.92 | 0.32 | 2.56 | 0.44 | 0.25 |
| 1997-2000 | 10.85 | 10.78 | 8.73 | 15.66 | 0.93 | 0.77 | 0.39 | 0.54 |

Note: (W/S)*100 – Share of wages to total sales of the firm, Export-Intensity: Share of exports to total sales of the firm, R&D Intensity: Share of (foreign) R&D expenditure to total sales of the firm, Tech. Import Intensity: share of import of capital goods plus remittances on royalty and technical fees to total sales of the firm

It is generally assumed that the foreign firms are more export oriented than their domestic counterparts because of their easy access to the global distribution networks, product quality, brand names, patents and other firm-specific comparative advantages. However, the evidence in Table 1 suggests that there is an opposite trend as the average export intensity of the domestic firms is consistently higher than that of the foreign firms. Since the post reform period of 1994, the average export intensity of both domestic and foreign firms is observed to be rising two to three folds as compared to pre-1994 period, which suggests that the Indian pharmaceutical industry is becoming more export-oriented in the global market.

Import of technology is an important determinant of the productivity growth for the domestic firms. It can be measured by the import of capital goods plus remittances on account of royalty and technical fees as a proportion of sales. The average technology import

as given in Table 1 is much higher than that of the foreign firms, which indicates the reliance of local firms to upgrade their technology through technology imports than foreign firms in the industry. Due to greater economic liberalization of imports, the technology imports seem to have increased after the policy changes in 1994 to remove import restrictions. Policy to reduce price controls, liberalize import, and scraping of various production control measures seems to have positive impact on efforts of the domestic firms to keep pace with the R&D activities of the foreign firms. This is expected to be a positive trend in the Indian pharmaceutical industry.

## 3. Empirical Model

The estimation framework adopted here is similar to Smarzynska (2002). The Cobb Douglas production is defined to study the relationship between local firm productivity and foreign presence in the domestic market. Thus firm *i*'s production is given as:

$$\ln Y_{it} = \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \beta_3 \ln M_{it} + \beta_4 Back_{it} + \beta_5 Horz_{it} + \alpha_t + \alpha_i + \varepsilon_{it} \quad (3),$$

where subscripts $i$ and $t$ refer to firm and time respectively. $Y_{it}$ $K_{it}, L_{it}$ and $M_{it}$ represent the log of output, capital, labour and material inputs respectively. $\alpha_t$ and $\alpha_i$ capture time and firm specific effects respectively.

The above model is estimated using Ordinary Least Square Method (OLS) with time and fixed effects. However, there are two major shortcomings in the OLS estimation. The key shortcoming is that it does not take account of the unobserved firm characteristics, such as managerial talent, availability of better infrastructure or access to financing that could driving some of the changes in the productivity of the firm. To address this issue, we re-estimate our model as a panel with firm fixed effects, which allow one to control for time invariant determinants of productivity across firms that are also potentially correlated with

ownership variables. Following Haskel et. al. (2002), we also used time differencing as well as a full set of fixed effects to address the above firm specific effects. Thus our specification is given as:

$$\Delta \ln Y_{it} = \delta_1 \Delta \ln K_{it} + \delta_2 \Delta \ln l_{it} + \delta_3 \Delta \ln M_{it} + \delta_4 \Delta Back_{it} + \delta_5 \Delta Horz_{it} + \alpha_t + \Delta \varepsilon_{it} \qquad (3a)$$

However, the estimation of the production function in differences still poses another problem. The estimation of equation (1a) may not be appropriate, since it treats labor and other inputs as strictly exogenous variables. As observed by Griliches and Mairesse (1998) that the key essence of the simultaneity problem is that the firm specific effects are only observable by the firm thereby affecting their choice of the levels of the inputs, but not otherwise observable and accounted by the data. In this case, the unobserved firm specific effects might be correlated with the inputs of the production function and thereby bias the estimated coefficients. To account for the simultaneity problem, we employ the recently developed semi-parametric estimation procedures of Olley and Pakes (1996) (henceforth Olley-Pakes), which was further extended by Levinsohn and Petrin (2003) (henceforth Levinsohn-Petrin). The summary of Olley-Pakes and Levinsohn and Petrin is given in the appendix.

A production function accounting for Olley-Pakes correction is estimated and from the results, we recover the measure of total factor productivity. Based on the derived total factor productivity, the final model estimated is given as:

$$\ln TFP_{it} = \alpha + \beta_1 Horz_{it} + \beta_2 Back_{it} + \alpha_i + \alpha_t + \varepsilon_{it} \qquad (3b)$$

It is important to note that the Olley-Pakes procedure is based on the assumption of factors fully adjusting to shocks in each period and markets being perfectly competitive. Levinsohn-Petrin argues that investment as used by Olley-Pakes does not fully control for

simultaneity problem and suggested the advantages of using materials inputs to identify the unobservable productivity. They highlight that intermediate inputs respond to the entire productivity term, whereas investment may only partially respond to the "news" in the unobserved term. The Olley-Pakes and Levinsohn and Petrin method are used to estimate firm specific total factor productivity, and then it is used as the dependent variable in OLS estimation of equation (3b).

## 4. Estimation Results

The results from OLS (with White's correction of standard errors), fixed effect, Olley-Pakes, and Levinsohn-Petrin methods are given in Table 2 and 3. In Table 2A, the OLS estimation reveals that HORZ is positive and the backward linkage variable, BACK, is negative. Given the biasness in the OLS estimation, we re-estimate the model with fixed, Olley-Pakes and Levinsohn-Petrin methods. The results are given in Table 2A and 2B.

The results are robust to the alternative estimation methodologies. The fixed effects estimation given in column3 of Table 2A suggests positive and significant horizontal spillovers from the activities of foreign affiliates. The result is also robust to the estimation of both Olley-Pakes and Levinsohn-Petrin methodologies as given in Table 2B. The implication of this result is that domestic firms tend to have benefited from the presence of foreign companies through foreign equity ownership. It points to the fact that foreign firms transfer new technologies and invest more productive resources in the production of their own affiliates, and hence foreign affiliates represent greater potential for spillovers. The positive impact of *HORZ* also reflects that foreign participation acts as possible quality control and screening of the domestic firm production through equity ownership.

Table 2A: OLS and Fixed Effects Estimation for Indian Pharmaceutical Industry: 1989-2000 (All Firms)

| | OLS | | Fixed Effects |
|---|---|---|---|
| | Level | First Difference | |
| K | 0.083** | 0.008* | 0.021* |
| | (4.04) | (1.98) | (1.99) |
| M | 0.839*** | 0.806*** | 0.846*** |
| | (37.9) | (14.5) | (17.7) |
| L | 0.116** | 0.174** | 0.149** |
| | (5.44) | (4.29) | (3.71) |
| Backward | -1.132** | -1.335** | -1.491** |
| | (-4.61) | (-2.79) | (-2.81) |
| Horizontal | 3.991** | 6.138** | 3.788** |
| | (3.83) | (3.38) | (4.33) |
| Constant | 0.565** | -0.0003 | 0.844** |
| | (3.56) | (-0.125) | (3.10) |
| Year Dummies | Yes | Yes | Yes |
| Adj. R squared | 0.97 | 0.84 | 0.98 |
| Obs. | 1504 | 1316 | 1504 |

Note: ***, **, * denote significance at the 1, 5, and 10 percent level.
t-vales are reported in the parenthesis.

The backward linkage variable is negative and robust to alternative estimations, which suggest that the procurement activities of foreign firms tend to reduce the productive performance of local firms. To establish robustness of the results, we also re-estimated the model with only domestic firms to remove the dominant effects of large foreign firms in the sample. The results are given in Table 3A and 3B. Again, we do observe the negative effects of the backward linkage and the result is also supported by the Olley-Pakes and Levinsohn-Petrin estimations. Further, as in the previous estimation, we also find positive impact of foreign equity ownership on domestic firms supporting the evidence that foreign participation through ownership structures will have positive impact on the domestic firms.

Table 2B: Olley-Pakes and Levinsohn-Petrin Estimation for Indian Pharmaceutical Industry: 1989-2000 (All Firms)

| | Olley-Pakes | | Levinsohn-Petrin | |
|---|---|---|---|---|
| | OLS | First Difference | OLS | First Difference |
| Backward | -0.463*<br>(-5.10) | -0.583**<br>(-2.70) | -0.093*<br>(-5.23) | -0.039**<br>(-2.84) |
| Horizontal | 1.841*<br>(7.88) | 2.749*<br>(5.88) | 0.386*<br>(8.35) | 0.247**<br>(4.28) |
| Constant | 1.469*<br>(8.63) | 0.073<br>(0.798) | 3.94**<br>(2.23) | -0.03**<br>(-2.00) |
| Year Dummies | Yes | Yes | Yes | Yes |
| Adj. R squared | 0.34 | 0.25 | 0.34 | 0.25 |
| Obs. | 1218 | 1039 | 1218 | 1039 |

Note: ***, **, * denote significance at the 1, 5, and 10 percent level.

t-vales are reported in the parenthesis.

Table 3A: OLS and Fixed Effects Estimation for Indian Pharmaceutical Industry: 1989-2000 (Domestic Firms)

| | OLS | | Fixed Effects |
|---|---|---|---|
| | Level | First Difference | |
| K | 0.094**<br>(4.24) | 0.019**<br>(2.32) | 0.018**<br>(2.34) |
| M | 0.838***<br>(37.6) | 0.815***<br>(14.6) | 0.847***<br>(17.2) |
| L | 0.104**<br>(4.65) | 0.173**<br>(4.22) | 0.149**<br>(3.48) |
| Backward | -1.505**<br>(-3.61) | -1.459*<br>(-1.72) | -1.412*<br>(-1.85) |
| Horizontal | 3.418**<br>(3.28) | 4.719**<br>(2.51) | 3.347**<br>(3.32) |
| Constant | 0.512**<br>(3.18) | -0.007<br>(-0.98) | 0.898*<br>(2.91) |
| Year Dummies | Yes | Yes | Yes |
| Adj. R squared | 0.97 | 0.84 | 0.98 |
| Obs. | 1331 | 1159 | 1331 |

Note: ***, **, * denote significance at the 1, 5, and 10 percent level.

t-vales are reported in the parenthesis.

Table 3B: Olley-Pakes and Levinsohn-Petrin Estimation for Indian Pharmaceutical Industry: 1989-2000 (Domestic Firms)

| | Olley-Pakes | | Levinsohn-Petrin | |
|---|---|---|---|---|
| | OLS | First Difference | OLS | First Difference |
| Backward | -1.52*<br>(-1.84) | -1.291*<br>(-1.62) | -0.863*<br>(-5.24) | -0.408**<br>(-2.77) |
| Horizontal | 1.153<br>(1.07) | 1.724*<br>(2.21) | 0.369*<br>(8.06) | 0.256*<br>(4.09) |
| Constant | -11.248*<br>(-1.94) | 0.04<br>(1.19) | 3.75**<br>(2.21) | -0.03*<br>(1.61) |
| Year Dummies | Yes | Yes | Yes | Yes |
| Adj. R squared | 0.31 | 0.020 | 0.30 | 0.19 |
| Obs. | 1068 | 898 | 1068 | 898 |

Note: ***, **, * denote significance at the 1, 5, and 10 percent level.

t-vales are reported in the parenthesis.

The negative backward linkage result tends to be very interesting in our study. Consider the effect of backward linkage as a measure of vertical spillovers, the effect of foreign presence on down stream firms. We observe negative and statistically significant coefficient associated with backward linkage (BACK) variable, which was also observed in other firm level studies (Aitken and Harrison, 1999; Djankov and Hockman, 2000). The result is also robust to alternation estimation by Olley-Pakes and Levinsohn-Petrin. The observation of the negative sign can be explained as follows. Firstly, the technology and efficiency gap between local and foreign firms might be too large for domestic firms to benefit fully from the production activities of foreign firms. The foreign investors entering a host country is less likely to source for domestic resources if the production capacity of the local firms is weak. Due to the fact that the foreign firms face higher costs of finding efficient

and reliable local suppliers, foreign firms are more inclined to integrate their production operations of their subsidiaries with supply network of the parent company. Thus domestic firms could only benefit from multinational activities if the technology and efficiency gap is not too large between local and foreign firms that allow local firms to absorb the spillover of knowledge from the multinationals (Kokko et. al., 1996). In the case of Indian pharmaceutical industry, there might be country specific factors such as limited patent protection that might have contributed to the negative backward linkage and foreign firms might be operating as "enclaves" with little interaction with local firms. Given that there is already a large reverse engineering activities on existing drugs by the domestic firms in the Indian pharmaceutical industry due limited or non-existence of patent protections on products, the enclave activities might be preemptive strategies by the foreign firms to reduce the flow of technologies to down stream local firms and to protect their firm-specific technology.

The technology gap between local and foreign firms is also observable from derived total factor productivity (TFP) from our estimation. The total factor productivity growth measure based on the Olley-Pakes estimation is given in Table 4. Comparing the total factor productivity (TFP) of domestic and foreign firms in the Indian pharmaceutical industry over the period of study, we may observe that foreign firms tend to have higher productivity growth than domestic firms in the Indian pharmaceutical industry. Interestingly, we observe a reversal in the trend in post 1996 period, after the policy announcement on the increase in foreign equity investment, thereby supporting the observation that domestic firms were protected from foreign competition. Over this period of 1996 to 2000, foreign firms reported positive TFPG of around 1.3 percent as compared to the domestic firms with a negative

TFPG of around 1.1 percent. The declining productivity growth for the local firm from 1996 suggests that local firms are protected and more backward with regard to their technologies as compared to the foreign firms, which also supports the evidence of negative backward linkages.

**Table 4: TFP Growth of Foreign & Domestic Firms In Indian Pharmaceutical Industry, 1990-2000 (%)**

| Year | Foreign | Domestic |
|---|---|---|
| 1990-1993 | 4.9 | 3.5 |
| 1994-1996 | 1.3 | -1.1 |
| 1997-2000 | 1.4 | -0.5 |

Note: TFPG is derived from Olley-Pakes estimation.

The overall results suggest that there are positive spillovers from the activities of foreign firms in the Indian pharmaceutical industry since the spillover from foreign ownership through equity holdings is larger than the negative impact from the backward linkage. However, as domestic firms face greater economic liberalization from foreign ownership and competition, productivity gap tends to widen between the local and foreign firms. The future growth of the Indian pharmaceutical industry depends critically on reducing the productivity and technology gap between local and foreign firms and for the pharmaceutical industry to benefit from the presence of foreign firms in terms of linkages and spillovers.

## 6. Conclusions and Policy implications

The paper investigated the spillover and linkage effects from the activities of foreign firms on the local firms in Indian pharmaceutical industry. The results suggest that foreign ownership through equity holdings has positive spillovers on the productive performance of local firms. However, we also found that the impact of foreign ownership depends on how closely the foreign firms integrate their operations with the local production chain through

their procurement activities. The effects of the procurement or the backward linkage indicate negative spillovers between local and foreign firms. The negative backward linkages between local and foreign firms suggest that there is a large technology and efficiency gap between local and foreign firms. The overall results suggest that there are positive spillovers from the activities of foreign firms in the Indian pharmaceutical industry as the effects of equity ownership are greater than the negative impact of the backward linkage. However, the future growth of the pharmaceutical industry still depends in narrowing their technology and efficiency gap between local and foreign firms.

The results suggest several policy implications to enhance the productivity growth of local firms with foreign participation in the Indian pharmaceutical industry. The results suggest that foreign equity participation has improved productivity of the domestic pharmaceutical industry, and further liberalization of the FDI policy in terms of foreign ownership will have positive impact on the industry. However, there should also be policy to strengthen the local linkage of FDI through specific tools and incentives to address the problems of high cost, poor quality and unreliability associated with local suppliers. This is essentially to encourage local suppliers to respond efficiently to the demand of foreign firms, which in turn depend upon supply network, support institutions, development of local skills and technological capabilities. Further, there should be incentives for domestic firms to develop their own in-house R&D capabilities so as to build indigenous technological capabilities.

The results of the paper also highlights that institutional arrangements such as giving protection for Intellectual Property Rights might be very crucial for attracting and creating linkages from the activities of foreign firms in the host country. One of the key obstacles for

the Indian pharmaceutical industry is the absence of patent protection for their products. Clearly, the intellectual property environment in a country affects the flow of foreign investment, particularly in those industries heavily dependent on intellectual property protection. India is unique among developing countries, since India has a thriving pharmaceutical industry dedicated to providing healthcare at the lowest possible cost.

India's pharmaceutical industry growth has been primarily driven by its strength in production of generic drugs. This has been possible because Indian laws have been based on protecting process rather than product innovations. India's pharmaceutical industry has grown in scale, and recent years it is beginning to generate patentable intellectual capital. It has resources to make selective acquisition of firms abroad; and to make tentative moves towards branded drugs. It will be important to observe the changes in the intellectual property protection in 2006, which will increase the protection given to products.

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# Appendix

## A1: Olley and Pakes Correction

Olley-Pakes method allows for firm specific productivity differences that exhibit idiosyncratic changes over time and thus addresses the simultaneity bias. The key innovation of Olley-Pakes is to proxy for the unobservable firm specific effects and thus introduces a new investment equation into the analysis. To illustrate the insights of the methodology, we start with the following production function.

$$va_{it} = y_{it} - m_{it} = \alpha + \beta_l * l_{it} + \beta_k * k_{it} + \omega_{it} + \eta_{it} \qquad \text{(A1)}$$

where $i$ and $t$ are subscripts denoting firm and time and $va$ is value added i.e., (output minus material inputs), $l$ is for labour, $k$ is for capital, and respectively. All of the above variables are in logs. Capital is treated as a fixed input while labor and materials are assumed to be freely variable inputs. Additionally, the error term $\varepsilon_{it}$ is assumed to be additively separable in two components, a transmitted component, $\omega_{it}$, and an i.i.d component, $\eta_{it}$. The key difference between $\omega_{it}$ and $\eta_{it}$ is that the former is a state variable, and hence impacts the firm's decision rules, while latter has no impact on the firm's decision. In other words, $\eta_{it}$ represents the error term capturing the unpredictable shocks, while $\omega_{it}$ represents a productivity shock which is unobserved by the econometrician but known to the firm. Firms adjust their variable inputs based on their anticipation or knowledge of the productivity shock $\omega_{it}$ [4]. Since there exists a correlation between the error term $\varepsilon_{it}$ i.e., $(\omega_{it} + \eta_{it})$ and explanatory variables, a simple OLS will lead to inconsistent estimate of the regression model. In a perfectly competitive environment where input and output prices are common across firms, the capital investment can be written as just a function of two state variables, $k_{it}$ and $\omega_{it}$ or we can express it as

$$i_t = i_t(\omega_t, k_t) \qquad \text{(A2)}$$

Olley-Pakes shows that under certain conditions that optimizing firms choosing to invest tend to have investment functions that are strictly increasing in the unobserved productivity shock. In our model, this assumption might be appropriate as the removal of foreign ownership and imports tariffs by the Indian government is expected to increase the investment in new technologies in capital goods such as plants, equipments and buildings.

By inverting equation (A2), we can express unobserved productivity $\omega_{it}$ as a function of observable investment and capital and thus we can control for $\omega_{it}$ in estimation. We can express the equation as follows.

$$\omega_{it} = \phi(i_t, k_t) \qquad \text{(A3)}$$

Given this monotonicity condition, we can rewrite equation (A1) as:

$$va_{it} = y_{it} - m_{it} = \alpha + \beta_l * l_{it} + \beta_k * k_{it} + \phi(i_{it}, k_{it}) + \eta_{it} \qquad \text{(A4)}$$

[4] The major innovation of Olley-Pakes is to bring a new equation, the invest equation, as a proxy for $\omega$, the unobserved transmitted component of $\varepsilon$. Trying to proxy for the unobserved $\omega$ has several advantages over the usual within estimators or the more general Chamberlin and GMM type estimators. It does not assume that $\omega$ reduces to a "fixed" (over time) effect and it leaves more identifying variance in x and k. Hence it is a less costly solution to the omitted variable and/or simultaneity problem and it should also be substantively more informative (Griliches and Mairesse, 1998).

It must be highlighted that the functional form of $\phi(.)$ is not known. Thus, Olley-Pakes suggest using a two-stage approach to estimate $\phi(.)$. In the first stage, a semi parametric estimator (non parametric in $\phi_t$) can be used to obtain consistent estimates of the coefficients on the freely variable inputs. We estimate the partially linear model using a polynomial in capital and investment to approximate the functional form $\phi(.)$. By doing so we obtain the consistent estimate of labor input coefficients ($\beta_l$) as well as the estimate of the third order polynomial in $i_{it}$ and $k_{it}$, which has been denoted as $\chi_{it}$. We write the equation as

$$\chi_{it} = \alpha + \beta_k^* k_{it} + \phi(i_{it}, k_{it}) \qquad \text{(A5)}$$

Thus, $$\phi(i_{it}, k_{it}) = \chi_{it} - \beta_k * k_{it} \qquad \text{(A6)}$$

We proceed with the second stage, where we estimate the effect of capital and materials on output. Assuming $\omega_{it}$ follows a first order Markov process, we can rewrite $\omega_{it+1}$ as a function of $\omega_{it}$, letting $\xi_{it+1}$ be the innovation in $\omega_{it+1}$. Thus $\omega_{it}$ can be replaced with function of $\phi(i_{it}, k_{it})$ and the equation in the second stage becomes:

$$va_{it+1} - \beta_l * l_{it+1} = c + \beta_k * k_{it+1} + g(\phi_{it}(\cdot)) + \xi_{it+1} + \eta_{it+1} \qquad \text{(A7)}$$

Since the functional form of $g(\cdot)$ is not known, we again use the third order polynomial expansion (with all interactions) in equation (A7). Since we assume that the capital is known in the beginning of the period, and $\xi_{it+1}$ is mean independent of all variables known at the beginning of the period, $\xi_{it+1}$ is mean independent of $k_{it+1}$. The consistent coefficient $\beta_k$ can thus be estimated by running non-linear least squares on equation (A7).