Linkages, Spillovers and Foreign Ownership: Evidence from the Indian Pharmaceutical Firms

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Abstract

The paper examines the presence of spillovers to domestic firms from the activities of foreign firms through backward and horizontal linkages in the Indian pharmaceutical industry. A comprehensive panel data consisting of nearly 200 firms from 1989 to 2000 is used in the current study. The recent semi-parametric estimation methods as suggested by Olley and Pakes (1996) and Levinsohn and Petrin (2003) that accounts for the endogeneity in the input demand are adopted in the study. Our results suggest the existence of positive and significant horizontal spillover in the Indian pharmaceutical industry. However, we also found negative and significant spillovers from the backward linkages with foreign firms. This suggests that full foreign ownership results in negative externalities to domestic firms in upstream 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 sustain growth of the industry in the globally competitive environment depends on narrowing the technology and efficiency gap between local and foreign firms. The institutional arrangements that protect intellectual property rights such as product patents as opposed to patents for protecting processes will be important for establishing linkages and spillovers for local and foreign firms in the Indian pharmaceutical industry.

Keywords: FDI, Backward and Horizontal Linkages, Olley-Pakes Estimation.

JEL classification: F23 C23 O3
1. Introduction

Although China is the largest recipient of FDI, recent evidence also suggests that India is increasingly becoming an important destination for FDI in Asia. According to UNCTAD's World Investment Report 2003, FDI inflow to India has risen to US $3.45 billion in 2002 from US $3.40 billion in 2001, although there was a fall in the FDI inflows across the world during the same time period. India's share in world FDI has been steadily increasing from 0.17% in 2000 to 0.41% in 2001 and to 0.53% in 2002. Since 1990, the Indian government is progressively liberalizing the FDI policy, which has strengthened investor confidence in new sectors like integrated townships, defence industry, tea plantations, telecommunications, pharmaceutical, etc. The sectoral reforms and deregulation in key sectors to foreign competition and ownership is expected to create benefits through spillovers over to the Indian economy, thereby resulting in domestic firms becoming more productive and competitive in the export market.

In this paper, we examine if such linkages and spillovers from multinationals on domestic firms exist in the Indian pharmaceutical industry. The Indian pharmaceutical industry tends to stand out of all other industries in the current economic liberalization. Firstly, there is a large pharmaceutical industry in India that is largely based on reverse engineering on existing drugs (Kremer, 2002), which directly allow us to address the spillover and linkages issues. In addition, one of the key characteristics of pharmaceutical industry is that the industry has very high fixed R&D costs and low marginal costs of production. In such cases the institutional arrangements such as protection for intellectual property rights will affect the decisions of foreign firms to operate and undertake R&D activities in the host economies. This suggests that strong institutions, in addition to domestic
absorptive capacity, will be crucial for linkages to develop between the local and foreign firms.

With the growing importance of FDI, most host countries are not only seeking more of such investments, but are also interested in the advance technology and distributional networks of the foreign firms, which are the key propriety assets of the foreign firms. Although it is expected that the foreign 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. For instance, foreign affiliates could create externalities or spillovers onto the domestic economy through one of these channels: (a) ownership structures, (b) by enhancing domestic competition and efficiency, (c) technology transfer through imitation or reverse engineering, (d) by training of local entrepreneurs and workers, and (e) creating production and distributional linkages in the domestic economy (Dimelis and Louri, 2002; Gorg and Greenaway, 2002).

Given the benefits of the activities of foreign firms, it must be highlighted that the spillovers on to the domestic firms are not direct or certain as the host country characteristics in terms of relative backwardness of the industrial structure and the institutional characteristics of the domestic economy significantly determines the relative size and extend of the spillovers (Glass and Saggi, 1998; Grima et al, 2001). Perhaps the most important way to tap these complimentary benefits of foreign firm activities and local industrial capabilities is through production linkages between foreign affiliates and domestic firms. Backward linkages occur when foreign affiliates acquire goods or services from domestic firms, and forward linkages when foreign affiliates sell goods and services to domestic firms. Horizontal linkages involve interactions with domestic firms engaged in competing activities.
By generating markets for indigenous firms in upstream and downstream industries, linkages may enable domestic firms to develop more successfully in the same or in related industrial sectors as foreign firms. Furthermore, linkages between multinationals and indigenous firms may lead to industry agglomerations, and to the introduction of new technologies in the host country through spillovers from the MNC.

A foreign affiliate like any other firm has three options for obtaining inputs in a host country: imports, local in-house production, or procure them from a local (foreign or domestically owned) supplier. The extent to which foreign affiliate forges linkages with domestic suppliers is determined by balance of costs and benefits, as well as differences in firm-level perceptions and strategies. While the costs and benefits reflect a large number of industry-specific factors, the most important one concerns the local availability of qualified suppliers. Foreign affiliates producing primarily for the domestic market generally procure a large share of inputs locally than export oriented ones or those that are part of integrated international production systems. In the latter case, cost and quality considerations are particularly stringent, and affiliate tend to be guided by corporate global sourcing strategies. The lack of efficient domestic suppliers is often the key obstacle to the creation of local linkages. In many demanding activities, MNCs therefore, actively encourage foreign suppliers to establish local facilities or prefer to produce in-house.

There is a vast empirical literature that investigates if there is any spillovers from foreign affiliates over to the host economy or operate in so called “enclave sectors” with no links to the domestic economy (see 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 regressed on a range of
independent variables. The proxies for “intra-sectoral” spillovers such as the share of foreign affiliates’ employment or sales to total industrial activities as an independent variable to capture activities of foreign activities.

There is no general conclusion as to the effect or the extent of the spillovers from the activities of the foreign firms over 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 through backward and horizontal linkages stemming from the presence of the foreign firms in the Indian pharmaceutical industry. A panel data consisting of nearly 200 firms from 1989 to 2000 is used in the current study. The long time series in our panel allows us to study the spillover effects over a longer time period and thus accounts for dynamic spillover effects over time. Recent studies highlights that industry level and cross-sectional studies may lead to biased results 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 for control for unobservable firms effects and hence it is able to identify the spillover effects from multinational activities. The semi-parametric estimation methodology as suggested by Olley and Pakes (1996) and Levinsohn and Petrin (2003) that accounts for endogeneity of input demand is 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 production function\textsuperscript{3}.

Our results suggest the existence of positive and significant horizontal spillover in the Indian pharmaceutical industry. However, we found negative and significant spillovers from the backward linkages with foreign firms. This suggests that full foreign ownership results in negative externalities to domestic firms in upstream 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. Section 2 discusses the overview of the FDI policies in Indian pharmaceutical industry. The sources of the data and estimation methodologies are given in section 3. In Section 4, we report the results. Section 6 concludes the paper.

2. FDI Policies in Indian pharmaceutical industry: An Overview

The pharmaceutical industry is one of the key industries that are affected by the current liberalization of the Indian economy. Since 1970s, the government enacted the Foreign Exchange Regulation Act (FERA) to reduce the foreign ownership in domestic industries that requires domestic firms to reduce their foreign equity ownership to less than 40% to qualify for the status of domestic firms. This led to a drastic reduction in the share of foreign collaboration and multinational activities in the pharmaceutical industry. According to Keayla (1998), the share of domestic firms in the production of bulk drugs went up from

\textsuperscript{3} 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.
38% in 1975 to 82% in 1988 and the share in the production of formulations went up from 50% in 1975 to 60% in 1988.

In 1994, under the economic liberalization, the Indian government allowed 51% equity to be held by foreign companies. During the same year, under Open General Licence, the government announced the removal of the restrictions on the imports of almost all foreign drugs into the domestic economy (GOI Annual Report 1997-98). These initiatives led many of the foreign firms, which had initially reduced their equity stake to less than 40% under the Foreign Exchange Regulation Act (FERA), to increase their equity stake to 51% (GOI Annual Report 1993-94).

However, the full impact of the economic liberalization through the flow of FDI is not felt directly by the Indian pharmaceutical industry. The Indian government by choosing the ten-year transition to introduce product patent protections under the Trade Related Intellectual Property Rights (TRIPs), it is expected that the real effects of economic liberalization will only be felt after the Indian government introduces the product patents in 2005. 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 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.
Other liberalization policies such as removal of restrictions on the royalty or technical fee payments, removal of restrictions on inclusion of restrictive clauses in the agreement, no scrutiny for repetitive imports etc., which were announced in the 1990s had little impact on the number of collaborative agreements between local and foreign firms in the pharmaceutical industry. According to Narsalay (2000) the total number of technical collaboration approvals in the drug industry during 1991-2000 was 187, which formed only 3.1 percent of total technical collaboration agreements approved in India during the same time period.

3. Data and Methodology

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 covering period 1989-2000. The sample consists of 192 firms, which 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. The firms having ownership share more than 25 percent is identified as foreign affiliated or owned firms. Due to data limitations, we do not consider entry and exit of the firms in the present study. 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 have been calculated from the matrix of input-output transactions 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 proxied by the value of tangible fixed assets and it is deflated using the capital stock deflator. The series on labour is constructed using data from ASI. Based on the data on total wages and salaries of the firms, the series on number of employees is constructed using the wage rate in corresponding industries estimated from ASI.

The key variables in our study are the Horizontal (HRZ) and Backward (BACK) linkages from the presence of foreign firms. The Horizontal linkage (HORIZ) variable captures the extent of foreign presence in the industry and the benefits local firms derive from the presence of foreign firms. The HORIZ is defined as foreign equity participation averaged over all firms in the sector, weighted by each firm’s share in sectoral output.\(^4\) We can write it as follows.

\[
\text{Horz}_{jt} = \frac{\sum_{i=1}^{n} \forall i \in j \frac{FS_{it} * Y_{jt}}{\sum_{i=1}^{n} \forall i \in j Y_{jt}}}
\]

where \(FS_{it}\) is defined as the share of foreign equity in firm \(i\), operating in industry \(j\) at time \(t\) and \(Y_{jt}\) represents share of output in firm \(i\), operating in industry \(j\) at time \(t\). The HORIZ variable increases with the rising output of the foreign firms and the share of foreign capital in the domestic firms. This measure could also represent the degree of quality control and screening that is imposed on the domestic firms by MNCs through their equity ownership. The Backward Linkage (Back) variable intends to capture the extent of potential contacts between domestic suppliers and multinationals. We have defined this variable as share of local raw material expenses by local firms to total foreign industry raw material expenses weighted by the sales ratio of the respective firm. We can write it as follows.

\(^4\) The above definition is similar to Smarzynska (2000), which uses output as weights. Aitken and Harrison (1999) used employment as weights.
\[
Back_{jt} = \frac{\sum_{f} \forall f \in jFRAWM_{jit} \times sales_{jit}}{\sum_{i} \forall i \in jsales_{jit}}.
\]

where \( f \) denotes all foreign firms in the industry \( j \) and \( i \) denotes all firms in the industry \( j \). \( LRAWM \) denotes expenses incurred on local raw material by the local firms in the industry \( j \) and \( FRAWM \) denotes expenses incurred on the total raw materials by all the foreign firms in the industry \( j \). The backward linkage variable increases with the local procurement of local raw materials by the foreign firms and also with share of local sales activity by the firms. It must be noted that the backward linkage variable defined captures not only the local procurement by foreign firms but also the competitive nature of local and foreign firms. If the local firms are strong competitors for the domestic market and if there are significant vertical spillovers from the local procurement of raw materials, foreign firms have more incentive to reduce the linkage with local firms and source for intermediate inputs abroad, thereby reducing their reliance on local intermediate products market. The backward linkage variable also reflects the domestic capacity of local firms, where inefficient local suppliers could possibly lower the local procurement of raw materials by the foreign firms.

### 3.1 Comparisons between Foreign and Local firms

The comparison of the key activities of domestic and foreign firms in the pharmaceutical industry is given in Table 1.

**R&D intensity**: The average level of R&D spending in the Indian pharmaceutical industry is found to be very low, which is hardly one percent of the total sales of the industry. In fact, most of the R&D activities are driven by foreign firms and the average R&D intensity of the foreign firms is higher than their local counterparts. In 1990-2000, the average R&D intensity of foreign firms is nearly 0.35 as compared to 0.30 for the domestic firms and most
of the increases in R&D intensity for the local firms are actually observed after the
government announcement of the increase in foreign equity share to 51 percent in 1994. Due
to the greater liberalization, it is likely that in recent years the domestic firms might be facing
greater competition from the presence of foreign firms and hence started to build-up their
own R&D capabilities.

Table 1: The Trend of the Key Variables for the Foreign and Domestic Firms

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

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.

*Export intensity:* 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, evidence in India as given in Table 1 suggests the opposite trend. The average export intensity of the domestic firms is consistently higher than that of the foreign firms, which suggests that foreign firms are mainly focused on serving the domestic market as opposed to many local firms. However, since 1994, in the post reform period, the average export intensity of both domestic and foreign firms is observed to be rising two to three folds compared to pre-1994 period. This suggests that the Indian pharmaceutical industry is becoming more export-oriented in the global market.
Wages: It is a well-known fact that on the average foreign firms pay higher wages than local firms (Aitken et. al. 1996). This could be attributed to the ownership of technology specific assets by the multinationals which is of more advance levels than that of the local firms. The small wage differentials between local and foreign firms tend to suggest that the local firms use similar type of labour as that of foreign firms, thereby indicating that the domestic Indian pharmaceutical firms are employing similar type of labour as that of foreign firms.

Technology imports: 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. We could observe from Table 1 that the average technology import intensity of domestic firms is much higher than that of the foreign firms in the Indian pharmaceutical industry. This suggests that the local firms are more inclined to upgrade their technology through technology imports than foreign firms in the industry. This may be due to increased competition the domestic firms have to face due to policy changes that took place in 1986 and 1994 to remove import restrictions, which include the reduction of price controls, liberalizing import regime, and scraping of various production control measures. Due to these changes, it seems that domestic firms are making efforts to keep pace with the R&D activities and also to compete with foreign firms in an increasingly liberalized policy era. This is expected to be a positive trend in the Indian pharmaceutical industry.
4. Empirical Model

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:

\[
\ln Y_{it} = \alpha + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \beta_3 \ln M_{it} + \beta_4 \text{Back}_{ji} + \beta_5 \text{Horz}_{ji} + \alpha_i + \alpha_t + \epsilon_{it} \tag{1},
\]

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. \( \alpha_i \) and \( \alpha_t \) capture time and firm specific effects respectively.

The above model could be 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, which may affect firm productivity. 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 used time differencing as well as full set of fixed effects for firms and time to address the above issue. These specific effects control for the unobservables that may be driving some of the changes in productivity. Thus our specification becomes as follows.

\[
\Delta \ln Y_{it} = \alpha + \delta_1 \Delta \ln K_{it} + \delta_2 \Delta \ln L_{it} + \delta_3 \Delta \ln M_{it} + \delta_4 \Delta \text{Back}_{ji} + \delta_5 \Delta \text{Horz}_{ji} + \alpha_i + \epsilon_{it} \tag{1a}
\]

The estimation of the production function in differences still poses another problem. The OLS estimation of equation (1a) may not be appropriate, since it treats labor and other inputs as strictly exogenous variables. Griliches and Mairesse (1998) suggest the key essence
of the simultaneity problem is when the firm specific effects are observable by the firm and hence affects the choice of the levels of the inputs, but not observed and accounted for by the econometrician. In this case, the unobserved firm specific effects might be correlated with the inputs of the production function and thereby not accounting for this endogeneity of input choices may bias the estimated coefficients. To account for the above simultaneity problem, we employ the semi-parametric estimation procedures suggested by Olley and Pakes (1996) (henceforth Olley-Pakes), which was further extended by Levinsohn and Petrin (2003).

4.1 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.

\[
va_{it} = y_{it} - m_{it} = \alpha + \beta_l * l_{it} + \beta_k * k_{it} + \omega_{it} + \eta_{it}
\]  

(2)

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 \(\epsilon_{it}\) 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 \( \omega_u \). Since there exists a correlation between the error term \( \varepsilon_u \) i.e., \( (\omega_u + \eta_u) \) 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, \( k_u \) and \( \omega_u \) or we can express it as

\[
i_t = i_t(\omega_t, k_t)
\]  

(3)

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 (3), we can express unobserved productivity \( \omega_u \) as a function of observable investment and capital and thus we can control for \( \omega_u \) in estimation. We can express the equation as follows.

\[
\omega_u = \phi(i_t, k_t)
\]  

(4)

Given this monotonicity condition, we can rewrite equation (2) as:

\[
v a_u = y_u - m_u = \alpha + \beta_t * l_u + \beta_k * k_u + \phi(i_t, k_t) + \eta_u \]  

(5)

5 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 $\phi(.)$) 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 ($\beta_i$) as well as the estimate of the third order polynomial in $i_t$ and $k_t$, which has been denoted as $\chi_{it}$. We write the equation as

$$
\chi_{it} = \alpha + \beta_i^* k_t + \phi(i_t, k_t)
$$

(6)

Thus,

$$
\phi(i_t, k_t) = \chi_{it} - \beta_k^* k_t
$$

(7)

We proceed with the second stage, where we estimate the effect of capital and materials on output. Let’s consider the expectation of $va_{t+1} - \beta_l^* l_{t+1}$ conditional on the information time $t$ assuming that $\omega_{it}$ follows a first order Markov process. Thus one can rewrite $\omega_{it+1}$ as a function of $\omega_{it}$, letting $\xi_{it+1}$ be the innovation in $\omega_{it+1}$. And $\omega_{it}$ can be replaced with function of $\phi(i_t, k_t)$. Therefore, the equation to be estimated in the second stage becomes:

$$
va_{it+1} - \beta_l^* l_{it+1} = c + \beta_k^* k_{it+1} + g(\phi_i) + \xi_{it+1} + \eta_{it+1}
$$

(8)

Since the functional form of $g(.)$ is not known, we again use the third order polynomial expansion (with all interactions) in equation (8). 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 (8).
A production function, taking into account the Olley-Pakes correction, is estimated. Based on the estimation, we recover the measure of total factor productivity, which is the difference between the actual and predicted output, which is then used in the estimation of our basic model. So the final estimated model is as follows.

\[ \ln TFP_{it} = \alpha + \beta_1 \text{Horz}_{jt} + \beta_2 \text{Back}_{jt} + \alpha_i + \alpha_t + \epsilon_{it} \]  

(1b)

We may note here that the Olley-Pakes procedure rests on the assumption of factors fully adjusting to shocks in each period and markets being perfectly competitive. Levinsohn and Petrin (2003) (henceforth 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. In addition, they also show a stronger linkage to economic theory and estimation with material inputs as valid proxy as compared to investment. The results of Levinsohn-Petrin estimation are also provided together with OLS, fixed-effects and Olley-Pakes estimation.

5. 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. 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 (1b).
Table 2: OLS, Fixed Effects, Olley-Pakes and Levinsohn-Petrin Estimation for Indian Pharmaceutical Industry: 1989-2000 (All Firms)

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>Fixed Effects</th>
<th>Olley-Pakes</th>
<th>Levinsohn-Petrin</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Level</td>
<td>First Difference</td>
<td>OLS</td>
<td>First Difference</td>
</tr>
<tr>
<td>K</td>
<td>0.083**</td>
<td>0.008*</td>
<td>0.021*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4.04)</td>
<td>(1.98)</td>
<td>(1.99)</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>0.839***</td>
<td>0.806***</td>
<td>0.846***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(37.9)</td>
<td>(14.5)</td>
<td>(17.7)</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>0.116**</td>
<td>0.174**</td>
<td>0.149**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(5.44)</td>
<td>(4.29)</td>
<td>(3.71)</td>
<td></td>
</tr>
<tr>
<td>Backward</td>
<td>-1.132**</td>
<td>-1.335**</td>
<td>-1.491**</td>
<td>-0.463*</td>
</tr>
<tr>
<td></td>
<td>(-4.61)</td>
<td>(-2.79)</td>
<td>(-2.81)</td>
<td>(-5.10)</td>
</tr>
<tr>
<td>Horizontal</td>
<td>3.991**</td>
<td>6.138**</td>
<td>3.788**</td>
<td>1.841*</td>
</tr>
<tr>
<td></td>
<td>(3.83)</td>
<td>(3.38)</td>
<td>(4.33)</td>
<td>(7.88)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.565**</td>
<td>-0.0003</td>
<td>0.844**</td>
<td>1.469*</td>
</tr>
<tr>
<td></td>
<td>(3.56)</td>
<td>(-0.125)</td>
<td>(3.10)</td>
<td>(8.63)</td>
</tr>
<tr>
<td>Year Dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Adj. R squared</td>
<td>0.97</td>
<td>0.84</td>
<td>0.98</td>
<td>0.34</td>
</tr>
<tr>
<td>No. of observations</td>
<td>1504</td>
<td>1316</td>
<td>1504</td>
<td>1218</td>
</tr>
</tbody>
</table>

Note: ***, **, * denote significance at the 1, 5, and 10 percent level. t-values are reported in the parenthesis.
Table 3: OLS, Fixed Effects, Olley-Pakes and Levinsohn-Petrin Estimation for Indian Pharmaceutical Industry: 1989-2000 (Domestic Firms)

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>Fixed Effects</th>
<th>Olley-Pakes</th>
<th>Levinsohn-Petrin</th>
</tr>
</thead>
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<tr>
<td></td>
<td>Level</td>
<td>First Difference</td>
<td>OLS</td>
<td>First Difference</td>
</tr>
<tr>
<td><strong>K</strong></td>
<td>0.094**</td>
<td>0.019**</td>
<td>0.018**</td>
<td>(4.24)</td>
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<tr>
<td></td>
<td>(90.6)</td>
<td>(2.32)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>M</strong></td>
<td>0.838***</td>
<td>0.815***</td>
<td>0.847***</td>
<td>(37.6)</td>
</tr>
<tr>
<td></td>
<td>(90.6)</td>
<td>(14.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>L</strong></td>
<td>0.104**</td>
<td>0.173**</td>
<td>0.149**</td>
<td>(4.65)</td>
</tr>
<tr>
<td></td>
<td>(90.6)</td>
<td>(4.22)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Backward</td>
<td>-1.505**</td>
<td>-1.459*</td>
<td>-1.412*</td>
<td>(-3.61)</td>
</tr>
<tr>
<td></td>
<td>(90.6)</td>
<td>(-1.72)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal</td>
<td>3.418**</td>
<td>4.719**</td>
<td>3.347**</td>
<td>(3.28)</td>
</tr>
<tr>
<td></td>
<td>(90.6)</td>
<td>(2.51)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.512**</td>
<td>-0.007</td>
<td>0.898*</td>
<td>(3.18)</td>
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<tr>
<td></td>
<td>(90.6)</td>
<td>(-0.98)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year Dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Adj. R squared</td>
<td>0.97</td>
<td>0.84</td>
<td>0.98</td>
<td>0.31</td>
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<tr>
<td>No. of observations</td>
<td>1331</td>
<td>1159</td>
<td>1331</td>
<td>1068</td>
</tr>
</tbody>
</table>

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

In both Tables, column 1 and 2 point to the positive and significant horizontal spillovers from the activities of foreign affiliates. The result is robust to the estimation of Olley-Pakes and also Levinsohn-Petrin methodologies. The implication of this result is that domestic firms benefit from the presence of foreign companies in the same sector. It points to the fact that foreign firms transfer new technologies and invest more resources in knowledge transfer to their own affiliates and thus such affiliates represent a greater potential for spillovers. It appears from the result that local firms are able to imitate the technology of
foreign firms operating in the local market and thus benefiting the latter through horizontal linkage. Another possible reason for the positive horizontal spillovers might due to the greater mobility of workers across the domestic and foreign firms. As observed in Table 1 that the wages to sales ratio is not significantly different between foreign and local firms, which indicates that there is greater labour mobility between the two types of firms. The positive horizontal linkage could also be driven by the quality control and screening of viable domestic firms by MNCs through equity ownership.

Next we consider the effect of backward linkage as a measure of vertical spillovers, the effect of foreign presence in down stream firms. We observe negative and statistically significant coefficient associated with backward linkage (BACK) variable, which tends to find support in most panel firm level analysis. It appears that foreign ownership results in negative externalities to downstream local firms. The estimation by Olley-Pakes and Levinsohn-Petrin also supports the result that the backward linkage is negative and statistically significant. The implication of the negative sign can be explained as follows. First, the technology and efficiency gap between local and foreign firms might be too wide for any backward spillovers to local firms. The foreign investors entering a host country through Greenfield projects or full acquisition are less likely to source inputs locally than those invested through joint ventures or partial acquisitions, which may be captured by the horizontal linkage. This may be due to the fact that the foreign firms face higher costs of finding local suppliers and they tend to reduce the number of existing suppliers as they integrate the subsidiary in the supplier network of the parent company. Kokko et. al. (1996) suggests that domestic firms could only benefit from multinational presence if the technology and efficiency gap is not too wide, which allows the local firms to absorb the knowledge
available from the multinationals. Second, the negative backward linkages might also suggest that 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 in the Indian pharmaceutical industry and with little patent protections on products, the enclave activities of the foreign firms might be preemptive strategies to reduce the flow of technologies to downstream local firms and to protect their proprietary firm-specific technology.

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

<table>
<thead>
<tr>
<th>Year</th>
<th>Foreign</th>
<th>Domestic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990-1993</td>
<td>4.9</td>
<td>3.5</td>
</tr>
<tr>
<td>1994-1996</td>
<td>1.3</td>
<td>-1.1</td>
</tr>
<tr>
<td>1997-2000</td>
<td>1.4</td>
<td>-0.5</td>
</tr>
</tbody>
</table>

Note: TFPG is derived from Olley-Pakes estimation.

The total factor productivity 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. Over this period (1996-2000), foreign firms reported positive TFPG of around 1.3 percent and the domestic firms witnessed a negative TFPG of around 1.1 percent. The declining productivity growth for the local firm from 1996 suggests that local firms are more backward with regard to their technologies as compared to the foreign firms, which supports the evidence of negative backward linkages. As they face greater economic liberalization from foreign ownership and competition, productivity gap tends to widen between the local and foreign firms. Increasingly the
productivity growth of the local firms, as well as by reducing the technology gap between local and foreign firms, will be the crucial factors for the pharmaceutical industry to benefit from the presence of foreign firms in terms of spillovers.

6. Conclusions and Policy implications

The main objective of this paper is to investigate the linkages between multinationals and local firms in Indian pharmaceutical industry. The results suggest negative and significant backward linkages between local and foreign firms. However, we do find positive and significant horizontal spillover. The impact of foreign participation depends on how closely they integrate in the local production chain through sourcing for raw materials locally. The negative backward linkages between local and foreign firms suggest that there might be a large technology and efficiency gap between local and foreign firms. Thus the sustain growth in the pharmaceutical industry depends on narrowing the technology and efficiency gap between local and foreign firms.

The results suggest several policy implications to enhance local productivity growth with foreign participation in the Indian pharmaceutical industry. The results suggest that foreign equity participation has improved productivity of the domestic pharmaceutical industry. Thus, further liberalization of the FDI policy will have positive impact on the industry. There should be policy to strengthen the local linkage of FDI through specific tools and incentives to address the problem of high cost, poor quality and unreliability associated with local suppliers. This is essentially to encourage local supplier of raw materials to respond efficiently to the demand of foreign firms, which in turn depend upon supplier network, support institutions, development of local skills and technological capabilities. Further, there could be incentives provided for domestic firms to develop their in-house R&D
capabilities so as to build indigenous technological capabilities. This will have positive impact on the local firms apart from encouraging them to acquire new technology and purchase new equipment through dissemination of information, expediting processing of licensing agreements, and liberalizing imports for the industry. It could be possible to increase the skill content in the workforce of domestic firms through investment in training, which is also an important way to improve their productivity and spillovers between local and foreign firms.

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 pharmaceutical industry is the absence of pharmaceutical product patents in India. 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 because of the 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 confidence and 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. Impact of changes in intellectual property protection in 2006 will have great impact on the activities of the MNCs and Indian firms. Their responses will determine the future of pharmaceutical industry.
References


