The Impact of Foreign Ownership on Research and Development Intensity and Technology Acquisition in Indian Industries: Pre and Post Global Financial Crisis

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This study examines how interfirm heterogeneities in modes of technology acquisition and technology intensities are linked to firm ownership in India using a panel data set of about 2,000 firms listed on the Bombay Stock Exchange for the period 2003–2014 drawn from the Prowess database of the Center for Monitoring Indian Economy. Foreign ownership is categorized according to the level of control exercised by foreign firms as defined under the Companies Act of India. A comparative analysis of domestic and different categories of foreign firms was conducted for two time periods: (i) the global boom period of 2004–2008, and (ii) the post global financial crisis period of 2008–2014. A horizontal cluster analysis of 3-digit, industry-level data shows that foreign firms cluster in high-technology industries. The propensity score matching analysis, however, reveals that in a matched sample of foreign and domestic firms, majority-owned foreign firms spend less on research and development and more on technology transfers than their local counterparts, demonstrating that the level of equity holdings by a foreign firm matters. There is little evidence of the global financial crisis affecting the relocation of research and development activities to India. An alternative assessment based on panel data regression analysis confirms these findings and validates the propensity score matching results.

Keywords: domestic firms, foreign firms, global financial crisis, local R&D, majority-owned foreign subsidiaries, minority-owned subsidiaries, technology acquisition
JEL codes: G21, G32, K22, L25

I. Introduction

Rapid advances in technology, which have been reinforced by the process of globalization, have exposed firms in developing economies to intense technological competition both in domestic and export markets. Efforts toward building

technological capabilities are increasingly becoming vital for them to compete. However, building these capabilities is costly, cumulative, and evolutionary; it takes time and progress is uncertain (Lall 1992). Realizing this, the governments of developing economies have encouraged multinational enterprises (MNEs) to set up local production facilities in the hope of importing new technologies and building the technological capabilities of domestic firms. It is expected that the presence of MNEs will entail technology transfers to domestic firms through spillover mechanisms such as labor turnover, imitation, competition, and demonstration. However, there is evidence that technology spillover effects are neither robust nor consistent across economies (see, for example, Mebratie and van Bergeijk 2013, Demena and van Bergeijk 2017). There is growing recognition that foreign direct investment (FDI) can ensure more profound knowledge spillovers to domestic firms if MNEs perform a larger share of their research and development (R&D) activities in host economies (UNCTAD 2005). Therefore, attracting R&D-intensive FDI is a critical concern for national policy makers in developing economies.

The present study analyzes the technological behavior of MNEs in India and investigates whether MNE subsidiaries are significantly different from their domestic counterparts in terms of technology intensity and modes of technology sourcing. Specifically, it examines whether MNEs spend more on R&D than their domestic counterparts or whether they are more likely to acquire new technologies from their global networks through licensing and imported capital goods.

It is assumed that R&D-intensive MNE subsidiaries (with significantly more R&D spending than domestic firms) are likely to have more robust effects on the technological capabilities of host economies than those subsidiaries that depend on technology imports from their parent firms (i.e., spending more on technology imports than their domestic counterparts). The former are better embedded into the local innovation systems and have greater potential for technological spillovers. The possibility that MNEs are not significantly different from domestic firms in either R&D spending or technology imports cannot be ruled out. Such MNEs would be considered technological laggards. The opposite is true if MNEs spend significantly more on both R&D and technology imports than their local counterparts. These MNEs may have the greatest potential for knowledge transfers to host economies.

In general, the distribution of corporate R&D spending is highly skewed across industries. A few high-technology sectors account for the overwhelming share of R&D activity (Hirschey, Skiba, and Wintoki 2012). Given that MNEs undertake the bulk of global R&D expenditures and tend to have a strong presence in high-technology industries, differential technological behavior of foreign affiliates may reflect the fact that MNEs are attracted to such industries (Globerman, Ries, and Vertinsky 1994; Girma, Greenaway, and Wakelin 2001; Bellak 2004). However, the possibility that they predominate in resource- or labor-intensive industries cannot be ruled out either. Selection bias can thus be a major problem in such studies (Damijan et al. 2003, Javorcik and Spatareanu 2008, Hake 2009).

Therefore, this analysis begins by identifying the sectoral distribution of MNEs in India by technological intensity using cluster analysis. This is followed by the use of propensity score matching methods to match each foreign firm with a domestic counterpart within broad industry groups to estimate the impact of foreign ownership on different forms of technological spending. To check the validity of my results, I also conduct panel data regression analysis on matched samples. The data are partitioned into two periods: (i) the global boom period of fiscal year (FY)2003–2004 to FY2007–2008, and (ii) the global financial crisis and postcrisis period of FY2008–2009 to FY2013–2014.[1] I conduct a separate analysis for each period to investigate the impact of global conditions on the technological behavior of foreign and domestic firms. There is evidence that the global relocation of R&D activities suffered following the global financial crisis (Kinkel and Som 2012; Dachs, Stehrer, and Zahradnik 2014). This paper explores how the crisis impacted on the technology sourcing and technology spending of MNEs and domestic firms in India in a comparative analytic framework.

The study contributes to the existing literature in the following ways. First, it offers a systematic analysis of the differential technological behavior of MNEs and domestic firms. Indeed, there are studies that indicate the impact of foreign ownership on the R&D intensity of firms (Becker 2013; Tomiura 2003; Kumar and Saqib 1996; Kumar and Aggarwal 2005; Sasidharan and Kathuria 2011; Balsari, Özkan, and Varan 2015). Yet, few have analyzed the technology strategies of foreign firms by considering alternative modes of technology sourcing. Second, most existing studies are concerned with foreign ownership; the strategic importance of the share of foreign ownership holding is largely ignored. This study identifies three levels of foreign ownership holding (10%–25%, 25%–50%, and 50% and above) and analyzes how impacts vary with the level of foreign ownership. Finally, the firm ownership data available from secondary sources, which form the basis of most studies (particularly for India), are subject to several limitations including a lack of transparency in the identification of foreign firms. Ownership data for the latest year are used for identifying foreign firms for all previous years. Given that a firm's ownership structure (particularly of publicly traded firms) is subject to continuous change, this practice is likely to yield spurious results. The present study addresses this gap through scrutiny of changes in ownership patterns for each firm over the relevant time periods.

Since the economic liberalization of the early 1990s, India has increasingly lowered barriers to entry for FDI. It is expected that FDI strengthens the competitiveness of Indian industries through technology transfers and by upgrading the technological capabilities of domestic firms through spillover effects, thereby contributing to restructuring and growth in the Indian economy. This study is

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[1] In India, a fiscal year is the period between 1 April and 31 March.

expected to have important implications for policy makers in India and other developing economies that have adopted a similar growth path.

The rest of the study is organized as follows. Section II discusses the changing role of FDI in the Indian economy and establishes the relevance of India as the reference economy. Section III describes the theoretical underpinnings of the analysis. Sections IV and V provide methodological and data-related detail, respectively. Section VI presents the empirical results and section VII concludes.
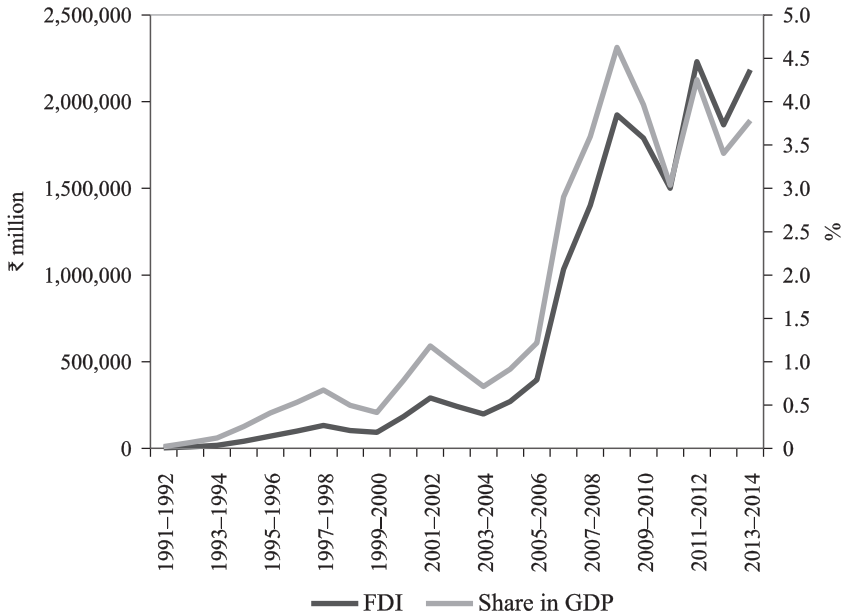
II. Foreign Direct Investment in India

There has been a tremendous increase in inward FDI in India since economic reforms were adopted in 1991, particularly since 2005. Prior to 1991, FDI was only allowed in core technology-intensive industries in which little technological progress had been made domestically. The Foreign Exchange Regulation Act imposed numerous restrictions on MNEs' ownership control, entry into markets, and growth, including the setting up of joint ventures with domestic partners, local content clauses, export obligations, and promotion of local R&D. In the post-1991 period, FDI has provided access to international networks and become a critical source of scarce capital, technology, and managerial skills. There has been a complete shift in government policy in favor of FDI since 1991, including the amendment of investment laws and guidelines to facilitate and promote inflows of FDI. In 2005, the Government of India began to accelerate its FDI reforms, lowering caps on foreign ownership across all sectors, particularly in construction, development of townships, defense, insurance and pensions, and single brand and e-commerce retail sectors. Currently, 100% foreign ownership is allowed in most sectors with a few exceptions.[2] In addition, attempts have been made to ease the norms, streamline rules and regulations, and improve the business climate.

These reforms have led to annual FDI inflows in India growing from about $129 million (₹3.2 billion) in FY1991–1992 to over $46 billion (₹2.2 trillion) in FY2011–2012 (Figure 1). FDI inflows as a percent of gross domestic product also grew steadily during this period, with the ratio of FDI to gross domestic product improving from less than 2% in FY1991–1992 to over 4.5% in FY2008–2009, before declining to 3.8% in FY2013–2014.

The stock of FDI has increased astronomically since FY1991–1992. According to the RBI (2015), total foreign liabilities were only $1.23 billion in 1992. This figure rose sharply to $265 billion as of 31 March 2015 (RBI 2015). Nearly half of the total FDI stock at market prices was in the manufacturing sector in

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[2]These exceptions include defense (49%), broadcasting content services (49%), print media (26%), insurance (49%), infrastructure in securities markets (49%), and private security agencies (49%). In addition, a small negative list includes lottery, gambling, chit funds, manufacturing of cigars and cigarettes, real estate business, and sectors not open for the private sector (e.g., atomic energy and railway operations).

Figure 1. **Inward Foreign Direct Investment Flows and Gross Domestic Product in India, FY1991–1992 to FY2013–2014**

FDI = foreign direct investment, FY = fiscal year, GDP = gross domestic product.
Source: Reserve Bank of India. *Monthly Bulletins* (various issues). Mumbai.

2015. Information and communication services (15.5%) and financial and insurance (13.6%) were the other major activities attracting FDI. Globally, India has become one of the most attractive destinations for FDI by improving its position vis-à-vis other economies. During FY2005–2006, India was the fourth-largest recipient of FDI in the world. After the global financial crisis, it temporarily fell from among the top 10 recipients of FDI before rejoining this grouping in 2014. On a regional basis, India accounts for more than 90% of all FDI in South Asia.

There has also been a proliferation of wholly and majority-owned foreign companies in India in the postreform period. The foreign share of total equity in foreign companies was about 72% at the end of 2014, while in the manufacturing sector it was about 85% (RBI 2015). This is significant because prior to FY1991–1992 the foreign equity share was restricted to 40% in most sectors.

Finally, there is anecdotal evidence that India is receiving R&D-intensive FDI. According to the National Science Foundation, firms from the United States spent $73 billion on R&D in host economies in 2013; of this total, around $6 billion (8%) was spent in India.[3] Many prominent United States firms have set up their R&D centers in India, including GE, Intel, Microsoft, and IBM, which has two labs

[3]National Science Foundation. Statistics. http://www.nsf.gov/statistics/.

in India employing over 500 scientists (Patra and Krishna 2015). In this context, the present study is important because it provides systematic evidence on whether foreign ownership is important for stimulating domestic R&D activities in India.

III. Theoretical Discussion

A.   Technological Activities: Multinational Enterprises versus Domestic Firms

The theoretical literature on the technological behavior of MNEs comprises four major strands and is largely ambiguous with regard to predictions. The traditional international business literature, comprising the industrial organization (Caves 1996, Hymer 1976) and transaction cost theories (Dunning 1993, Williamson 1975), argues that the existence of MNEs hinges on the relative monopolistic advantages that they enjoy against rival domestic firms. They derive their competitive advantages from the assets they have generated in their home economies. Proprietary technology is the key firm-specific asset and it is guarded closely through internalization. Therefore, R&D activities are mostly being carried out at firms' headquarters and the subsidiaries depend upon imported technologies. Their own R&D activities are at best limited and mainly to adapt products and services in line with local tastes and requirements. Therefore, R&D expenditures among MNE subsidiaries are likely to be smaller than those of their local counterparts, while the opposite might be true for imports of embodied and disembodied technologies.

The resource-based view turns the focus from the firm (MNE) to the subsidiary (Peng 2001; Rugman, Verbeke, and Nguyen 2011). It conceptualizes an MNE subsidiary as a semiautonomous entity with its growth driven by its own distinctive capabilities developed through entrepreneurial efforts, including the creation and development of local technological competencies complementary to the rest of the MNE.

The newly emerged literature on R&D relocation (Cantwell and Janne 1999, Kuemmerle 1999, Dunning and Lundan 2009) focuses on the internationalization of R&D by MNEs and views it as part of their strategic business decisions, which are driven by the motivations of accessing talent at lower costs, tapping into local centers of excellence, commercializing products in foreign markets with the speed required to remain competitive, and contributing to their headquarters' stock of knowledge. But the decision to internationalize R&D is contingent upon specific MNE, home country, and host country advantages (e.g., market size, scientific and engineering capabilities, lower costs, university research, and level of industrialization) that shape the decisions of MNEs (see, for example, OECD 2008a; Dachs, Stehrer, and Zahradnik 2014).

The social network theory focuses on parent–subsidiary relationships, subsidiary roles and strategies, and subsidiary resources and capabilities. Its

proponents (Ghoshal and Bartlett 1990; Gupta and Govindarajan 1991; Birkinshaw, Hood, and Jonsson 1998; Birkinshaw, Hood, and Young 2005; Cantwell and Mudambi 2005) argue that an MNE is not a compact, rationally conceived organization with a uniform goal, but a differentiated network of a variety of subsidiaries that face heterogeneous national contexts. There are three levels of networks:

(i)   intraorganizational networks that encompass headquarters and subsidiaries, and their interrelationships;

(ii) interorganizational networks that are formed between the MNE and other organizations in joint ventures, strategic alliances, and licensing agreements; and

(iii) MNE local networks with customers, suppliers, and authorities.

The extent to which an MNE subsidiary is embedded in these networks determines its technological behavior. The greater it is embedded within intraorganizational networks the greater will be its dependence on the headquarters for technological knowledge and information. On the other hand, a greater embeddedness of MNEs in local networks is associated with greater technology creation in host economies. But the network embeddedness of subsidiaries is essentially a matter of the strategic choices of the parent firm, which in turn are influenced by subsidiaries' own initiatives, resources, and capabilities, as well as the locational advantages of host economies.

The arguments related to technology spending by MNEs in host economies are ambiguous. Thus, we set up competing hypotheses for quantitative testing:

(i)   Hypothesis 1: MNE subsidiaries have an R&D intensity significantly higher than that of domestic firms.

(ii) Hypothesis 2: MNE subsidiaries exhibit a higher intensity of spending on royalty payments for technology imports from international networks than their local counterparts.

B.   Ownership and Technological Activity

The classical international business theories postulate that a strategic (controlling) ownership stake ensures greater embeddedness of subsidiaries within internal networks to minimize leakages of their proprietary technology. In contrast, the network approach argues that the subsidiaries that are subject to a controlling or majority ownership stake are more likely to compete for excellence within

the organization and commit larger resources to R&D spending because such subsidiaries are vital to the success of the parent firms and are therefore more likely to be assessed with regard to their long-term objectives. This argument also underpins the institutional approach, which posits that a firm's strategic behavior is influenced by the surrounding institutional environment (Dunning and Lundan 2008). When the regulatory environment is weak in the host economy and/or the social and cultural distance between the home and host economies is large, the company lowers its ownership stake and commits lower resources. The lower the ownership stake, the lower the level of support that subsidiaries receive from their parents for local initiatives. This also implies that their dependence on internal networks is higher. There are thus conflicting arguments regarding the impact of ownership stakes also. We therefore test two competing hypotheses:

(i)   Hypothesis 3: Majority-owned subsidiaries exhibit a greater tendency to embed in local networks and incur larger R&D expenditures than their local counterparts.

(ii) Hypothesis 4: Majority-owned subsidiaries are more likely to depend on imported technologies from their parent firms and other internal network actors.

C.   Global Crisis, Ownership, and Technological Activity

In contrast to the above, there is no clear theoretical prediction regarding the effects of global economic and financial crises on the globalization of R&D activities by MNEs. One argument is that negative market growth expectations during a crisis can drive MNEs to lower the coordination costs of dispersed R&D. The opposing argument is that amid economically challenging conditions, firms tend to minimize costs by relocating more of their activities to cheaper locations (Kinkel and Som 2012). Empirically, Dachs, Stehrer, and Zahradnik (2014) find that in most economies, the R&D spending of MNEs is more severely affected by global crisis than that of domestic firms. They observed a reversal in the trend of R&D internationalization in the period following the recent global financial crisis. Kinkel and Som (2012), on the other hand, find that small firms were hurt by the crisis even as large firms continued to relocate their R&D amid the crisis. Thus, once again I set up opposing hypotheses:

(i)   Hypothesis 5: Foreign firms exhibit higher R&D intensity than their local counterparts during periods of economic crisis.

(ii) Hypothesis 6: Foreign firms exhibit lower R&D intensity than their local counterparts during periods of economic crisis.

IV. Methodology

For empirical analysis, I used a multilevel methodology, which is discussed below.

A.   Identifying Foreign Firms

Following International Monetary Fund guidelines, a direct investment enterprise in India is defined as an incorporated or unincorporated enterprise in which a foreign direct investor owns 10% or more of the ordinary shares or voting power (for an incorporated enterprise) or the equivalent (for an unincorporated enterprise). There is, however, recognition that a numerical guideline of 10% does not capture the essence of FDI for economic analysis. This definition is adopted for the sake of consistency and cross-country comparability of FDI statistics and is based on the premise that a share as low as 10% of voting rights or equity capital allows the investor to "influence the management," providing the basis for an FDI relationship. The System of National Accounts Framework of the United Nations uses "controlling stakes" as the basis for economic analysis of FDI for which more than 50% ownership is necessary. OECD (2008b, 21–23) defines "companies with a 50% or more stake as FDI subsidiaries (controlled enterprises), while those with a 10%–50% stake are FDI associates (influenced enterprises)." Under the Companies Act of India, there are three threshold levels of shareholding from the perspective of defining "influence" and "control" (10%, 25%, and 50%). Based on this classification and the available data, I have identified three types of foreign firms:

(i)   minority holding (10%–25%) with minor influence,

(ii)   dominant minority holding (25%–50%) with dominant influence, and

(iii)   majority holding (above 50%) with controlling stake.

In addition, I have created a category for experiential foreign firms. These firms are not predominantly foreign firms; rather, they have foreign ownership for only a short time during the review period.

B.   Investigating the Sectoral Distribution of Multinational Enterprises by Technology Intensity Using Cluster Analysis

To identify the sectors targeted by MNEs, I clustered industries at the 3-digit level by technological orientation and brand value using the "wards linkage"

method of hierarchical clustering (Everitt, Landau, and Leese 2001). Based on the dendograms and appropriate stopping rules, I determined the number of clusters in the sample and then examined the presence of foreign firms by ownership stake in each group. The analysis was conducted at the 3-digit level of aggregation using the STATA statistical package and the following variables:

(i)   R&D spending-to-sales ratio $= 1$ if it is > 0 for the industry and 0 otherwise,

(ii) ratio of royalty payments abroad to sales $= 1$ if it is > 0 for the industry and 0 otherwise,

(iii) ratio of capital goods imports to sales $= 1$ if it is > 0 for the industry and 0 otherwise,

(iv) ratio of advertisement expenditures to sales $= 1$ if it is > 0 for the industry and 0 otherwise, and a

(v)   dummy variable $= 1$ if the firm is in the manufacturing sector and 0 if it is in the service sector.

C.   Assessing the Difference in Technology Intensity between Local and Foreign-Owned Firms

1.   Propensity Score Matching

Propensity score matching is a nonparametric estimation method that creates a comparison group (domestic firms) with identical distributions of observable characteristics to those in the treatment group (foreign firms) to address the issue of endogeneity. The basic idea is to find for every foreign firm a matching domestic firm in terms of all relevant observable characteristics X. The mean effect of foreign ownership (or the average treatment effect) is then calculated as the average difference in outcomes between the foreign and matched domestic firms.

For matching, I constructed four propensity score models corresponding to four categories of the foreign firms using firm- and industry-specific attributes.[4] In each case, it was ensured that the balancing property was satisfied. A kernel method was used to identify the domestic firms that match the foreign firms. The condition of common support resulted in discarding some firms. The level of rejection of unmatched domestic firms varied between 14% and 23%. Considering that there are a large number of domestic firms, this does not amount to a significant loss of

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[4]Further details are available upon request.

data and is therefore unlikely to compromise the representativeness of the results. To assess the quality of matching, appropriate tests were conducted. However, while matching removes any bias caused by selection on observable variables, it leaves the possibility of bias due to selection on unobservable variables. Thus, perfect matching is not possible, which affects the quality of estimates. The propensity score matching analysis is therefore complemented by a generalized least squares (GLS) regression analysis based on the panel database to check the consistency and robustness of the results.

2.   Generalized Least Squares Regression on the Matched Sample

The variables representing technological activity are regressed on foreign ownership variables after controlling for firm- and industry-specific characteristics using the matched sample. The firms that are off the common support are dropped to include only those in the common support region. The following model is used for the analysis:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \upsilon_{it}$$

where Y_{it} is the dependent variable representing two alternative modes of technology sourcing: (i) R&D, and (ii) international transfer of disembodied technologies. These estimations are performed only for local R&D (RD_INT) and disembodied technology imports (ROY_INT). The control variables are drawn on the existing literature (see, for example, Becker 2013, Cohen 1995) and are described in Table 5.

The two modes of technology activity, R&D and acquisition, are not independent of each other. Technology imports by firms are likely to influence their R&D efforts, while the intensity of technology imports may itself depend on R&D efforts. Thus, there is possible simultaneity between the two. Further, with respect to most explanatory variables in the model, there could be a problem of endogeneity. To address these issues, I assume that both technology choice and intensity are strategic decisions with a long-term orientation. Firms do not spontaneously determine them based on current performance. Rather, they take account of past, current, and planned behavior and performances in making such decisions. Therefore, I converted the behavioral explanatory variables into a moving average of 3 years comprising the lagged year, current year, and lead year. However, tax rate (TAX) and profit margin (PCM) are lagged by 1 year only. The inclusion of lagged and lead variables addresses the issues of causality and simultaneity, and allows us to estimate the two models separately to explore the impact of foreign ownership on technology intensities.

A panel data approach is employed to control for unobserved firm- and time-specific characteristics. A fixed-effect specification of the model is normally considered ideal but has been ruled out here because it does not return estimates

of the time-invariant variables, which are the main variables. Thus, I have used the random-effect specification. In general, fixed-effect estimates are preferred over random effects because the latter produce biased estimates if the regressors and the residuals (firm effects) are correlated. Recent studies have found this justification insufficient to prefer fixed over random effects based on the argument that if the units are relatively similar on average, then the appropriate model should be guided by the researcher's goals (Clarke et al. 2010, Clark and Linzer 2015). Since I am using matched samples, the firms are rather similar. Therefore, the use of random-effect GLS estimates is not expected to be inferior. For ensuring the robustness of the GLS estimates, I have also controlled for the time effects by incorporating year dummies to capture fixed effects of intertemporal shifts and corrected the estimates for heteroscedasticity. For yet another validity check, I have obtained Mundlak estimates (see, for example, Bell and Jones 2015). These estimates relax the assumption in the random-effects estimator that the observed variables are uncorrelated with the unobserved variables. But these estimates cannot control for time-specific variations and heteroscedasticity. For a comparative analysis of the main variables, I have presented Mundlak's estimates only for the key variables in the text.

V. Data

Empirical analysis is based on firm-level data from Prowess, a database of the financial performance of over 27,000 listed and unlisted Indian firms from a wide section of the manufacturing, utilities, mining, and service sectors. The data are collected by the Centre for Monitoring Indian Economy from the balance sheets of firms and are updated continuously. Along with financials, the database also provides detailed information on the shareholding patterns of these companies. Most studies use the ownership data of the latest year, assuming that the shareholding patterns of firms remain the same over the years prior to the latest year. However, this assumption is not reasonable for two reasons. First, the shares of most of these companies are actively traded in the market and the acquisition of shares of the existing firms through the market has become an important mode of entry for foreign firms in India. Second, the data on shareholding patterns for a given period is available only for those firms that are actively traded in the market during that period. Clearly, the studies that use the ownership data from the latest year are subject to selectivity bias. For different periods, the results may vary depending upon the availability of ownership data and firms' ownership stakes in the latest year. There is evidence that the distributional properties of samples drawn from Prowess are not consistent for different periods (Choudhury 2002). To address this limitation, we procured the ownership data of 5,109 listed firms as of 31 March of each year from FY2000–2001 to FY2013–2014. The data were matched with the Stock Exchange Board of India and Bloomberg ownership

databases available online for validation purposes. For each firm, the data for the available years were cross-checked and gaps were filled wherever possible. Since the data pertain only to actively traded firms, it was cleaned for the purpose of making consistent comparisons. First, only those firms for which the information was available for each of the 11 years were included, leaving 2,004 firms. Second, those firms reporting zero or negative net sales were dropped. After the cleaning process, the final data set consisted of a balanced panel of 1,781 firms spanning 11 years (FY2003–2004 to FY2013–2014).

VI. Empirical Results

A. Cluster Analysis of the Sectoral Distribution of Multinational Enterprises by Technology Intensity

Based on the standard rules mentioned above, I identified five clusters of industries. Each of the clusters is well populated, confirming that each cluster is substantive. Table 1 gives the mean values of the variables in the five principal clusters. The main dividing line runs between the manufacturing and service industries on one hand, and between industries that score high and low on the technology and product differentiation variables on the other hand.

Table 2 reports the clustering results by ownership mode, which is of primary interest here. Between FY2003–2004 and FY2007–2008, the distribution of foreign companies was highly skewed in favor of high-technology manufacturing industries. As stated above, the technological or brand superiority of MNEs is the primary reason they venture into investing abroad in the first place. In India, this pattern can also be attributed to the legal framework prior to 1991, which sought to channel FDI into high-technology production by setting higher FDI caps in these sectors. By the period from FY2008–2009 to FY2013–2014, services had become more promising and the sectoral distribution of FDI became somewhat diffused (as shown by the reduced levels of standard deviations). There was a substantial restructuring in the distribution of experiential firms from services to manufacturing during this decade, reflecting a shift of FDI from manufacturing to services. But within each broad sector, changes have been marginal rather than substantive. Within manufacturing, there is a visible shift of foreign firms in favor of medium-technology consumer goods. However, over 62% of majority-owned companies still belonged to the high-technology manufacturing cluster and almost one-fourth of these were concentrated in the high-technology services cluster. Only about 15% could be classified as low technology, either in manufacturing or services.

A critical question is whether foreign firms are also more active in R&D than their local counterparts or if they continue to embed in internal knowledge networks. In the propensity score matching and regression analyses, I shall address

Table 1. Mean Values by Clusters

Variable	Manufacturing			Services	
	High Technology and High Product Differentiation	Medium Technology and High Product Differentiation	Low Technology and Low Product Differentiation	High Technology and High Product Differentiation	Medium Technology and High Product Differentiation
Number of industries	83	67	53	25	52
R&D expenditure-to-sales ratio (%)	0.65	0.30	0.00	0.39	0.00
Royalty payments abroad-to-sales ratio (%)	0.35	0.04	0.00	0.10	0.05
Capital goods imports-to-sales ratio (%)	1.79	2.54	1.19	2.32	3.50
Advertisement expenditure-to-sales ratio (%)	1.50	2.17	0.91	0.98	3.02

R&D = research and development.
Source: Author's calculations.

Table 2.   **Classification of Firms by Technological Orientation of Industries (%)**

	FY2003–2004 to FY2007–2008				
	Majority Owned	**Dominant_ Minority**	**Minority Owned**	**Experiential_ Foreign Firms**	**Domestic Firms**
High technology and high product differentiation manufacturing	64.6	62.3	62.2	36.7	37.7
Medium technology and high product differentiation manufacturing	6.3	7.5	2.7	10.0	13.2
Low technology and low product differentiation manufacturing	1.3	9.4	13.5	0.0	5.5
High technology and high product differentiation services	19.0	18.9	13.5	46.7	32.2
Medium technology and high product differentiation services	8.9	1.9	8.1	6.7	11.4
Total	100.0	100.0	100.0	100.0	100.0
Standard deviation	25.7	24.4	24.0	20.4	14.1
	FY2008–2009 to FY2013–2014				
	Majority Owned	**Dominant_ Minority**	**Minority Owned**	**Experiential_ Foreign Firms**	**Domestic Firms**
High technology and high product differentiation manufacturing	62.4	56.0	50.0	46.2	37.7
Medium technology and high product differentiation manufacturing	7.3	12.0	9.3	19.2	12.9
Low technology and low product differentiation manufacturing	0.9	4.0	11.1	7.7	5.4
High technology and high product differentiation services	22.9	22.0	18.5	26.9	32.0
Medium technology and high product differentiation services	6.4	6.0	11.1	0.0	11.9
Total	100.0	100.0	100.0	100.0	100.0
Standard deviation	25.1	21.3	17.1	17.9	14.0

Source: Author's calculations.

this question after matching each foreign firm with a domestic counterpart within the broad industrial classifications adopted above.

B.   Propensity Score Matching and Generalized Least Squares Results

Descriptions of the variables are provided in Table 3. Table 4 reports the summary results of matching quality assessment tests.

The results of matching for individual covariates show large differences in the covariates between the foreign and domestic firms in the original sample. These

Table 3. **List of Variables**

Category	Variable	Description
Foreign ownership	DFOR50	Firms that had been majority holders (above 50%)
	DFOR25	Firms that had been dominant minority holders (25%–50%)
	DFOR10	Firms that had predominantly been minority holders (10%–25%) (Predominantly is defined as more than two-thirds of the period.)
	DFOR_EXP:	The remaining firms that have been under a 25% or more foreign ownership stake in at least one of the years but less than two-thirds of the period.
Modes and intensities of technological activities	RD_INT	Total research and development expenditure of ith firm as a proportion of its sales (%)
	ROY_INT	Royalties and technical fees paid abroad by ith firm as a proportion of its sales to measure acquisition of disembodied technologies (%)
	CAPIMP_INT	Imports of capital goods by ith firm as a proportion of its sales to measure acquisition of embodied technologies (%)
Firm specific	SIZE	Net sales (transformed into logarithms)
	SIZE2	Square of SIZE
	AGE	The current year net of the year of incorporation
	EX_INT	Exports of goods and services as % of net sales
	CAPINT	Net fixed assets as % of net sales
	IMPR_INT	Imports of raw materials and components as % of net sales
	PCM	Profits before tax as % of net sales
	Tax	Profits before tax as % of profits after tax
Industry specific (Based on the cluster analysis)	HTECH_MFG	High technology and high product differentiation manufacturing industry $= 1$
	MTECH_MFG	Medium technology and high product differentiation manufacturing industry $= 1$
	LTECH_MFG	Low technology and low product differentiation manufacturing industry $= 1$
	HTECH_SER	High technology and high product differentiation services
	MTECH_SER	Medium technology and high product differentiation services

Source: Author's description.

differences are considerably reduced after the kernel matching. In all the cases, the absolute mean bias turns out to be insignificant.

The pseudo R-squared, which is obtained by regressing treatment propensity scores on all covariates used in matching on the matched and unmatched samples, substantially decreased after matching in all cases. Rosenbaum and Rubin (1983) suggest that a standardized difference of more than 20 should be considered to be large. Our results show that, post matching, none of the standardized differences have an absolute value larger than 3. Finally, the likelihood ratio is insignificant in

Table 4.   **Kernel Matching Performance: Results of the Mean and Median Absolute Bias, Pseudo R-Squared, and LR Tests**

	Pseudo R^2	LR chi^2	p>chi^2	Mean Bias	Medium Bias
Unmatched	0.102	64.78	0	33.5	24.2
Matched	0.002	0.49	1.000	2.6	2.2
Unmatched	0.049	23.36	0.005	20.9	15.3
Matched	0	0.06	1.000	1.3	1.1
Unmatched	0.063	22.71	0.007	23.2	20.2
Matched	0.006	0.65	1.000	3.3	1.1
Unmatched	0.057	17.05	0.03	19.1	14.1
Matched	0.002	0.14	1.000	3.2	2.6
Unmatched	0.071	58.26	0.000	28.0	24.9
Matched	0.001	0.27	1.000	2.0	1.1
Unmatched	0.026	11.94	0.217	17.0	10.3
Matched	0	0.03	1.000	0.8	0.6
Unmatched	0.024	11.80	0.225	13.4	11.0
Matched	0.002	0.35	1.000	0.9	0.4
Unmatched	0.015	3.88	0.867	19.0	9.6
Matched	0	0.01	1.000	0.7	0.6

LR = likelihood ratio.
Source: Author's calculations.

all models in the matched samples, confirming the results of the previous two tests. Matching clearly removes a large part of mean and median biases across the board.

The average treatment effects presented in Table 5 show the average difference in the technology intensities between foreign and domestic firms. The GLS estimates are presented in Table 6.

The results reveal that the majority-owned and dominant-minority MNEs were technologically more active than their minority-holding and experiential counterparts during the precrisis period, even though they largely depended on their internal networks to acquire technologies. The modes of technology acquisition adopted by them and technology intensities were also found to be different from those of matched domestic firms. The firms with minority ownership were not significantly different from their local counterparts, while experiential firms appear to be the technological laggards, possibly because they were clustered in the service sector where R&D expenditures were relatively small. The gap between technology expenditures by local and foreign enterprises across all categories narrowed considerably in the postcrisis period. The GLS estimates indicate that this was due to MNEs accelerating their technological expenditures. I discuss the results by mode of technology sourcing below.

1.   Research and Development Activity

It may be seen that the average treatment effect on R&D intensity is negative across almost all groups in the pre global financial crisis period. The average R&D

Table 5. **Propensity Score Matching Estimates of the Average Effect of Foreign Ownership and Ownership Stakes**

	Foreign Firms	Domestic Firms	Technology Spending Indicator	Average Treatment Effect	Bootstrapped Standard Deviation	t-statistics
			FY2004–2005 to FY2007–2008			
DFOR50	77	1,549	RD_INT	−.131	.079	−1.658[*]
	77	1,549	ROY_INT	.520	.118	4.410[***]
	77	1,549	CAPIMP_INT	−.496	2.342	−.212
DFOR25	53	1,336	RD_INT	0.147	0.237	0.619
	53	1,336	ROY_INT	0.403	0.181	2.219[**]
	53	1,336	CAPIMP_INT	−0.305	0.424	−0.721
DFOR10	37	1,305	RD_INT	−0.168	0.165	−1.1018
	37	1,305	ROY_INT	−0.018	0.061	−0.299
	37	1,305	CAPIMP_INT	0.615	1.173	0.524
DFOR_EXP	30	1,206	RD_INT	−0.276	0.129	−2.132[**]
	30	1,206	ROY_INT	−0.087	.050	−1.1734
	30	1,206	CAPIMP_INT	0.520	1.054	0.493
			FY2009–2010 to FY2013–2014			
DFOR50	109	1,499	RD_INT	0.091	0.133	0.685
	109	1,499	ROY_INT	0.526	0.111	4.760[***]
	109	1,499	CAPIMP_INT	0.136	0.320	0.426
DFOR25	50	1,340	RD_INT	0.604	0.560	1.079
	50	1,340	ROY_INT	0.220	0.120	1.830[*]
	50	1,340	CAPIMP_INT	0.291	0.464	0.627
DFOR10	50	1,340	RD_INT	−.005	0.184	−0.027
	50	1,340	ROY_INT	0.031	0.046	0.672
	50	1,340	CAPIMP_INT	−0.135	0.351	−0.384
DFOR_EXP	26	1,209	RD_INT	2.703	2.836	0.953
	26	1,209	ROY_INT	0.112	0.115	0.974
	26	1,209	CAPIMP_INT	0.034	0.569	0.059

Note: [***], [**], and [*] denote significance at the 1%, 5%, and 10% level, respectively.
Source: Author's calculations.

intensity of majority-owned subsidiaries is 0.13 percentage points less than that of matched domestic firms and was significant at 10%. The GLS estimates presented in Table 6 confirm this result. This gap in R&D intensity increased as foreign equity holdings declined, with dominant-minority MNEs being an exception. The gap is as large as –0.276% for experiential MNEs. In general, the R&D intensities of foreign firms (leaving aside dominant-minority firms) across all categories turned out to be less than that of matched domestic firms during the global boom period. These findings are in line with earlier studies on the post-1991 period, which suggest that MNEs are not significantly more R&D intensive than their local counterparts in India. In an earlier study on the R&D behavior of manufacturing firms in India, Kumar and Aggarwal (2005) used firm-level data from FY1992–1993 to FY1998–1999. Their findings reveal that MNEs have increased their R&D expenditures

Table 6.   **GLS Estimates of R&D and Technology Transfers on Matched Samples**

Variable	FY2004–2005 to FY2007–2008		FY2009–2010 to FY2013–2014	
	RD_INT	**ROY_INT**	**RD_INT**	**ROY_INT**
	Model 1	Model 5	Model 9	Model 13
SIZE	−0.0149	0.0272*	0.0489	0.0314**
	(−0.741)	(1.716)	(1.430)	(2.113)
SIZE^2	0.00480	−0.000495	−0.00402	–0.00198
	(1.512)	(−0.307)	(−0.925)	(−1.508)
AGE	−0.00381**	7.14e-05	−0.00428**	0.000673
	(−2.082)	(0.0387)	(−2.057)	(0.489)
3 years average of ROY_INT	−0.00330		−0.0911	
	(−0.770)		(−1.112)	
3 years average of RD_INT		−0.000169		−0.00667
		(−0.452)		(−1.177)
3 years average of CAP_INT	−4.93e-06	4.01e-06*	−5.58e-07	1.15e-07
	(−0.672)	(1.722)	(−0.759)	(0.340)
3 years average of CAP_IMP	0.00831	−0.000104	0.000207	2.30e-05
	(0.845)	(−0.234)	(0.935)	(0.210)
3 years average of EXINT	0.0198***	0.000595	0.0169***	−0.000569
	(2.638)	(0.617)	(3.018)	(−0.886)
3 years average of IMPR_INT	−0.00911***	−0.000325	0.00111	0.00123*
	(−2.648)	(−0.636)	(0.422)	(1.700)
PCM with 1-year lag	−2.89e-06	5.48e-07	1.42e-05	1.84e-07
	(−1.276)	(0.419)	(1.261)	(0.298)
MTECH_SER	−0.0332	−0.0791	−0.109*	0.0292*
	(−0.655)	(−0.726)	(−1.769)	(1.688)
HTECH_SER	0.179	0.110	0.133	0.208***
	(1.290)	(0.679)	(0.947)	(2.823)
HTECH_MFG	0.448***	−0.0469	0.454***	0.0961***
	(5.014)	(−0.342)	(4.708)	(4.815)
MTECH_MFG	−0.0311	−0.125	−0.159***	0.0130
	(−0.754)	(−1.047)	(−2.805)	(0.874)
DFOR50	−0.296***	0.450***	0.0565	0.520***
	(−3.517)	(3.948)	(0.401)	(4.883)
DFOR25	−0.109	0.482**	−0.0490	0.242*
	(−0.908)	(2.228)	(−0.420)	(1.771)
DFOR10	−0.268***	0.00817	−0.0835	0.0377
	(−3.321)	(0.180)	(−0.720)	(0.894)
DFOR_EXP	−0.189*	−0.0735	0.583	0.186
	(−1.761)	(−1.192)	(0.721)	(1.067)
TAX with 1-year lag	−8.71e-07	−9.07e-07	−1.16e-06	2.11e-06
	(−0.265)	(−1.006)	(−0.518)	(1.168)
Constant	0.122	−0.0659	0.204**	−0.175***
	(1.037)	(−0.716)	(2.113)	(−3.033)
Year dummies	Yes	Yes	Yes	Yes
Observations	4,800	4,800	5,229	5,229
Number of code	1,690	1,690	1,615	1,615

GLS = generalized least squares, R&D = research and development.
Notes: Parentheses represent t-statistics. ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.
Source: Author's calculations.

faster than their local counterparts in response to the process of liberalization. However, after controlling for the effects of other firm-specific characteristics, their average R&D intensity still turned out to be less than that of domestic firms. The study was revisited by Sasidharan and Kathuria (2011). They showed that the average R&D intensity of foreign firms was significantly lower than that of domestic firms between FY1993–1994 and FY2004–2005. For other economies, the results are mixed. Rasiah (2007) reviewed the cases of the People's Republic of China; Indonesia; Malaysia; the Philippines; and Taipei,China; and García, Jin, and Salomon (2013) reviewed the case of Spain (a developed economy with a lower level of dynamism). These studies found that firms with foreign ownership preferred technological transfer instead of R&D investment as a technological achievement policy (see, for example, Fors and Svensson 2002). However, in probit estimates based on 28,000 firm observations, Falk (2008) shows that foreign-owned firms are more innovative than domestic firms, particularly in new European Union member states. Balsari, Özkan, and Varan (2015) and Pamukçu and Utku-İsmihan (2009) found similar results for Turkey. Evidence from the People's Republic of China is mixed. While Fu (2008) and Yang and Lin (2012) show positive effects, Chen et al. (2008) are not so optimistic.

In contrast to the precrisis period, foreign firms in the post global financial crisis period in India outperformed local firms in R&D intensity, albeit weakly. Table 6 shows that it was due to acceleration in the R&D intensity of MNEs, which may have been partly due to accelerated reforms in the FDI regime in India that were initiated in the post-2005 period (Figure 1). It could also be that the crisis in advanced economies shifted the focus to emerging markets where competition for market share intensified, forcing MNEs to increase their technological efforts. But the possibility of the global financial crisis affecting companies' offshoring strategies for R&D as a result of the credit crunch in the developed world cannot be ignored. This could have forced firms to search for highly qualified personnel at lower cost. Apparently, India offered an ideal location with its pool of engineers and technologists growing at breakneck speed. The share of students enrolled in engineering and technology institutions as a percentage of total enrollments increased from 13% in FY2006–2007 to 26% in FY2011–2012 on average annual growth of around 25%; growth in enrollment at education and medical institutions followed closely at around 16% per year (Government of India 2013). Thus, contrary to global patterns of contraction in R&D relocation (Kinkel and Som 2012; Dachs, Stehrer, and Zahradnik 2014), India exhibited growing R&D spending by MNEs in almost all categories except for minority-held companies. India's experience mirrored that of France, Poland, and the United Kingdom, which also showed rising trends in R&D relocation activities during the review period (Dachs, Stehrer, and Zahradnik 2014). However, in no case was the R&D intensity of foreign firms significantly greater than that of matched local firms.

2. Royalty Payment Intensity

During the precrisis period of FY2003–2004 to FY2008–2009, majority-owned and dominant-minority firms spent significantly more on royalty payments than matched local counterparts. Their average royalty-to-sales ratios were 0.53 and 0.40 percentage points higher than that of local firms, respectively. In the postcrisis period, the gap did not show any perceptible change. However, the other two categories, minority-holding and experiential firms, which appeared to be technologically laggards in the precrisis period, enhanced technology acquisition from internal networks and managed to outperform domestic firms, albeit insignificantly, in the postcrisis period. These results support the traditional view of the greater embeddedness of MNEs in internal networks to protect against the spillover of proprietary technologies. This translates into a slow process of R&D relocation and is in line with the results related to R&D spending. The GLS estimates in Table 6 confirm these results. DFOR50 and DFOR25 are significant in all specifications for ROY_INT during both periods. The results for other categories of foreign firms also indicate that foreign firms are not technologically embedded in India. They are more likely to depend on their parent labs.

3. Capital Goods Imports

Imports of capital goods have been a significant mode of technology transfer for both local and foreign-owned firms in India. In the precrisis period, minority-holding and experiential foreign firms were associated with larger spending on capital goods imports than matched local firms; while in the postcrisis period, MNEs with higher ownership stakes enhanced their spending on capital goods imports, along with R&D, over their local counterparts. The minority-holding companies focused more on disembodied technology acquisition. However, the difference in average spending on this mode of technology acquisition is not significantly different between foreign and domestic firms in either period for any category of foreign firms.

Mundlak's estimates presented in Table 7 validate the results for the main variables. A comparison of these results with the GLS estimates shows that the results are robust.

Finally, it is observed that R&D and royalty intensities are affected differently by other strategic explanatory variables (Table 6). High-technology industries in both the manufacturing and service sectors attract significant technology transfers, but only those in manufacturing induce significantly higher R&D intensities. Thus, promoting high-technology manufacturing is more likely to accelerate R&D efforts in Indian industries. Further, exporting is significantly associated with local R&D efforts, while its relationship with technology imports is insignificant. Age turns out to be negative, indicating that younger firms are more likely to undertake R&D. The

Table 7. **Mundlak Estimates of the Main Variables**

	ROY_INT			RD_INT	
Variable	**Coefficient**	**t-statistics**	**Variable**	**Coefficient**	**t-statistics**
FY2004–2005 to FY2007–2008					
DFOR50	0.451	3.91***	DFOR50	−0.336	−1.34
DFOR25	0.467	2.15**	DFOR25	−0.054	−0.18
DFOR10	−0.023	−0.40	DFOR10	−0.172	−0.49
DFOR_EXP	−0.042	−0.89	DFOR_EXP	−0.164	−0.42
FY2008–2009 to FY2013–2014					
DFOR50	0.525	6.61***	DFOR50	0.073	0.36
DFOR25	0.240	2.07**	DFOR25	0.004	0.02
DFOR10	0.029	0.26	DFOR10	−0.081	−0.29
DFOR_EXP	0.170	1.05	DFOR_EXP	0.595	1.47

Note: ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.
Source: Author's calculations.

size variable indicates that relatively larger firms are more likely to engage in R&D, while relatively smaller firms exhibit a greater tendency to import technologies. Finally, the relationship between R&D intensity and technology transfers is found to be negative; the gap appears to have widened over time. Thus, technology transfers may not positively influence local R&D efforts. It is important to identify the triggers for such efforts to augment the technological capabilities of firms.

VII. Conclusion

Majority-owned and dominant-minority-owned firms are considered to be conduits of technology transfers. This study finds that their local R&D intensities are less than those of their local counterparts in India. The activities of technology generation are found to be concentrated in the home economies of MNEs located in India. It is also found that minority-owned firms are not significantly different from their local counterparts. Finally, the technological dynamism of MNEs was found to have increased across all categories in the postcrisis period. But, it did not result in significant changes in the modes of technology acquisition or significantly larger technology intensities than that of local firms. I find no evidence of a significant increase in relocation of R&D activity to India by production firms after the global financial crisis despite India being much less affected by the crisis than many other economies and having an expanding pool of skilled labor.

The global distribution of R&D is essentially the result of strategic decisions among firms to gain global efficiency through local responsiveness and worldwide learning. A firm's strategic objective is to leverage its innovative advantages to exploit a host economy's knowledge base by tapping into local clusters (e.g., well-educated workforce and high-quality research institutions) and by creating

network relations with external partners (e.g., customers and suppliers) and building a strong knowledge base and competitiveness advantages (Andersson, Forsgren, and Holm 2002). Their ability to create, manage, and take advantage of internal and external network-based knowledge flows is a strong source of their competitiveness. Therefore, the host-specific advantages in creating assets are the key attractions for them; markets and resources alone are not sufficient. There are numerous studies that have analyzed the factors affecting the internationalization of R&D by MNEs. According to Hall (2010, 12), "[t]he variables that most strongly affect location choice are invariably the size of the market, the R&D intensity of the host country, the availability of technical and educated workers, and the presence of lead customers." Their decision to relocate R&D depends in part on the quality of host economy R&D networks, the sophistication of its markets, and the intellectual property rights regime. India is benefiting from a growing pool of engineers and technologists, as well as from the presence of a World Trade Organization-compliant intellectual property rights regime. At the same time, India needs to focus on improving the quality of its skilled labor and local networks, and pursue more effective implementation of the intellectual property rights regime to establish itself as a hub of R&D-intensive FDI. The results in this paper have important policy implications for governments in developing economies such as India. They must strengthen their capabilities to attract knowledge-intensive FDI and exploit the benefits generated through knowledge spillovers (see, for example, Fu, Pietrobelli, and Soete 2011). Building strong local technological capabilities through a well-designed innovation strategy should be at the core of an FDI-induced development strategy.

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