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Exports, outward FDI and technology upgrading: Firm level evidence from India

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Abstract

This paper evaluates the individual and combined effects of exporting and outward foreign direct investments (OFDI) on firms' technology investments at home using firm-level data from the pharmaceutical industry in India. The analysis accounts for unobserved firm heterogeneity and the endogeneity of the choice of foreign market participation, and shows that exporting has been an important channel through which Indian multinational expansion has encouraged greater domestic technological activity. However, all else constant, higher levels of OFDI have rather acted as substitutes for such technological efforts.

Key words: Outward FDI, exports, technology investment, emerging markets multinationals.
JEL codes: C23, F23, O31.

1. Introduction

During the past three decades policy makers from a number of developing countries have undertaken outward-oriented economic reforms with a view to stimulating the acquisition of global capabilities and promoting greater domestic economic activity. The liberalization of trade and foreign direct investment regimens have been two important features of such reforms, which have resulted in firms from developing countries rapidly expanding their presence in international trade and foreign direct investment. However, the extent to which the deliberate outward orientation of such firms is related to greater domestic economic activity is still a sparse area of research. In particular, whether firms' international activities in the form of exports and outward foreign direct investments (OFDI) affect their technological effort at home remains an important open question.

From a theoretical perspective, recent work in international economics has emphasised that improved access to foreign markets due to trade liberalization encourages firms to undertake complementary investments in technology adoption and innovation. This connection between exporting and technology investments has been modelled and tested empirically in a number of different contexts.[1] For example, Bustos' (2011) provides empirical evidence from Argentina showing that firms in industries facing reductions in Brazil's imports tariffs, as mandated by MERCOSUR, increased their investment in technology faster, and exporters upgraded technology more rapidly than other firms in the same industry. Lileeva and Trefler (2010) show that Canadian plants that were induced to start exporting, or export more, due to the elimination of U.S. tariffs displayed higher rates of technology adoption and innovation. Constantini and Melitz (2008) show how anticipation of trade liberalisation leads firms to innovate in preparation for future

participation in export markets, and Atkeson and Burstein (2010) show that a reduction in marginal trade costs induces exporting firms to spend more on process innovation than non-exporting firms, amplifying the superiority of exporting firms over time.[2]

While the above models have focused on the technological effects of improved access to foreign markets in the context of liberalization of trade regimes, the technological effects resulting from the increased access to foreign markets due to outward FDI liberalization has been absent from existing theoretical work in international economics. This issue is particularly relevant in the context of developing countries where capital controls have been relaxed in recent years, allowing an increasing number of firms to rapidly expand their international operations. However, as yet, little effort has been devoted to investigating the effect of such investments on firms' technological performance at home. The international business literature, on the other hand, has focused primarily on understanding the characteristics and motivations of developing countries multinationals to invest abroad, but little is known about the consequences of such investments for the investing firms in their home countries. [3]

Understanding the role of outward FDI for technological improvements in the home country is central as there is a considerable concern as to whether the activities of multinational enterprises affect the home economies; an issue that is particularly relevant in the context of developing countries with scarce capital. On one hand, flows of outward foreign direct investment generate fears that such investments come at the cost of reducing economic activity at home. In contrast, an alternative perspective suggests that greater outward foreign direct investment could enrich home activities by improving the competitiveness of the parent investing firms (Desai, et. al., 2005).

The limited empirical literature on the technological implications of overseas investments by multinational firms has provided mixed results. In the context of developing countries, Chuang and Lin (1999) find that the overseas investments of Taiwanese manufacturing firms substitute their R&D investments at home, whereas Lin and Yen (2005) find complementary effects in the Taiwanese electronic industry. Chen and Yang (2013), on the other hand, show that the relationship between outward FDI and domestic R&D is undetermined because overseas investments induce complementary as well as substitutive effects. In the case of India, Pradhan and Singh (2009) find that outward FDI by automotive firms exerts a positive impact on the R&D intensity of the investing firm. Those mixed results reveal that the impact of OFDI is likely to differ depending on many factors, including the context and the motivations behind such investments. Anecdotal evidence and numerous case studies performed on developing country multinationals show that those firms are not an homogeneous group. Rather, they differ in a number of dimensions, such as their country of origin, the industry in which they operate, and their competitive advantage, amongst other aspects (Ramamurti, 2009). Hence, any attempt to evaluate the effects of outward FDI on firms' performance should take into account those specificities.

Overall, the sparse empirical literature examining the home-country technological effects of the process of globalization of emerging market firms have mainly focused on the individual effects of exporting and/or investing abroad. Yet, the complementary technological impact of these two activities remains unexplored in the literature. This study investigates empirically the individual effects of exporting and investing abroad, as well as their complementary impact on the rate of technology investment at home. Examining the individual and complementary effects of these two forms of foreign market participation is central to better understanding the channels through which foreign activities of emerging market firms shape their technological capabilities at home. From a theoretical perspective, this paper aims to contribute to future theoretical work in

international economics by exploring the relevance of a firm's multinational (OFDI) status for the technology-exporting link, as well as the direct link between overseas and technological investments. The international economics literature tends to regard exporting and investing abroad as substitute modes of foreign market participation, yet empirical data show that in many contexts firms engage in both activities simultaneously. Hence, the interplay between exporting, investing abroad and investing in technology is still an open area for future theoretical and empirical research.

Apart from considering the complementary effects of exporting and investing abroad on firms' domestic technological efforts, this paper extends previous works by considering a broader measure of technology investment that includes not only expenditures on in-house R&D, but also expenditures on computers and software, royalty fees, and the imports of capital goods. Also, unlike most theoretical models that express technology investment as a binary choice for the sake of mathematical tractability, this paper employs continuous measures of technology investment which correspond more closely to the notion of technology upgrading. Moreover, this paper accounts for firm unobserved heterogeneity and the potential endogeneity of the choice of foreign market participation, an issue that has been largely neglected in previous empirical studies analysing the effects of OFDI on firms' technological efforts.

The policy relevance of this work stems from the fact that Indian policy makers have been active in promoting international agreements and liberalising trade and FDI regimes in order to encourage technology acquisition by indigenous companies, especially from 2000 onwards. While these efforts have produced remarkable results in terms of export and multinational expansion, the cost-effectiveness of such policies in generating greater domestic economic activity remains open to question. India's rapid economic growth and successful integration with the global economy makes it an excellent case study for this topic. As many developing countries are becoming active global players, there is a growing interest from researchers and policy makers in understanding the strategic responses of firms from these countries as they adjust to trade and

FDI liberalization. The analysis covers the years from 1999 to 2007, a period of on-going globalization of Indian firms, in contrast to studies based on developed countries where the process of internationalisation is not new.

This study focuses on the pharmaceutical industry in India and is based on the Prowess database compiled by the Centre for Monitoring the Indian Economy. The Indian pharmaceutical industry is an ideal case to study the relationship between exporting, OFDI and technology investments. During the period 1999–2007, exports earnings by Indian pharmaceutical firms was a staggering US$14.3 billion, accounting for 2.4% of India's total exports.[4] Parallel to this development, and taking advantage of the investment liberalisation policy of the government, Indian pharmaceutical firms have been also busy in overseas markets having invested US$1.3 billion in transnational acquisitions during the period 2000-2006 (Pradhan and Alakshendra, 2006). Moreover, the Prowess dataset used in this paper shows that within the manufacturing sector, pharmaceuticals is the top industry in terms of flows of outward FDI during the period 1999-2007.[5] Understanding the technological implications of foreign activities of Indian pharmaceutical firms is particularly interesting, as it has been observed that firms in this industry are investing abroad with the purpose of acquiring global capabilities to overcome their lack of cutting-edge technologies. This analysis is therefore illustrative, as it is now well documented that an increasing number of developing country firms have started to venture abroad with the purpose of acquiring foreign technologies to cope up with increasing global competition and stronger international property rights regimens (Athreye and Kapur, 2009).

As documented by Pradhan (2008), strategic government interventions facilitated the building of strong indigenous capabilities and conquest international markets via exporting in the pre-1990s period by Indian pharmaceutical firms. In particular, the soft patent policy that remained in place from the early 1970s until the mid-2000s allowed Indian pharmaceutical firms to patent

manufacturing processes instead of final products. By permitting the adaptation of imported technology and reverse engineering, this patent regime facilitated the development of local innovations, but was mainly based on cost-effective process rather than in the creation of new products. However, with the migration to a stronger patent regime in 2005, as mandated by the WTO, Indian pharmaceutical firms have been observed to increasingly start investing in developed countries with the purpose of quickly acquiring new products and foreign knowledge, rather than using their limited resources in costly long-term innovations (Pradhan, 2008).[6] As such, it is expected that the overseas investments of Indian pharmaceutical firms may substitute domestic investments in technology.

However, on the other hand, it might be the case that a potential foreign market expansion induced by firms' overseas investments would encourage greater technological investments at home, as greater sales create more incentives to invest in costly technology. This potential channel for in-house technological improvements is tested in this paper by looking at the relevance of a firm's multinational (OFDI) status for the technology-exporting link. In line with the insights from recent models of exporting and technology adoption, it is likely that the increase in exports that have accompanied the recent wave of overseas investments by Indian pharmaceutical companies might have provided them with a new impetus to upgrade their technological capabilities at home.

Controlling for unobserved firm heterogeneity and the endogeneity of the choice of foreign market participation, this paper shows that the export-intensity of Indian pharmaceutical multinationals is associated with higher rates of technology adoption. However, there is no evidence that the exports of non-multinational firms stimulate greater technology activity. These results highlight the importance of taking the interaction between exporting and firm's multinational status into account. Another major finding is that OFDI appears to substitute

technology investments at home, suggesting that technology-seeking overseas investments tend to divert national resources from home to foreign countries rather than enriching domestic technological activities.

The remainder of the paper is structured as follows. The next section presents the empirical approach. Section 3 describes the dataset. Section 4 reports the main findings from the econometric estimations, and Section 5 concludes.

2. Empirical approach

This section describes the empirical approach used to identify the individual and combined effects of exporting and OFDI on the rate of technology adoption. The following non-linear panel data model of technology investment describes technology investment in the current period in terms of the previous period's firm characteristics:

$$\left(\frac{I}{K}\right)_{it} = \beta_0 + \beta_1 AGE_{it-1} + \beta_2 SIZE_{it-1} + \beta_3 CASHFLOW_{it-1} + \beta_4 PROD_{it-1} + \beta_5 EXP_{it-1} + \beta_6 OFDI_{it-1} + \beta_7 (EXP * MNE)_{it-1} + OWN_i + D_t + f_i + \varepsilon_{it} \quad (1)$$

where *i* and *t* index firms and time periods respectively. The dependent variable is the amount of technology investment (*I*) normalised by total assets (*K*)[7], f_i denotes time-invariant firm-specific heterogeneity and ε is a random error term. In the above model *EXP* and *OFDI* capture the export intensity and the amount of OFDI respectively. The export intensity is also interacted with the firm's multinational status (MNE) to allow for the fact that the investment-export nexus is likely to differ for multinational and non-multinational companies.

Firm age captures learning-by-doing effects, whereas firm size reflects the extent to which economies of scale enhance firms' ability to undertake performance-enhancing investment. A

firm's internal liquidity is also likely to affect its ability to fund the cost of technological investments. To allow for this possibility the cashflow ratio is included as a measure of firm's internal liquidity. Another control variable is firm's productivity, which may impact technology investments in two opposing ways. On one hand, more productive firms may be more likely to afford investing in further productivity improvements (Bustos, 2011). On the other hand, least productive firms may investment more to catch-up with their competitors, which is consistent with the notion of firm level productivity-convergence (e.g. Bernard and Jones, 1996).

Finally, Equation 1 is estimated using a full vector of time dummies (D_t) and a vector of two dummy variables (OWN_i), which indicate whether the firm belongs to a business group and whether the firm is owned by the State, respectively.

The treatment of the time-invariant unobserved heterogeneity, f_i, and its relationship with the explanatory variables, constitutes an important concern when estimating equation 1. In non-linear panel data models with small time periods, it is not possible to treat the unobservables as fixed parameters to be estimated by standard maximum likelihood due to the incidental parameter problem. In order to identify the partial effects of the explanatory variables, this paper adopts the Mundlak-Chamberlain approach by modelling the distribution of f_i in a parametrical way. A common practice is to assume a linear relationship between f_i and either the time means of the explanatory variables or a combinations of their lags and leads. In terms of implementation this approach has the effect of adding firm-specific time averages (or a full set of leads and lags) of the regressors to the set of explanatory variables in Equation 1 (Wooldridge, 2008, 2009).

However, a potential problem with this approach is that it relies on the assumption of strict exogeneity of the explanatory variables conditional on the unobserved effects. But arguably, some explanatory variables in Equation 1 (i.e. productivity, size, liquidity, exporting and OFDI) might be contemporaneously determined with, or even impacted by firms' technology investments. In

Equation 1 the covariates are lagged one period in order to minimize the potential problem of contemporaneous endogeneity. However, in order to better deal with potential endogenous explanatory variables, this paper uses a control function approach consisting of: 1) estimating a reduced form of each hypothesised endogenous variable on their lagged values and all other endogenous and exogenous regressors[8]; 2) obtaining the reduced residuals from these estimations; 3) including these residuals in the list of covariates in Equation 1; and 4) performing the estimations using a pooled Tobit model with robust standard errors clustering at the firm level. The hypothesis of strict exogeneity is rejected if the coefficients on the residuals are significantly different from zero (Wooldridge, 2008).

3. Database description

This paper draws on the Prowess database compiled from audited company balance sheets and income statements by the Centre for Monitoring the Indian Economy. Prowess covers both publicly listed and unlisted firms from a wide cross-section of manufacturing, services, utilities, and financial industries. The companies covered by the database account for more than 70% of industrial output, 75% of corporate taxes and more than 95% of excise taxes collected by the Government of India.

Table 1 gives the frequency distribution of the pharmaceutical firms in the sample by year and global status. Firms in Table 1 have been classified in five categories. The first category comprises those Indian firms that only serve the domestic market. The second group includes Indian firms that also export. The third category consists of those indigenous firms that export and invest abroad (Indian MNEs). The fourth group are those Indian MNEs that invest abroad but do not export, and the last category comprises all foreign firms operating in India. The category of foreign firms is dropped from the empirical analysis, since the main interest of this paper is to

examine whether exporting and investing abroad has encouraged technology upgrading by *indigenous* companies in India. It can be observed that the number of Indian pharmaceutical multinationals started to show a marked increase after 2000. This increase is largely due to significant improvements in the regulatory framework governing Indian outward investment. For example, since 2000 Indian companies have been allowed to make overseas investments by market purchases of foreign exchange without the approval of the Reserve Bank of India up to 400% of their net worth, compared to the previous limit of 50%. It is also interesting to note that most Indian MNEs are engaged in exports. During the whole period, only a few pharmaceutical firms set up operations abroad without exporting. Since the sample size is very small for this group of firms for all years, this category of firms is also dropped from the empirical analysis.

[Table 1 about here]

The variables used in the regression analysis are defined in Table 1A in the appendix and their summary statistics are given in Table 2. Table 2 shows that about 59 percent of firms undertake technology investments and that, on average, these firms invest 4 percent of their total assets in technology. Table 2 also shows that, on average, more than 60% of pharmaceutical firms export and the fraction of output exported increased from 24% in the first half of the sample (1999-2002) to 28% in the second half. The percentage of firms engaged in overseas investments and the amount of such investments also displayed significant increases between the two periods.

[Table 2 about here]

Figures 2 depicts the share of firm-year observations and technology investment ordered by exporting and OFDI status. It is striking that although only 9.5% of pharmaceutical firms engaged in both exporting and OFDI, they enjoyed a disproportionately high share of the value technology investment, compare to the significantly larger fraction of firms that only export. This

appears to reinforce the idea that export-oriented Indian multinationals appear to be most willing to develop their technological capabilities.

[Figures 2 about here]

In order to isolate the causal effects of exporting and OFDI on the rate of technology adoption as well as to evaluate the interaction between them, it is important to control for a host of observable and unobservable firm characteristics. This is achieved within the non-linear panel data framework described in the previous section.

4. Empirical findings

Table 3 reports the marginal effects of exporting and OFDI on the expected amount of technology investments from pooled Tobit estimates. Full estimation results including all control variables are reported in Table 2A in the appendix. The marginal effects are calculated at the sample averages of the control variables and the standard errors are adjusted to allow for clustering at the firm level. In order to make this work comparable to previous related research, the first column of Table 3 reports the individual effects of exporting and OFDI on firm's technology investments without accounting for firm heterogeneity. Similar to previous research examining the determinants of R&D in the context of India (Pradhan, 2002, 2009; 2010), the results show that firms' export intensity is positively associated with the pace of technology upgrading. However, in this specification the amount of overseas investments does not appear to have significant technological effects.

[Table 3 about here]

To allow for the fact that the technology-exporting nexus is likely to differ for multinational and non-multinational companies, in column 2 of Table 3 the export intensity is interacted with the firm's multinational (MNE) status. Interestingly, this exercise provides evidence

of heterogeneous technology-effects from exporting related to firm's multinational status. While the export intensity of non-multinationals does not appear to encourage technology investments, there is strong evidence of a positive relationship between the export intensity of Indian MNEs and their technology investment at home. The results show that a 1 percentage point increase in the export intensity of Indian MNEs results in a 0.013 percentage point increase in the intensity of domestic technology investments. This impact is economically important given that the average technology investment by Indian pharmaceutical firms (as a fraction of total assets) is 4.0 percent as reported in Table 2. This finding is consistent with the notion of market-seeking exporting Indian MNEs being induced to invest in technology at home in order to become more competitive in international markets. The results in column 2 of Table 3 also uncover evidence of a substantial substitutive effect of firms' overseas investments on their rate of technology investments at home. The estimates show that all else constant a 1 percentage point increase in outward FDI reduces the amount of firms' technology investments by 0.011 percentage points.

The previous results do not account for potential unobserved firm heterogeneity. However, it is likely that firms' international activities in the form of exports and overseas investments are correlated with unobserved factors, such as managerial quality or risk behaviour, that also influence their technological decisions. In column 3 of Table 3 firm's heterogeneity is accounted for by including the mean values of the covariates, as described in section 2. The results confirm the previous findings, indicating that the exports of Indian multinational firms are a channel through which firm's multinational expansion enhances technology investments at home and that the higher the level of outward FDI, the lower the rate of domestic technology investments.[9]

As mentioned in Section 2, the above approach relies on the assumption of strict exogeneity once firm's unobserved heterogeneity is controlled for. However, this assumption

might be violated. For example, it might be plausible that a firm's technological effort might affect its export and/or outward FDI strategies. To check whether the previous results are driven by the assumption of strict exogeneity conditional on firm's unobserved effects, column 4 of Table 3 presents the results of using a control function approach, where the residuals from estimating a reduced form of each hypothesised endogenous variable are included in the list of covariates.[10] As judged by the significance of the coefficients on the reduced residuals, it appears that firm's size, total factor productivity and outward FDI are likely to be endogenous (see column 4 of Table 2A in the appendix). Interestingly, while the magnitude of the positive technological effects of the exports of Indian MNEs remains almost unchanged, the magnitude of the negative impact of overseas investments on firms' technological efforts increases significantly once firm's heterogeneity and the potential endogeneity of some regressors are accounted for. The estimate results show that a 1 percentage point increase in outward FDI reduces the amount of firms' technology by approximately 0.04 percentage points. This effect is almost 4 times higher than the effect presented in column 2.

The previous results are obtained using the whole unbalanced panel dataset of Indian pharmaceutical firms. Therefore, there is a potential risk that they might suffer from attrition bias. In order to check whether the results are robust to this potential problem, column 5 in Table 3 reports the estimation results using only the subset of firms that are observed for all years. These estimates confirm that overseas investments and firms' technology investments at home are substitutive activities, with these negative effects being stronger in the balanced dataset. The results also confirm the positive effects of exporting amongst Indian MNEs.

So far, the combined effects between exporting and firms' multinational status have been accounted for by interacting the export intensity with a dummy variable for Indian MNEs (i.e. Indian firms with positive overseas investments). This approach treats all Indian MNEs with large

and small overseas investments symmetrically. However, in order to check whether the technology-exporting link of Indian MNEs varies with the amount of OFDI, in column 6 of Table 3 the export intensity is interacted with 5 OFDI dummy variables, one for each quintile of the OFDI distribution. The results indicate that the positive technological enhancing effects from exporting are confined to Indian MNEs with low levels of overseas investments. It might be plausible that only low levels of overseas investments are required to help firms to expand their exports, with the subsequent positive technological implications of such expansion. The results from this exercise show that, a 1 percentage point increase in the export intensity of Indian MNEs in the lowest two quintiles of the OFDI distribution increases the rate of technology investments by approximately 0.015. These results became stronger when the dataset is reduced to a balanced panel as shown in column 7 of Table 3.

To check that the results presented in Table 3 are not inconsistent due to the imposed parametric specification of unobserved firm's heterogeneity (i.e. as a linear function of firm-specific time average of the regressors), columns 1 to 4 in Table 4 report the estimated results obtained from modelling the distribution of unobserved heterogeneity as a linear function of all the leads and lags of the covariates instead of using their mean values. The main results from this exercise are in line with the previous results presented in Table 3.

In addition, in order to allow firm's heterogeneity to be correlated with the regressors in an unrestrictive way, columns 5 to 8 in Table 4 report the estimated results from a linear fixed effect model. As before, these results show that the exports of Indian multinationals exert a positive effect on the rate of technology investments at home, whereas the amount of overseas investments acts as a substitute for such investments.

[Table 4 about here]

Overall, the previous results highlight the importance of taking the interaction between exporting and multinational status into account and suggest that incurring the fixed cost of investing in technology is only attractive for exporting firms that have become multinationals in recent years, probably due to the larger sales in foreign markets that come with their overseas investments. The lack of evidence of technology enhancing effects from exporting amongst non-multinational firms suggests that possibly these firms were induced to invest in technology in the past, when they started to export, but now, with less scope to improve foreign market access, they have less incentive to continue to upgrade their technological base. This is an interesting result, as the fundamental complementarity between exporting and investing abroad –in particular, the increase in foreign market access that comes with overseas investments- has been absent from the existing work on trade and technology investments.

Does the industry matter?

So far the analysis has focused on the pharmaceutical industry. As argued in the introduction, there are good reasons for the choice of this industry, in particular its leadership in overseas investments by Indian manufacturing firms; as well as the well-documented behaviour of firms from this industry investing abroad with the purpose of acquiring global technologies to overcome their limited capabilities. Nonetheless, it is interesting to consider another equally important global oriented sector in India. Within the service sector, the Indian software industry is the top industry in terms of Indian outward FDI. This industry offers an intriguing contrast to the pharmaceutical industry, not only for being predominantly service-based, but also because firms in this industry are considered to be technological leaders in a global scale. Therefore, the motivations behind their overseas investments are more for technological diversification rather than for technological acquisition (Pradhan, 2008). As such, there is not so much scope for further domestic technological improvements in this industry. Estimation results using data from this industry show

no effects from exporting and/or outward FDI on firms' domestic technology investments.[11] These contrasting results highlight the importance of taking into account the sectoral heterogeneity of exporting and OFDI performance when evaluating the effects of globalization on firms' technological efforts.

5. Conclusion

Recent work in international economics has shown that improved access to foreign markets due to trade liberalization encourages firms to undertake complementary technology investments. Using firm-level data from the pharmaceutical industry in India, this paper contributes to this literature by examining whether the increase in foreign market access that comes with overseas investments also encourages indigenous firms to upgrade their technological capabilities at home. The analysis accounts for unobserved firm heterogeneity and the endogeneity of the choice of foreign market participation, and shows that the decision to invest abroad is crucial in determining the technology-exporting link. While there is evidence of technology-enhancing effects from exporting amongst Indian multinationals, this paper fails to find evidence that exporting non-multinational firms invest more in technology than non-exporting ones. This finding is consistent with the notion of market-seeking exporting Indian multinationals being encouraged to invest in technology at home in order to take advantage of improved foreign market access and become more competitive abroad. Another striking result from this paper is the negative relationship between the level of overseas investment (OFDI) and firms' domestic technology investments, a result that is consistent with the notion of technology-seeking Indian multinational firms devoting their scarce resources to accessing existing technology abroad.

Overall, this study contributes to academic efforts that seek to pin down the channels through which the choice of foreign market participation shapes firms' competitive advantages. In particular, this paper informs existing economic theory by cautioning for the need to consider the heterogeneous nature of the exporting-technology investment link and take explicit account of the OFDI decision when examining this link.

From a policy perspective, this paper shows that although outward FDI has a negative effect on firms' domestic technological efforts (a concern that has been raised amongst some academics and policy makers), the potential increase in exports induced by overseas investments creates an alternative opportunity for technological improvements at home. Policies aimed at promoting export-oriented OFDI can therefore be conducive for technological upgrading in the home economies. However, OFDI with the singular purpose of acquiring foreign technology might help the investing firms to overcome their lack of state-of-the art technology, but that would come at the cost of discouraging technology change in their home countries.

Overall, conclusions regarding the role of outward FDI for technology enhancing investments should take into account the motivations behind such overseas investments. In the case of Indian pharmaceutical firms it has been documented that outward FDI are mainly motivated by the desire to improve foreign market access (market-seeking motivation) and acquire foreign technology (technology-seeking motivation). As such, these effects are likely to operate in opposite directions.

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Notes

[1] See Melitz and Redding (2012) for a general description of the modelling techniques used in the international trade literature to capture the complementarities between exporting and investing in technology.
[2] Other related papers examining the relationship between productivity, exporting and innovation more generally include Aw et al. (2007); Aw et al. (2011); Baldwin and Gu (2004); and Girma et al. (2008). In the case of India, early studies have found positive spillovers from exporting on R&D expenditures in the context of the liberalization reforms implemented during the 1990s (i.e. Kumar and Aggarwal, 2005 and Pradhan, 2002).
[3] See Amighni et al. (2015) for a recent literature review of academic work on emerging markets multinationals.
[4] Data from the Directorate General of Commercial Intelligence and Statistics of the Indian Ministry of Commerce and Industry, available at: http://www.dgciskol.nic.in/
[5] Figure 1 shows the sectoral distribution of Indian manufacturing overseas investments in the Prowess database.
[6] Pradhan (2008) shows that more than 80 percent of Indian pharmaceutical outward FDI during the period 2000-07 was directed to developed countries, indicating a strong technology-seeking motivation behind such investments.
[7] Detail of the construction of the variables used in the empirical analysis is discussed in the next section and summarised in Table 1A in the Appendix.
[8] Firms' age, group and state affiliation, and a set of time dummies are considered to be exogenous.
[9] The technology enhancing effects from exporting amongst Indian MNEs is also found by estimating Equation 1 using a random effects Tobit model. However, a major disadvantage of this estimation technique is that it relies on the critical assumptions that the unobserved effects are uncorrelated with the explanatory variables and that, conditional on the regressors and unobserved heterogeneity, observations across time are independent. These assumptions are unlikely to hold.
[10] As mentioned in Section 2, firm's size, liquidity, productivity, exporting and investing abroad are suspected to be endogenous. The reduced form estimations for each of these hypothesised endogenous variables is carried out using pooled OLS. The results presented in column 4 of Table 3 are obtained by regressing each potential endogenous variable on their second and third lagged values and on a vector of exogenous regressors including firms' age, group affiliation, state ownership, and a set of time dummies. The choice of the control variables in these reduced form estimations was made by estimating an instrumental variables Tobit model using these variables as instruments and performing an Amemiya-Lee-Newey test for the validity of the instruments. The main results are, however, robust to alternative specifications of the reduce form estimations.
[11] Results are available upon request.

References

Amighni, A., Cozza, C., Giuliani, E., and Pavia, R., Scalera, V. (2015). Multinational enterprises from emerging economies: what theories suggest, what evidence shows. A literature review. *Economia e Politica Industriale*. 42 (3), 343-370.

Athreye, S. and Kapur, S. (2009). The internationalization of Chinese and Indian firms: trends, motivations and strategy. *Policy brief*. 1. United Nations University, UNU-MERIT.

Atkeson, A., and Burstein, A. T. (2010). Innovation, Firm Dynamics, and International Trade. *Journal of Political Economy*, 118, 433-84.

Aw, B.Y, Roberts, M.J and Winston, T (2007). "Export Market Participation, Investments in R&D and Worker Training, and the Evolution of Firm Productivity." *The World Economy*, 14(1), 83–104.

Aw, B.Y, Roberts, M.J and Xu, D. Y. (2011). R&D investment, exporting, and productivity dynamics, *American Economic Review*. 101,1312-1344.

Baldwin, J. R. and Gu, W. (2004). Trade liberalization: Export-market participation, productivity growth and innovation*, Oxford Review of Economic Policy*. 20, 372–392.

Bernard, A.B. and Jones, C.I., (1996). Comparing apples to oranges: Productivity convergence and measurement across industries and countries, American *Economic Review*. 86, 1216–1238.

Bustos, Paula (2011). Trade Liberalization, Exports, and Technology Upgrading: Evidence on the Impact of MERCOSUR on Argentinean Firms, *American Economic Review*. 101, 304-40.

Chen, K. and Yang, S. (2013). Impact of outward foreign direct investment on domestic R&D activity: evidence from Taiwan's multinational enterprises in low-wage income. *Asian Economic Journal* 27 (1), 17-38.

Chuang, Y., and Lin, C. (1999). Foreign direct investment, R&D, and spillover efficiency: Evidence from Taiwan's manufacturing firms. *Journal of Development Studies* 35 (4), 117–34.

Constantini, J.A. and Melitz, M.J. (2008). The Dynamics of Firm-Level Adjustment to Trade Liberalization, in Helpman, E., D. Marin and T. Verdier Eds, *The Organization of Firms in a Global Economy*. Harvard University Press.

Desai, M., Foley, F. Hines, J. (2005). Foreign direct investment and domestic economic activity. *NBER Working Paper* No. 11717.

Girma, S., Görg. H. and Hanley, A. (2008). R&D and Exporting: Comparison of British and Irish firms, *Review of World Economics*. 144, 750-773.

Kumar, N. and Aggarwal, A. (2005). Liberalization, outward orientation and in-house R&D activity of multinational and local firms: A quantitative exploration for Indian manufacturing, *Research Policy*, 34, 441-460.

Lileeva, A. and Trefler, D. (2010). Improved Access to Foreign Markets Raises Plant-Level Productivity….For Some Plants, *The Quarterly Journal of Economics*. 125, 1051-1099.

Lin, H. and Yen, R. (2005). The interdependence between FDI and R&D: an application of endogenous switching model to Taiwan's electronic industry. *Applied Economics*. 37, 1789-99.

Melitz, M. J. and Redding, S. (2012). Heterogeneous Firms and Trade. *NBER Working Paper* 18652.

Pradhan, J. and Alakshendra, A. (2006). Overseas Acquisition versus Greenfield Foreign Investment: Which Internationalization Strategy is better for Indian Pharmaceutical Enterprises? *MPRA Paper No. 12339*, available at http://mpra.ub.uni-muenchen.de/12339.

Pradhan, J. P. (2002) 'Liberalization, firm size and R&D performance: A firm level study of Indian pharmaceutical industry'. *Journal of Indian School of Political Economy* 14 (4), 647-666.

Pradhan, J. (2008). Overcoming innovation limits through outward FDI: the overseas acquisition strategy of Indian pharmaceutical firms. Institute for Studies in Industrial Development. New Delhi.

Pradhan, J. and Singh, N. (2009). Outward FDI and knowledge flows: a study of Indian automotive sector. *International Journal of Institutions and Economics* 1 (1), 156-187.

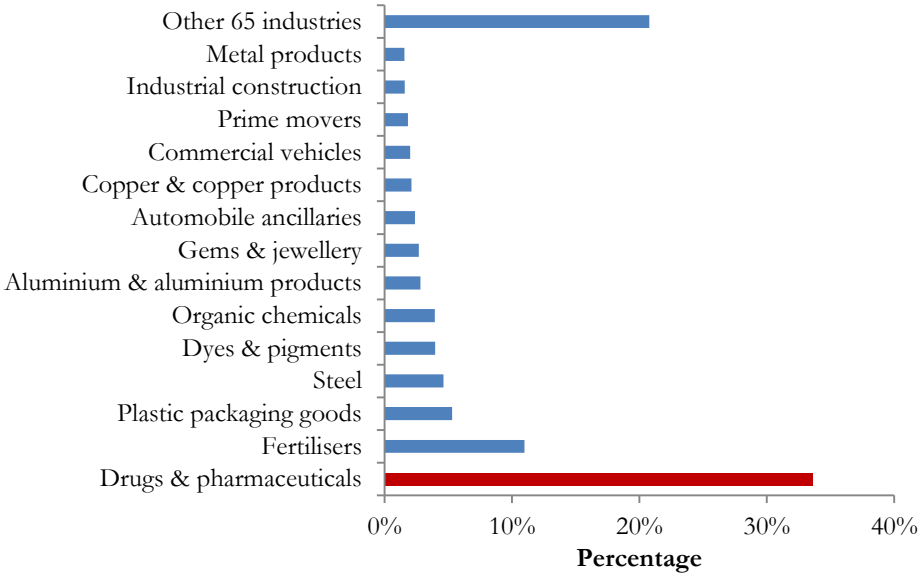
Pradhan, J. (2010). R&D strategy of small and medium enterprises in India: trends and determinants. *MPRA Paper No. 20951*, available at https://mpra.ub.uni-muenchen.de/20951/1/MPRA_paper_20951.

Ramamurti, R. (2009). What have we learned about EMNEs? In *Emerging Multinationals in Emerging Markets*, Ramamurti, R. and Singh JV. (Eds), Cambridge University Press: Cambridge, UK, 399-.426.

Wooldridge, J (2008). Inference for partial effects in nonlinear panel-data models using Stata. Presentation at Summer 2008 North American Stata User's Group Meetings. Chicago.

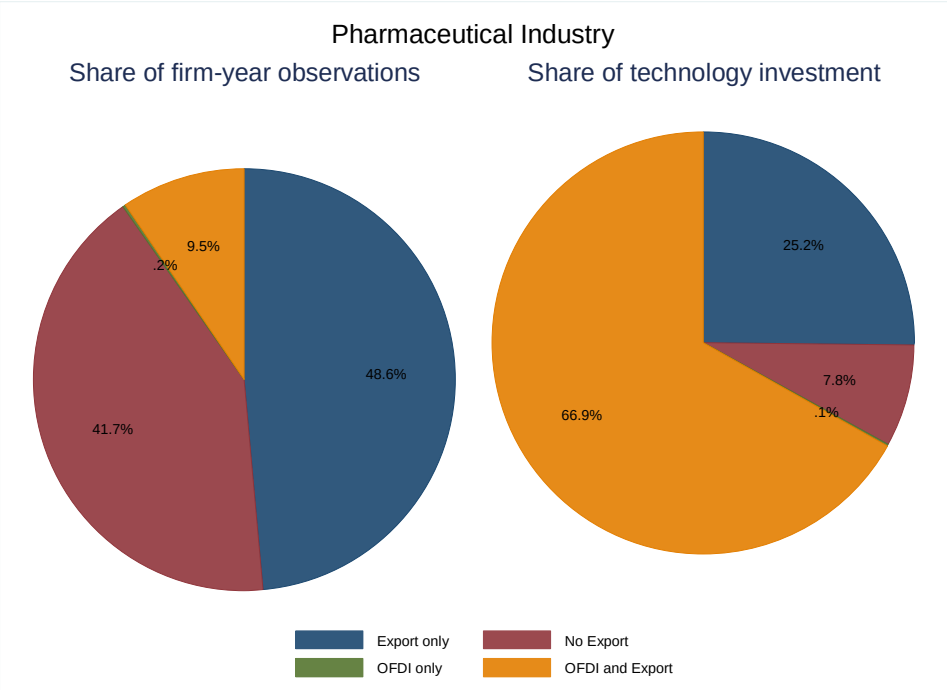
Wooldridge, J. (2009). Developments in Econometrics. Nonlinear Panel Data Models. Cemmap Lectures, UCL.

Figure 1: Sectoral distribution of overseas investments by Indian manufacturing firms, 1999-2007



Source: Author's analysis based on the Prowess dataset.

Figure 2: Distribution of firm-year observations and share of technology investment by global status



Source: Author's analysis based on the Prowess dataset.

Table 1
Frequency distribution of pharmaceutical firms by year and global status

Year	Domestic	Exporter	Exporter Indian MNE	Non Exporter Indian MNE	Foreign MNE	Total
1999	88	149	2	0	27	266
2000	108	145	4	0	29	286
2001	102	121	20	0	31	274
2002	103	109	24	1	29	266
2003	113	130	28	1	26	298
2004	130	130	31	0	27	318
2005	119	117	33	0	27	296
2006	102	102	37	1	37	279
2007	68	84	34	2	34	222
Total	933	1,087	213	5	267	2,505

Source: Author's analysis based on the Prowess dataset.

Table 2
Summary statistics of main variables of interest:

	1999-2002		**2003-2007**	
	mean	Std dev.	mean	Std dev.
Total technology investment (dummy)	0.58	0.49	0.59	0.49
Total technology investment intensity (investors)	0.04	0.26	0.04	0.15
Exports dummy	0.61	0.49	0.61	0.49
Export intensity (exporters)	0.24	0.28	0.28	0.27
OFDI dummy	0.05	0.21	0.14	0.34
OFDI intensity (Indian MNEs)	0.06	0.13	0.12	0.25
Size	3.33	1.56	3.30	1.99
Total factor productivity (log)	-4.66	1.29	-4.23	1.54
Cash flow ratio	0.15	0.97	0.19	0.73
Age	21.76	17.72	24.36	17.51

Note: see table 1A in the appendix for the exact definition of the variables.

Table 3: Technology investment, exporting and OFDI

Dependent variable: technology investment

	Without controlling for firm's heterogeneity		Accounting for firm's heterogeneity (Models with FDI-export interaction)				
	Baseline Model (1)	Model with FDI-export interaction (2)	(3)	Accounting for potential endogeneity			
				Unbalanced Panel (4)	Balanced panel (5)	Unbalanced Panel (6)	Balanced panel (7)
Exports	0.0054**	0.0036	0.0012	-0.0016	-0.0095	-0.0010	-0.0095
	(0.0026)	(0.0027)	(0.0044)	(0.0098)	(0.0107)	(0.0099)	(0.0107)
OFDI	0.0056	-0.0111*	-0.0143**	-0.0366***	-0.0615***	-0.0161	-0.0403**
	(0.0058)	(0.0065)	(0.0066)	(0.0130)	(0.0109)	(0.0161)	(0.0164)
Exports*Indian MNEs		0.0134***	0.0123**	0.0109**	0.0141*		
		(0.0050)	(0.0052)	(0.0054)	(0.0079)		
Exports of Indian MNEs interacted with quintiles of OFDI							
Exports*Quintile 1						0.0152***	0.0231***
						(0.0055)	(0.0070)
Exports*Quintile 2						0.0147*	0.0291**
						(0.0083)	(0.0129)
Exports*Quintile 3						0.0059	-0.0002
						(0.0094)	(0.0083)
Exports*Quintile 4						0.0046	0.0061
						(0.0092)	(0.0108)
Exports*Quintile 5						-0.0108	-0.0092
						(0.0087)	(0.0115)
Control variables	yes	yes	yes	yes	yes	yes	yes
Average values of the control variables	no	no	yes	yes	yes	yes	yes
Residual terms from reduced-form estimations of potential endogenous variables	no	no	no	yes	yes	yes	yes
Observations	1641	1641	1641	914	521	914	521

Notes:

a. All results based on a pooled Tobit model
b. Marginal effects on the expected amount of technology investments are calculated at the sample means of the regressors.
c. Standard errors (clustered at firm level) in parentheses
d. *significant at 10%; ** significant at 5%; *** significant at 1%

All specifications include the full set of time dummies.

Table 4: Technology investment, exporting and OFDI

Dependent variable: technology investment

Robustness checks

	Modelling unobserved heterogeneity as a function of all the history of the covariates				Allowing for unobserved heterogeneity to be correlated with the regressors in an unrestrictive way			
	Unbalanced panel (1)	Balanced panel (2)	Unbalanced panel (3)	Balanced panel (4)	Unbalanced panel (5)	Balanced panel (6)	Unbalanced panel (7)	Balanced panel (8)
Exports	-0.0059	-0.0059	-0.0054	-0.0054	0.0040	0.0110	0.0045	0.0119
	(0.0096)	(0.0096)	(0.0095)	(0.0095)	(0.0059)	(0.0103)	(0.0059)	(0.0102)
OFDI	-0.0593***	-0.0593***	-0.0536**	-0.0536**	-0.0372**	-0.0480***	-0.0023	-0.0081
	(0.0143)	(0.0143)	(0.0216)	(0.0216)	(0.0166)	(0.0173)	(0.0222)	(0.0271)
Exports*Indian MNEs	0.0127*	0.0127*			0.0270***	0.0320**		

	(0.0071)	(0.0071)			(0.0104)	(0.0154)		
Exports of Indian MNEs by quintiles of overseas investments								
Exports*Quintile 1			0.0203***	0.0203***			0.0334***	0.0524***
			(0.0067)	(0.0067)			(0.0106)	(0.0181)
Exports*Quintile 2			0.0065	0.0065			0.0485***	0.0583***
			(0.0065)	(0.0065)			(0.0150)	(0.0145)
Exports*Quintile 3			-0.0017	-0.0017			-0.0026	0.0010
			(0.0078)	(0.0078)			(0.0172)	(0.0178)
Exports*Quintile 4			0.0097	0.0097			0.0241	0.0287
			(0.0091)	(0.0091)			(0.0158)	(0.0173)
Exports*Quintile 5			0.0040	0.0040			-0.0051	-0.0069
			(0.0128)	(0.0128)			(0.0214)	(0.0259)
Residual terms from reduced-form estimations of potential endogenous variables	yes	yes	yes	yes	no		no	no
Leads and lags of the regressors	yes	yes	yes	yes	no	no	no	no
Obs	521	521	521	521	1641	689	1641	689

a. All results in the first four columns are based on a pooled Tobit model. Marginal effects on the expected amount of technology investments are calculated at the sample means of the regressors. Note that modelling firm's heterogeneity as a linear function of all the leads and lags of the covariates forces the panel to be balanced. Hence, results in column 2 (4) are identical to those in column 1 (3).
b. Results in the last fourth columns are obtained using a linear fixed effects model.
c. Robust standard errors in parentheses
d. *significant at 10%; ** significant at 5%; *** significant at 1%

All specifications include the full set of time dummies.

Appendix

Table 1A

Variable	Definition
Technology investment	The sum of real expenditures on own R&D, computers, software, royalty fees and imports of capital goods normalized by total assets
Size	Log of total sales
Total factor Productivity	Log of total factor productivity estimated based on 3-input (labour cost, value of fixed capital and cost of intermediate material inputs) production function using the Levinshon-Petrin (2003) technique which accounts for the endogeneity of inputs.
Age	Firm age since incorporation.

Exports intensity	Exports/total sales
Cashflow ratio	Cash flow/tangible fixed assets
Outward foreign direct investment (OFDI)	Investment by Indian multinationals in their overseas subsidiaries normalized by total sales.
Indigenous firms' multinational status (MNE)	Dummy variable equal to one if the Indian firm is engage in overseas investment, zero otherwise.

Table 2A: Technology investment, exporting and OFDI

Dependent variable: technology investment

	Without controlling for firm's heterogeneity		Accounting for firm's heterogeneity (Models with FDI-export interaction)				
	Baseline Model (1)	Model with FDI-export interaction (2)	(3)	Accounting for potential endogeneity			
				Unbalanced Panel (4)	Balanced panel (5)	Unbalanced Panel (6)	Balanced panel (7)
Size	0.0039***	0.0037***	0.0037**	0.0023	0.0003	0.0024	0.0004
	(0.0006)	(0.0006)	(0.0015)	(0.0022)	(0.0029)	(0.0022)	(0.0029)
Productivity	-0.0006	-0.0003	0.0010	0.0017	0.0011	0.0013	0.0005
	(0.0007)	(0.0007)	(0.0014)	(0.0024)	(0.0028)	(0.0024)	(0.0028)
Cash flow ratio	0.0005	0.0006	0.0000	0.0002	-0.0026	-0.0000	-0.0023
	(0.0008)	(0.0008)	(0.0008)	(0.0036)	(0.0041)	(0.0035)	(0.0040)
Age	0.0001*	0.0001*	-0.0010	0.0002	0.0000	0.0003	0.0000
	(0.0001)	(0.0001)	(0.0008)	(0.0011)	(0.0001)	(0.0011)	(0.0001)
Private group	-0.0001	-0.0001	0.0000	0.0005	0.0012	0.0004	0.0011
	(0.0018)	(0.0017)	(0.0018)	(0.0022)	(0.0029)	(0.0023)	(0.0029)
State ownership	-0.0119***	-0.0114***	-0.0114***	-0.0138***	-0.0191***	-0.0137***	-0.0189***
	(0.0041)	(0.0041)	(0.0042)	(0.0048)	(0.0040)	(0.0048)	(0.0039)
Exports	0.0054**	0.0036	0.0012	-0.0016	-0.0095	-0.0010	-0.0095
	(0.0026)	(0.0027)	(0.0044)	(0.0098)	(0.0107)	(0.0099)	(0.0107)
OFDI	0.0056	-0.0111*	-0.0143**	-0.0366***	-0.0615***	-0.0161	-0.0403**
	(0.0058)	(0.0065)	(0.0066)	(0.0130)	(0.0109)	(0.0161)	(0.0164)
Exports*Indian MNEs		0.0134***	0.0123**	0.0109**	0.0141*		
		(0.0050)	(0.0052)	(0.0054)	(0.0079)		
Exports of Indian MNEs by quintiles of overseas investments							
Exports*Quintile 1						0.0152***	0.0231***
						(0.0055)	(0.0070)
Exports*Quintile 2						0.0147*	0.0291**
						(0.0083)	(0.0129)
Exports*Quintile 3						0.0059	-0.0002
						(0.0094)	(0.0083)
Exports*Quintile 4						0.0046	0.0061
						(0.0092)	(0.0108)
Exports*Quintile 5						-0.0108	-0.0092
						(0.0087)	(0.0115)
Average values of the control variables							
Size			-0.0002	0.0016	0.0025	0.0015	0.0024
			(0.0014)	(0.0022)	(0.0027)	(0.0022)	(0.0026)
Productivity			-0.0016	-0.0025	-0.0037	-0.0020	-0.0031
			(0.0014)	(0.0022)	(0.0028)	(0.0022)	(0.0028)

Cashflow ratio			0.0018	0.0012	0.0031	0.0011	0.0031
			(0.0025)	(0.0028)	(0.0047)	(0.0028)	(0.0047)
Age			0.0011	-0.0001	0.00001	-0.0002	0.00001
			(0.0008)	(0.0011)	(0.0001)	(0.0011)	(0.0009)
Exports			0.0028	0.0059	0.0123	0.0053	0.0120
			(0.0057)	(0.0106)	(0.0137)	(0.0107)	(0.0136)
OFDI			0.0085	0.0272	0.0563**	0.0478**	0.0772***
			(0.0148)	(0.0209)	(0.0225)	(0.0222)	(0.0235)
Residual terms from reduced-form estimations of potential endogenous variables							
Size				0.0048**	0.0049**	0.0048**	0.0050**
				(0.0023)	(0.0020)	(0.0023)	(0.0020)
Productivity				-0.0056***	-0.0046*	-0.0055***	-0.0045*
				(0.0021)	(0.0025)	(0.0020)	(0.0024)
Cashflow				-0.0006	0.0011	-0.0005	0.0008
				(0.0033)	(0.0040)	(0.0033)	(0.0039)
Exports				-0.0034	0.0029	-0.0038	0.0030
				(0.0076)	(0.0087)	(0.0077)	(0.0088)
OFDI				0.0268**	0.0451***	0.0217*	0.0404***
				(0.0130)	(0.0112)	(0.0127)	(0.0100)
Observations	1641	1641	1641	914	521	914	521

Notes:

a. All results based on a pooled Tobit model
b. Standard errors (clustered at firm level) in parentheses
c. *significant at 10%; ** significant at 5%; *** significant at 1%

All specifications include the full set of time dummies