

Outward FDI and Knowledge Flows: A Study of the Indian Automotive Sector

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Abstract: In recent years developing countries have emerged as significant participants in the OFDI (outward foreign direct investment), seeking strategic assets. Such asset exploiting-cum-augmenting OFDI involves potential two-way cross-border knowledge flows. This study examines several dimensions of OFDI in the Indian automotive industry – currently internationalizing rapidly in terms of OFDI. This study undertakes a quantitative analysis of the influence of OFDI activities on the in-house (domestic) R&D performance of the Indian automotive firms during 1988-2008, and finds expected favourable impact on the R&D intensity. The study concludes with suggestions to promote OFDI, particularly the strategic asset enhancing OFDI.

Keywords: OFDI, knowledge flows, strategic asset-seeking FDI, R&D, automobiles

JEL classifications: F21, F23, O32, L62

1. Introduction

It is now widely acknowledged that outward foreign direct investment (OFDI) can play an important role in cross-border knowledge flows in many industries. The home country tends to benefit from technological learning and knowledge spillovers if it invests in relatively innovation-intensive foreign countries. This is especially true for developing country firms undertaking OFDI in R&D-driven developed countries. Also the FDI host countries receive knowledge flows as the inward FDI brings with it a bundle of knowledge assets in the form of new products, technologies, skills, managerial practices, new capital equipment, etc.

Traditionally, the innovation-driven developed countries have been the major source of global FDI and the associated knowledge flows. Very recently, a new and diversified pattern of FDI is emerging with an increasing participation of developing country firms in outward foreign direct investment, also to developed countries for seeking strategic assets and markets. Therefore, the FDI-led unidirectional pattern of knowledge flows from the

home to host nation is no longer a valid characterization. While there is an increasing emphasis on technology sourcing motives of firms from India, China, Korea, Taiwan and other developing home countries entering into developed countries (Dunning, Hoesel and Narula, 1996; Chen and Chen, 1998; Hoesel, 1999; Poon and MacPherson, 2005; Pradhan and Abraham, 2005; UNCTAD, 2006; Pradhan, 2008a, b; Gammeltoft, 2008), the empirical evidence on knowledge flows/spillovers from such activities to the home country and outward investing firms are still lacking.

Given this backdrop, the aim of this paper is to investigate the cross-border knowledge flows between the home and the host countries, taking the case of OFDI from the Indian automotive sector; the paper focuses on the technological gains to the outward investors. India has made considerable progress in building domestic capability in this technology-intensive industry and is now emerging as a global centre for automotive manufacturing (Singh, 2007; KPMG, 2007). The Indian vehicle manufacturers and auto component companies with their cost competitive and quality engineering products and services are emerging as developing country participants in the global/regional automotive value chains. The rise of OFDI from such a technology-intensive and export oriented industry based in a developing nation clearly offers an interesting case study for understanding the process of cross-border knowledge flows.

The subsequent analysis in this study is structured as follows: Section 2 begins with a summary of the process of technological capability formation and learning in the Indian automotive sector. It examines the crucial links between the technological activities of domestic automotive firms and changing government policy regimes with respect to inward FDI and technology, etc. Section 3 discusses the various potential cross-border knowledge flows associated with the outward FDI, with special reference to the Indian automotive sector; various dimensions of OFDI from this sector are examined further. Section 4 undertakes a quantitative analysis of the link between OFDI and in-house R&D performance of the Indian automotive firms during 1988-2008. The basic objective is to explore whether the OFDI status and OFDI intensity serve as channels of knowledge inflows to stimulate the R&D of outward investing firms. Section 5 concludes the study with a few policy remarks.

2. Technological Capability Building and Learning

In India the period after independence till the 1970s was a period of pervasive regulation and protection for the automotive sector as well (Kathuria, 1996; Singh, 2007); the virtual sellers' (domestic) market left little incentive for R&D and technology upgradation.¹ The policy changes during the 1980s

introduced limited liberalization of industrial licensing, inward-FDI and technology import, paving way for internal competition in this sector. However, the car segment had a near monopoly by Maruti-Suzuki, an Indo-foreign JV concluded in the early 1980s. Maruti emphasized timely delivery and quality culture among its auto component suppliers.

Notwithstanding the negative impacts of restrictive policies, the pre-1990s phase saw the Indian automobile companies being forced to go for local production rather than just assembling imported parts. This created an indigenous supply base in the automotive sector, of course, with low technology and suboptimal scale of production. The policy emphasis on indigenization – through quantitative and qualitative import controls – and external local procurement (vs. in-house production) of auto components provided a boost to the domestic auto ancillary sector.

The July 1991 Industrial Policy abolished the compulsory industrial licensing requirement for the automotive sector (excepting the car segment), and allowed automatic approval of inward-FDI up to 51 per cent foreign equity (higher foreign equity needed an approval). These changes were introduced for the car segment in 1993 and 1997 respectively. The 1991 Policy also liberalized the technology import in general. Later the 1997 Auto Policy imposed the trade-balancing and localization obligations on vehicle producers. The Auto Policy 2002, doing away with these requirements, has permitted automatic approval of foreign equity investment up to 100 per cent for the manufacturing facilities for automobiles and auto components.

A number of international vehicle producers entered India during the mid-1990s, bringing along also many of their preferred global vendors of auto components. Some other major vehicle producers started their component sourcing operations in India. This implied intense domestic competition and significant potential knowledge spillovers for the locally-owned firms. The falling tariffs on automotive products since July 1991 and the dismantling of quantitative import restrictions in early 2001 have contributed to the increasing competition.

The recent technological and competitive capability developments of the Indian automotive firms have been strongly supported by a network of institutions with the State playing a lead role. Box 1 summarizes the major recent policy initiatives for the automotive sector; for brevity, our comments/remarks on these measures have been mentioned there only. Besides the strategic State interventions (facilitation), there has been remarkable institutional support from the automotive industry associations. Both the ACMA (Automotive Component Manufacturers Association of India) and SIAM (Society of Indian Automobile Manufacturers) have been actively networking with automotive bodies and overseas associations, and at various policy fora. In recent years the SIAM and ACMA have been

Box 1: Major recent policy measures/initiatives for the Indian automotive sector

Policy	Remarks/Details
Through appropriate support measures, the March 2002 Auto Policy aims to make India a global hub for automotive components and a regional hub for small cars, and promises to encourage the R&D and vehicle designing.	Advancing the 1990's FDI liberalization, this Policy allows automatic approval of 100% foreign ownership.
In 2003 a Core Group on Automotive Research (CAR) , involving the government, industry and academia, was formed (under TIFAC, DSIR, Delhi).	<ul style="list-style-type: none"> • The 2006 Technology Roadmap identified the priority topics for R&D. • The consortium technology projects involve the research institutes, and tech intensive SMEs and automotive firms.
Since July 2004, 150% deduction of R&D expenses from taxable income has been allowed.	Currently this Scheme is valid till March 2012.
<ul style="list-style-type: none"> • The National Automotive Testing and R&D Infrastructure Project, NATRIP was approved in July 2005 to enhance and upgrade the testing and validation infrastructure, and establish centres of excellence for automotive R&D. • It involves an investment of approx. \$380 million (Rs.17.18 billion, of which the Industry would contribute Rs.1.18 billion) over a 6 year period. 	<ul style="list-style-type: none"> • Expected to harness the Indian strengths in automotive engineering, IT and electronics; thus to encourage the automotive exports, including 'OEM/Tier Level' exports and outsourcing of design & engineering services, and to crowd-in private investment in R&D/innovation. • It would spur the systems solution capabilities of the Indian auto component firms and Indo-foreign JVs (Singh, 2009).
<ul style="list-style-type: none"> • In February 2006 India became a contracting party (voting member) of the 1998 GTR Agreement. The exposure to frontier technologies would facilitate global integration of the Indian automotive industry. • India has formed six 'WP.29 India Working Groups' for different auto component categories. 	<ul style="list-style-type: none"> • The 1998 GTR Agreement aims at developing through wide participation the Global Technical Regulations (GTRs) for automotive products, bearing on the vehicle safety, fuel efficiency and emissions. • At present India is not a signatory to the 1958 GTR Agreement, which imposes reciprocity for any Regulation adopted by a contracting party; India is an Observer, and is assessing the option of signing it.

Box 1: (continued)

Policy	Remarks/Details
<p>NATRIP-VCA MoU: In October 2006, the NATRIP Implementation Society has signed a Memorandum of Understanding with the Vehicle Certification Authority (VCA) of U.K. for the issue of certificates in India after the testing at NATRIP Centres.</p>	<ul style="list-style-type: none"> • So far India had no homologation (vehicle road-worthiness) certification agency which is globally accepted. The automotive exporters have to send the products abroad for testing and approval – costly and irksome, especially for iterative product/process development. • It shall reduce the cost of certification.
<p>The 'Automotive Mission Plan (AMP) 2006-2016' launched in January 2007 recommends:</p> <ul style="list-style-type: none"> • setting up of Automotive training Institute and Auto Design Centre, Special Auto Parks and auto component virtual SEZs; • enhancing exports and related infrastructure and streamlining training/research institutions in and around auto hubs; • setting up of a Technology Modernization Fund, with special emphasis on SMEs; and, • encouragement to establishing Development Centres for SMEs. 	<ul style="list-style-type: none"> • The AMP 2006-2016 targets \$40-45 billion automotive exports in 2016, including \$20-25 billion component exports and \$2-2.5 billion outsourcing of engineering services, like IT-intensive designing & styling. It also targets \$145 billion total automotive turnover in 2016.
<p>Sources: ACMA sources; <i>ACT Now</i>, April 2008, Volume IV, pp. 12-13, ACT, ACMA; <i>Economic Times</i>, October 27, 2006; Singh (2007, 2009); www.natrip.in</p>	

focusing on the global competitiveness and technology-related issues. ACMA and its Division, ACT have undertaken several activities – e.g. six-sigma training; quality circles; the ACT-ATOS training programs; Young Business Leaders Forum – besides the Cluster Programmes to improve the quality and productivity levels of the ACMA Members (*ACMA News*, and *ACT Now*, various issues, ACMA).

As the external technology licensing has been progressively liberalized since the mid-1980s, the Indian automotive firms have resorted to an increasing import of foreign technology. In 1991 out of 118 firms in our dataset, there are as many as 56 automotive firms incurring technological spending on royalties and technical know-how fees as compared to

just 4 firms incurring in-house R&D. This corroborates that until early 1990s, Indian automotive firms relied more on purchase of disembodied technologies, detailed specifications, designs, patents and trademarks than conducting their own R&D. For various years during 1995-2007, the share of automotive firms incurring disembodied technological spending in total number of automotive firms varies in the range of 41-48 per cent. There are a number of firms which are spending above 2 per cent of their sales on technology purchase.

An analysis of R&D growth rate of the Indian automotive firms during 2000-2007 indicates that a number of them have adopted a continuous R&D strategy since the late 1990s or early 2000s, moving from the 'minimal R&D status' into a rapid growth path of R&D investment to go up the technology ladder (Pradhan and Singh, 2008). The openness of the Indian automotive sector to global competitive forces as well as the emission and safety regulatory changes have prompted the existing Indian automobile firms to have focused and consistent in-house R&D activities. The imposition of Euro norms for pollution control since the mid-1990s, and of stringent safety features since 2000, have involved much technological improvements and imports in the automobile segments.

These regulations, the heightened competition from inward FDI and imports, and the stringent requirements from global buyers have forced a significant proportion of large auto component firms into in-house R&D investment and foreign alliances. The Indian component suppliers to local and foreign OEMs (Original Equipment Manufacturers), particularly the direct (Tier-1) suppliers were pushed to adopt the global standards of quality and manufacturing practices. The trade-balancing and localization requirements, imposed on the new OEM investors under the 1997 Auto Policy, also contributed to the emphasis on improvements in the product quality, employees' skills and productivity of auto component producers (Singh, 2007; Balakrishnan et al., 2007; McKinsey & Company, 2006; Okada, 2004). The vehicle producers fulfilled the trade balancing requirements largely as exports of auto components.

The large and medium-sized automotive units are increasingly adopting the automotive industry-specific quality management system (QMS) ISO/TS 16949 Standard. ACMA (2008) mentions this accreditation for 2/3rd of its members (for 382 out of 558 firms). For the Indian auto component firms, an econometric analysis by Singh (2009) finds a significant favourable effect of the industry-specific harmonized QMS Standard on the export participation at OEM and high Tier 'Levels'.

The locally-owned automobile units in India have been successful in designing and developing 4-wheeler and 2/3-wheeler vehicle models. In the passenger car segment the examples are Tata Motors's car models *Indica*

(1999) and *Nano* (unveiled in early 2008), and Mahindra & Mahindra's multi-utility vehicle *Scorpio* (2002). The Indian vehicle producers have collaborations with the Indian and foreign universities and R&D institutes, and internationally with design, development and engine firms. At present the Indian automotive sector has considerable dependence on the technology import. Almost all major automotive firms in India have foreign financial and/or technical collaboration. In the auto component sector the R&D is still primarily oriented towards process development; the R&D intensity is generally low or zero, though a small number of firms spend over 2 per cent of their sales revenue on R&D.

Rasiah and Kumar (2008) in an econometric analysis find similar R&D intensity – the average of R&D expenses to sales ratio and R&D employment intensity – of foreign and local auto component firms; however, a simple comparison indicates a relatively high R&D intensity of foreign affiliates. In the vehicle sector the average R&D intensity of locally-owned units has been higher than that of foreign affiliates (Narayanan and Vashisht, 2008; Singh, 2007); Kumar and Aggarwal (2005) indicate such ranking among firms in the vehicle and auto component sector together during the 1990s.

The overall and exports growth of the Indian automotive industry have been impressive in recent years. The total Indian auto component turnover and exports have grown rapidly at 27.1 per cent and 36.6 per cent per annum during 2002-03 to 2007-08; the exports account for as much as 20 per cent of sectoral turnover in 2007-08, with a majority of the exports being sent to OEMs and Tier-1 firms. For the vehicle sector the total turnover and export values have grown at 12.3 per cent and 20.9 per cent per annum during 2002-03 to 2007-08; its overall export intensity is 9.3 per cent in 2007-08.²

Against this backdrop of technological capability building and export competitiveness, we analyze below the outward foreign direct investment by the Indian automotive firms and its impact on the domestic in-house R&D.

3. Outward FDI and Cross-Border Knowledge Flows

Following the early works of Caves (1974), Globerman (1979) and Blomstrom and Persson (1983), the empirical studies on flows of knowledge spillovers through FDI have tested mainly how the entry of foreign affiliates impacts the productivity levels of domestic sectors or enterprises. In addition to these researchers, a large number of scholars like Ari Kokko, Mona Haddad, Ann E. Harrison and Brian J. Aitken, among others, have made substantial contribution to the literature on FDI-led knowledge spillovers on the host nations/sectors or domestic companies (Fan, 2002; Görg and Greenaway, 2004). Their analysis is from the host country/sector viewpoint.

3.1 Knowledge Flows to Outward Investors

Recently, there is a growing recognition that the investing foreign firms may also be learning from local firms in the host country and absorbing learning and knowledge spillovers at host sites. This may be specially so for OFDI in relatively more innovation-intensive host economies than the home country. Here the FDI-led knowledge spillovers are considered from the perspective of outward investing firms.

Branstetter (2000) using patent citations data has found that with an increase in the number of their affiliates obtained through acquisition in the U.S., the Japanese firms showed an increased tendency to cite the US patents as 'prior art' in their U.S. patent application. Branstetter argued that the acquisitions have not only provided the Japanese firms access to the proprietary knowledge assets of the acquired US firm, but also the latter's informal technological networks and knowledge sharing relationships in the U.S. innovation system.

In the case of 13 industrial countries, Potterie and Lichtenberg (2001) provided evidence that outward FDI acts as a conduit of technology spillovers from R&D-intensive host countries to the home country, more so in the 1980s vs. 1970s. They found that the foreign R&D capital stock embodied in outward FDI flows possesses positive and highly significant output elasticity for the home countries. Specifically, home countries like Germany, France, the United Kingdom, Greece and Japan investing in the U.S. have benefited more from the U.S. R&D capital stock through their outward investments than through their imports of goods and services from the U.S. However, Bitzer and Kerekes (2008) did not find a positive effect of the OFDI on home industry-output for OECD data. Another study (Bertrand and Zuniga, 2006) covering 14 OECD countries during 1990-1999 failed to find a significant impact of outward M&A on private R&D at the industry-level.

Braconier, Ekholm and Knarvik (2001) based on Swedish data reported no evidence of outward FDI-related R&D spillovers from OECD countries at the industry level productivity. As for the productivity of home operations of the MNE, the OFDI measure using the foreign affiliates' R&D spending as weights has a significant positive effect, implying a facilitative role of the R&D undertaken abroad by the OFDI investor in absorbing the foreign R&D results; the foreign affiliates' employment weighted measure of OFDI has a negative effect. They argued that the OFDI associated reversed technology flows/spillovers may be limited among nations having similar technology levels.

There is hardly any study on outward FDI and knowledge spillovers in the case of home developing countries. This is notwithstanding the increasing trend of developing country firms using outward FDI as a strategy of acquiring technological assets and skills. For a sample of Taiwanese firms,

Makino, Lau and Yeh (2002) found that the firms were more likely to invest abroad in developed than in developing nations when they had strategic asset-seeking motivations and prior experience of technology-seeking from developed country firms through licensing or OEM contracts; their perceived technological advantage over their domestic competitors had a similar effect.

The Chinese overseas investment has been dominated by the motive to develop trading infrastructure and to secure access to natural resources and raw materials. However, of late, a number of Chinese firms, such as Haier, TCL, Lenovo, Nanjing Automobile, and Shanghai Automobile, have undertaken OFDI primarily with a view to acquire foreign technology and management skills (Cai, 1999; Rui and Yip, 2008; Wang and Boateng, 2007); Rui and Yip provide evidence on the motives of Chinese overseas acquisitions during 2000-04.

Pradhan and Abraham (2005) observed 78 per cent of the Indian overseas acquisitions during 2000-2003 were being directed to developed countries. It reflects the Indian firms' desire to access large markets and to acquire firm-specific intangible assets like goodwill and brand names, technologies, marketing and distribution networks, and business expertise. The fact that the Indian acquirers from manufacturing sectors are large-sized and generally having relatively high R&D-intensity indirectly points that they possess critical absorptive capacity to effectively integrate the acquired foreign intangible assets.

The rising tendencies of developing country firms using OFDI to access new knowledge assets in (relatively) developed countries can be analyzed from the perspective of resource-based theory of the firm. Southern firms based in less innovative developing regions possess a relatively narrow range and intensity of knowledge competencies and need to improve their competitive advantages in globalizing markets. The OFDI for this purpose is likely to be biased towards advanced industrialized countries as they are relatively more endowed with the assets like technical knowledge, learning experiences, management expertise and organizational competence (Dunning, 1998). The strategic assets motive can be realized both through greenfield and brownfield outward investments, i.e. through the new or acquired facilities.

Theoretically, strategic acquisitions provide a quicker and an alternative way of acquiring innovative capabilities than undertaking long term in-house R&D efforts without any assured success (Deng, 2007; Pradhan, 2008b). Following the resource based view of the firm (Barney, 1991) it can be suggested that the developing region firms seeking these capabilities are more likely to engage in merger and acquisitions (M&As) as a strategy to quickly expand their knowledge base to meet growing competition (Gupta and Roos, 2001). For developing country acquirers having intermediate competencies, acquisitions allow them to achieve a higher bundle of resources or

capabilities by integrating the target's firm-specific valuable resources like product development capabilities, process know-how, managerial expertise, marketing skills, relationships and networks. This transfer of knowledge from the target to acquirer is direct and can be expected to create technological synergies that the parent company does not enjoy on its own. The OFDI is expected to enhance the competitive advantages of the investor firm, even vis-à-vis its domestic competitors in the home country.

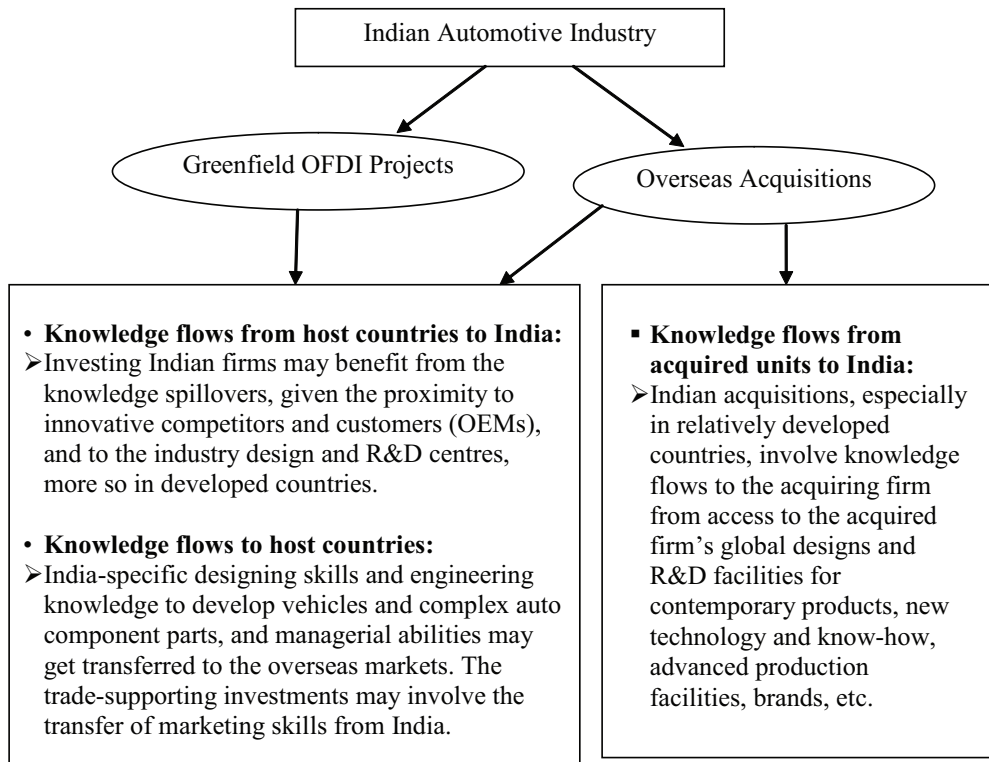
The OFDI – both as greenfield or brownfield investment – is likely to act as a channel of appropriating the potential externalities from the technology clusters and centres of innovation and excellence in the host developed country, i.e. the technological externalities associated with such locations. The OFDI may help to improve the investing firm's global visibility and its confidence in its own technological capabilities, and may enable a quick learning on the design and other preferences of customers in the host country (Deng, 2007). The OFDI facilitates more focused marketing, anticipating the customers' requirements, and learning about delivery norms and product liability issues.³ In this way, the proximity to centres of demand and technology through OFDI may help the outward investing firms in technological catching up with global competitors, buyers and suppliers.

3.2 Asset-Augmenting OFDI by Indian Automotive Firms

In the context of outward FDI from the Indian automotive sector, the potential bi-way knowledge flows between India and the host countries can be predicted (Figure 1). The Indian vehicle and automobile part companies have been substantially improving their designing and engineering service capabilities. As mentioned above, the Indian vehicle companies like Tata Motors, and Mahindra & Mahindra have shown remarkable strength in designing and building new vehicles. The Indian auto ancillary manufacturers too have experienced rapid upgradation of their manufacturing and quality capabilities. With these growing competitive strengths the Indian automotive firms are internationalizing their business activities. The outward investing Indian automotive firms have been seeking strategic assets. This is so even when the initial motivation for undertaking manufacturing abroad is market-seeking, including gains from the insider status based on the rules of origin under the preferential trade agreements of the host nation.

As per the industrial organization theory of FDI (Hymer, 1960; Kindleberger, 1969; Caves, 1971) and the OLI (ownership-location-internalization) eclectic approach (Dunning, 2001), the outward investment activities of the Indian automotive firms may partly be motivated to exploit their existing ownership or competitive advantages. The trade-supporting OFDI involves the outflows of specialized marketing skills of the Indian automotive firms. In the

Figure 1: Potential knowledge flows through types of Indian OFDI



case of OFDI for overseas production, also the firm-specific manufacturing and technological advantages of the investing firms may get transferred to the host countries.

The potential knowledge benefits to the outward investing automotive firms may be related to certain pertinent features of this industry. The automotive customers buying critical components and modules spend considerable time and effort in selecting the suppliers, implying high fixed costs in switching the suppliers. The auto component producers view the outward FDI as a gateway strategy to reach global OEMs – particularly the established customers of the acquired company. The direct supply relations with global automotive firms provide the supplier with opportunities of product and process developments and modifications through mutual learning and regular interactions (Singh, 2009). Thus, seeking access to major OEMs is not merely for the marketing of products, it is an important channel for knowledge flows in future. The OEMs may even expect system solutions from their Tier-1 suppliers. Moreover, the major OEMs and even some Tier-1 buyer firms insist upon the just-in-time delivery, especially for assemblies and sub-assemblies of components.⁴ Hence for the direct supplies to global OEMs, being close to the OEMs and the industry design centres is important.

For vehicle producers, having overseas operations in the vicinity of innovation networks and the industry design centres is directly useful. Again, there is a great potential for outsourcing automotive R&D, designing and engineering services from India. These outsourcing opportunities can be realized better with the Indian OFDI for automotive manufacturing and setting up R&D/technical/engineering centres. The outward investors may outsource some of these services from India. In fact, a number of Industrial Groups based in India which produce automotive products in India as well abroad have also their Group enterprises operating in these related areas. Thus the automotive manufacturing operations or R&D/technical centres abroad of these Groups imply potential knowledge flows for these service establishments too.

The growing cases of strategic asset acquisitions undertaken by the Indian automotive firms clearly involve inflows of new and complementary competencies. In the auto component sector global Tier-1 firms possess the product knowledge (many of these firms are already in India, also through alliances), while a lot of process technology resides with large Tier-2/3 firms in Europe (ACMA, 2008, p. 40). Strategic alliances with or acquisition of these Tier-2/3 firms would provide the Indian auto component sector access to both product and process proprietary technologies covering the entire supply chain. The vehicle sector acquisitions, relatively less in number, are usually acquisitions of some parts/business of a firm along with the proprietary technology, skills, brands, marketing and distribution centres, existing network of procurement, etc.

3.3 Extent of Outward FDI by Indian Automotive Firms

The automotive firms are observed to be early outward investors from the Indian economy.⁵ Probably their OFDI activities started since early 1970s. Tables 1 to 3 provide statistical information on greenfield and brownfield OFDI from the Indian automotive sector.

3.3.1 Greenfield OFDI Flows

After establishing modest manufacturing capabilities and frugal engineering skills, in the 1970s in order to exploit their competitive advantages and intermediate technology a few Indian automotive companies established auto component manufacturing operations in select developing countries with the local partners. The 1970s was also a period of severe controls on domestic expansion of large firms in India. The 1980s witnessed a number of new OFDI investors along with entry into developed countries like USA, Germany and Greece. During 1980-89, 6 Indian companies undertook OFDI

in 3 manufacturing joint ventures and 3 marketing ventures as wholly-owned subsidiaries (Table 1). Though the amount of OFDI investment outflow was small, the automotive sector OFDI was undertaken also for overseas vehicle assembling and marketing. The 1990s witnessed a revival in terms of the OFDI investment flow; the number of outward investing firms increased as well.

Table 1: Greenfield OFDI from Indian automotive sector, 1970-2007

Period	OFDI Value (US\$ million)			Number of Host Countries		
	Auto Components	Vehicles	Total	Developed	Developing	Total
1970-79	2.6 (5)	2.1 (1)	4.7 (6)		3	3
1980-89	0.2 (2)	0.6 (4)	0.8 (6)	3	2	5
1990-99	3.4 (6)	9.0 (5)	12.4 (10)	5	5	10
2000-07*	164.4 (43)	566.1 (8)	730.5 (50)	8	14	22
All years	170.6 (52)	577.8 (11)	748.5 (63)	9	18	27

Notes: Number of investing firms is in parenthesis; * Data for 2001 is only from January to March; 2002 data is from October to December; and 2007 data is from January to March.

Source: Calculation based on a dataset compiled from unpublished remittance-wise information from Reserve Bank of India, published reports of the Indian Investment Centre and unpublished firm-level information from the Ministry of Commerce.

The period 2000-07 represents a distinct rise in OFDI flows from this sector with US\$730 million worth of greenfield OFDI undertaken by a total of 50 Indian automotive firms. Another noteworthy change is in terms of the ownership pattern of greenfield OFDI approvals. In the 1990s a majority of the OFDI projects undertaken were joint ventures, even for developed host countries; all the investment approvals for developing countries were joint ventures then. However, during 2000-07 the wholly-owned subsidiary mode was strongly preferred (and permitted); 86 per cent of the total approvals were in this mode.

In terms of the geographical diversity the Indian greenfield OFDI in the automotive sector has grown to cover 9 developed and 18 developing countries as host. Of the total Indian automotive greenfield OFDI flows of US\$748.5 million during 1970-2007, developing countries host US\$547.8 million, i.e. about 3/4th (73 per cent) of the OFDI. Developing countries are

still the focus area for the greenfield projects. The host developing countries are expected to benefit from the research findings and skills that the Indian parent companies supply to their overseas enterprises. The Southern countries having factor conditions similar to India can be expected to get ‘somewhat intermediate’ technologies best suited to their level of economic development and consumer preferences.

3.3.2 Brownfield OFDI Flows

Very recently overseas acquisitions have gained prominence in the outward investment strategy of Indian automotive firms. During 2002-2008 as many as 58 overseas acquisitions were concluded by a total of 30 Indian automotive firms involving US\$1,129 million (Table 2). An important aspect of these brownfield investments is that a majority of the acquisitions are of firms in developed countries, unlike the greenfield outward FDI where developing region is the major destination. There are a total of 13 developed countries hosting acquisitions by Indian automotive firms, as compared to just 6 developing countries. Within the developed region, Europe, led by the UK and Germany, is the most dominant sub-region in attracting the Indian automotive brownfield investment (Table 3). The U.S. is the third important host country destination. Clearly, the Indian automotive acquisitions have been more concentrated in technology-intensive developed countries. Even

Table 2: Overseas acquisitions by Indian automotive firms, 2002-08

Year	Acquisition in US\$ Million*	Acquisition Deals	Acquiring Indian Firms	In Number		
				Target Countries		
				Developed	Developing	Total
2002	7.4	2	1	1		1
2003	41	4	3	2		2
2004	133	7	7	3	3	6
2005	288	16	14	7	2	9
2006	200.5	15	12	5		5
2007	380	10	9	5	2	7
2008 (Jan-March)	79.3	4	4	4		4
All years	1129.2	58	30	13	6	19

Note: * Value figures are only for those deals with disclosed amount.

Source: Based on dataset constructed from different reports from newspapers, magazines and financial consulting firms like *Hindu Business Line*, *Economic Times*, *Financial Express*, *Business World*, Grant Thornton India, etc.

Table 3: Regional composition of Indian automotive overseas acquisitions, 2002-08

Region/Country	Acquisition in US\$ Million	In Number	
		Acquisition Deals	Acquiring Indian Firms
<i>Developed region</i>	1002.2	51	28
USA	217.4	12	11
Europe	779.8	38	22
Germany	378	13	10
UK	231.8	15	9
<i>Developing region</i>	127	6	5
South Africa		1	1
China	8	2	2
South Korea	102	1	1
Malaysia		1	1
Singapore	17	1	1
<i>S.-E. Europe: Romania</i>		1	1
Grand Total	1129.2	58	30

Note and Source: Same as for Table 2.

the developing countries hosting brownfield OFDI from India are generally nations having significant automotive manufacturing, like China, South Korea, Malaysia and South Africa – the emerging automotive markets; therefore, these OFDI ventures have potential knowledge spillovers for the investing firms.

The Indian automotive firms are using brownfield OFDI for strategic asset-seeking. In the company press releases and the managerial comments on their acquisition deals, the Indian automotive firms have highlighted several technology related motives. The stated motives include seeking new products or service areas, new technologies and skills and operational synergy, in addition to the market access and enhancing global scale (Pradhan and Singh, 2008, Table 9). KPMG (2007, p. 18) reiterates similar drivers of overseas M&As by auto component firms. A majority of the overseas automotive sector acquisitions are of 100 per cent equity stake or close to it.

Overall, the massive increase in OFDI flows – both greenfield and acquisition types – from the Indian automotive sector since around 2003 may be explained as: (i) a number of the Indian automotive firms reaching a threshold level of global competitive advantages in terms of the technological

and other expertise, and (ii) the increasingly permissive OFDI policies in India since then. Also the heightened global and domestic competition, as well as the rising automotive exports from India and the need to provide local product and service support for exports have accelerated the rise in OFDI flows from this sector. The set of automotive firms joining the OFDI process to exploit and augment their competitive capabilities is growing.

4. OFDI and Domestic R&D

The previous Section argues that the Indian automotive firms are transferring-out their modest knowledge and transferring-in foreign knowledge through the outward FDI projects. The cross-border knowledge inflow to the investing firm in the case of strategic acquisitions seems to be direct and somewhat immediate. However, the relationship between greenfield OFDI and inflows of foreign knowledge may not be direct. We believe that outward greenfield investment too contributes to the knowledge base of the Indian automotive firms, as a channel of international knowledge diffusion to the outward investing firms. The outward greenfield presence provides the proximity to innovative competitors, foreign R&D infrastructure, knowledge centres and research results. In addition, the outward investing Indian firms will get access to information on changes in global consumer preferences, safety standards, packaging style, etc. Under the growing international competitive pressures, the Indian parent firms in turn are expected to internalize this inflow of foreign information to improve their competitive capabilities. Therefore, the outward greenfield presence may help the Indian automotive firms to learn from the technological developments and strategies of competitors in foreign countries and to move to a dynamic path of innovation. *Ceteris paribus*, appropriating the technological externalities is likely to be directly linked to the in-house R&D of the firm; the R&D enables better identification and assimilation of external knowledge. Hence, the outward investing Indian automotive firms are expected to step up their R&D to absorb the spillovers from proximity to foreign research and innovation centres. For emerging multinationals, while the initiation of OFDI activity may be feasible with a minimum threshold of technological capabilities, and the OFDI may have asset-augmenting and asset-exploring objectives, the success as an MNE requires sustained commensurate R&D efforts to turn the new ideas and opportunities into technological assets.

In this Section we have made a preliminary attempt to test the hypothesis that the outward greenfield presence is a channel of foreign knowledge inflows to the Indian automotive firms. We investigate if the status and intensity of outward greenfield investment cause any systematic differences in the Indian automotive firms' R&D behaviours. A favourable influence on the investing

firm's in-house R&D activities may be inferred as an evidence of the cross-border knowledge inflow to the firm having undertaken OFDI.

4.1 Empirical Evaluation

We examine here the firm-level determinants of R&D intensity. Apart from the OFDI, as the existing literature suggests, there are several other variables that can explain the inter-firm variation in R&D activities (see for example, Lall, 1983; Siddharthan, 1988; Kumar and Aggarwal, 2005; Singh, 2006; Narayanan and Thomas, 2007). These factors are discussed below.

Firm Age: The age of the firm is a proxy for the firm's accumulated stock of tacit knowledge from learning-by-doing, as learning from its production, marketing, R&D and organizational experience. In the long run, older (surviving) firms tend to have relatively large endowments of quality competitive assets as less efficient firms disappear. With an increase in age, the firm learns progressively from its search to achieve optimal scale economies in production and marketing, which in turn can have complementary effects on its technological activities.

Firm Size: Following Schumpeter's assertion that innovation is the key to capitalist development and large-scale enterprises are the most powerful engines of economic progress, a positive relationship between firm size and R&D activities can be deduced (Lunn, 1982). The R&D, apart from being a risky activity, requires huge resources; the large-sized firms tend to have higher risk taking capabilities too. A theoretical model by Fishman and Rob (1999) showed that the R&D is more profitable for bigger firms, as the effect of cost reduction (implemented through R&D) applies to a larger customer base. There exist numerous empirical studies investigating the influence of firm size on R&D intensity with some pointing to a non-linear relationship.⁶

Technology Purchase: Most often firms resort to purchase of technology to strengthen their competencies in certain product characteristics or processes. With the external sourcing of technology, the firm may substitute it for the in-house R&D to develop technologies. However, the imported technological know-how may require adaptive R&D for product and input modifications to suit the local demand and factor conditions. Therefore, the relationship between technology licensing and in-house R&D may be substituting type or complementary, depending upon these two opposite effects. Apart from technology licensing, to gain competitive advantages the firms may import capital goods and equipments embodying new technologies. We estimate the effects of both disembodied and embodied technology purchase. For the effect of disembodied technology import, the existing empirical evidence is mixed. Narayanan and Thomas (2007) provided a brief survey; they found a positive effect for the Indian pharmaceutical firms, but significant only for the sub-

sample of outward investors. Singh (2006) examined the inter-dependencies among the R&D, (disembodied) import of technology and trade intensities in a simultaneous equation framework. For a sample of pharmaceutical firms she found the technology import and R&D intensities to be complementary, the relationship being significantly positive both ways.

Export-orientation: Another form of internationalization of operations, namely the participation in export markets is expected to enhance the technological awareness and increase the firm's commitment to quality and efficiency improvement on a continuous basis. These improvements are crucially linked to the strategic in-house R&D efforts. Hence the export intensity is predicted to have a positive influence on R&D intensity.

Inward FDI: With the foreign-owned firms receiving technology and know-how transfer from their parent companies they may skip undertaking substantial local R&D activities, particularly the frontier type innovations. However, in recent years many multinational enterprises have increased the extent of internationalization of their R&D activities. Since the parent firms are looking for new locations with low cost skilled manpower and high innovation potential, their foreign affiliates are increasingly being entrusted with important R&D activities. Given that India has developed a dynamic environment for innovation related to the automotive sector, the possibility of foreign firms doing substantial R&D beyond minor local adaptation is very high. The previous evidence for the Indian automotive sector (Section 2) does not support a significant positive relationship between the foreign ownership of the firm and its R&D intensity.

Profit Margin: In the context of rapidly escalating costs of technology development, the profitability performance of firms can have a bearing on their R&D activities. Higher profit margins of firms increase the size of internally generated resources potentially available for supporting a sustained in-house R&D programme. Thus more profitable firms may have larger R&D budgets, the effect being especially strong in highly research-intensive sectors. However, Hundley, Jacobson and Park (1996) argued that unlike in the U.S., various stakeholders in Japanese companies have a long-term commitment to their enterprise. In Japan, when the short-term profitability declines, the firms are found to increase their R&D expenditures, viewing it as a strategy of longer-term growth and viability; the coefficient on one year lagged profitability is negative both for *kieretsu* members and other firms. Hence the attitude of key stakeholders, including managers and external financiers, character of capital market, etc. are important. *A priori*, for our sample we expect a positive impact of the firm profitability on R&D intensity.

Liberalization: As discussed above (Section 2), the Indian policy regime towards the automotive industry has become progressively outward looking and proactive over time. The dismantlement of industrial licensing, automatic

FDI approval, increased incentives for R&D, stringent safety standards, etc., are all liberalization and strategic policy measures that can have a favourable influence on the firms in-house R&D. In this study, covering the period 1988-2008 (1987-88 to 2007-08 financial years, ending March), we define three 1-0 dummies to represent progressive liberalization phases for the Indian automotive industry. LIBDUM1 represents the period 1988-1992 marked by relatively restrictive State policies (low liberalization). LIBDUM2 encompassing 1993-2002 is the liberalized phase exemplifying favourable industrial, trade, and FDI policies. LIBDUM3 spans 2003-2008 which, apart from having further liberalization, is the most active phase of State policies in terms of the R&D support and infrastructure, establishing required institutions, etc. In the estimation, the period 2003-2008 has been treated as the base with the inclusion of LIBDUM1 and LIBDUM2 dummies. We expect both these coefficients to be negative and a higher absolute value of the former.

Product Specialization: In the automotive sector, in general, primarily vehicle manufacturers are likely to have larger R&D requirements covering product designing, engineering and testing than companies which are only auto component producers. To capture this aspect, we have introduced a dummy variable, ACOMDUM, for firms that are exclusively into auto component production (i.e. not producing vehicles). It is expected to have a negative coefficient.

Outward FDI: The importance of outward FDI as a medium of learning and technological accumulation for investing firms has already been discussed. This variable measured in both dummy and intensity form is expected to play a positive role in the R&D activities of the Indian automotive firms.⁷ Alternatively, these two measurements of greenfield OFDI variable are analyzed from the angle of development status of the host region (namely host developed region versus host developing region) or that of ownership pattern (joint venture versus wholly-owned subsidiary).

Considering the regional dimension to outward FDI is important as there are theoretical reasons to postulate that the OFDI presence in innovative developed region would bring more intense cross-border knowledge flows to the investing Indian automotive firms than investing in developing region. The inflows of foreign knowledge can also be expected to differ between the joint venture and wholly-owned subsidiary types of OFDI. In the case of a joint venture OFDI, the Indian investing company may get an easier access to the local informal research networks in the host country. It can draw upon the technological information possessed by the joint venture partner. The joint ownership provides scope for cooperation in R&D, apart from getting useful information on markets, competitors and regulatory changes via the local partner. These possibilities do not exist in the case of only wholly-owned OFDI projects in a country.

The dependent variable in our study is the R&D intensity measured as total R&D expenses as a per cent of sales. Table 4 presents and defines the complete list of independent variables that are postulated to be affecting the R&D activities of the Indian automotive firms. Taking into account these variables, the empirical framework of the present study can be expressed as given below; ε_{it} is the random error term.

$$\begin{aligned} \text{RDINT}_{it} = & \beta_0 + \beta_1 \text{AGE}_{it} + \beta_2 \text{SIZE}_{it} + \beta_3 \text{DISTECH}_{it} + \beta_4 \text{EMTECH}_{it} + \beta_5 \text{EXPOINT}_{it} \\ & + \beta_6 \text{PROFIT}_{it} + \beta_7 \text{FDUM}_i + \beta_8 \text{LIBDUM1}_t + \beta_9 \text{LIBDUM2}_t \\ & + \beta_{10} \text{ACOMDUM}_i + \beta_{11} \text{OFDIDUM}_{it} \text{ (or OFDINT}_{it}) + \varepsilon_{it} \end{aligned} \quad \dots(\text{A})$$

4.2 Estimation Method and Data Sources

Our Equation (A) involves non-negative dependent variable censored at the lower end at zero value. When the error terms satisfy the classical assumptions, the application of Tobit-ML (maximum likelihood) estimation shall provide unbiased and consistent coefficient estimates as compared to biased estimates provided by ordinary least squares estimation. The present study has used Tobit estimation for estimating equation (A) with robust standard errors.⁸

This study covers a sample of 436 Indian automotive firms extracted from the Prowess database of the Centre for Monitoring Indian Economy (CMIE). The unbalanced panel dataset contains information for 1988-2008 (financial years 1987-88 to 2007-08), covering a total of 3,737 annual observations, of which 1,134 are R&D-performing and 2,603 are not R&D-performing observations. The firm-level stock of OFDI and the related variables have been calculated from a dataset compiled from unpublished remittance-wise information from the Reserve Bank of India, published reports of the Indian Investment Centre and unpublished firm-level information from the Ministry of Commerce. The Prowess information on equity share of foreign promoters in the Indian firms has been supplemented from the information on shareholding obtained from the Bombay Stock Exchange.⁹ The other firm-level variables have been computed using the Prowess database.

4.3 Impact of OFDI Presence

Tables 5 to 7 summarize the Tobit regression results on the determinants of R&D behaviour of the Indian automotive firms. High values of Wald Chi-Square statistics of estimated regressions suggest that they are statistically significant and the explanatory variables contribute importantly to the inter-firm differences in R&D intensity.

All the alternative OFDI dummy variables represented in different estimations in Table 5 generally come up with statistically significant coefficient with

Table 4: Description and measurement of variables

Variables	Symbols	Measurements
<i>Dependent Variable</i>		
R&D Intensity	RDINT	Total R&D expenses as a per cent of sales.
<i>Independent variables</i>		
Firm Age	AGE	Number of years from the year of incorporation.
Firm Size	SIZE	Annualized sales in Rs. million.
Technology Purchase	DISTECH	Expenses on royalties and technical know-how fees as a per cent of sales (disembodied technology purchase).
	EMTECH	Expenses on imports of capital goods and equipment as a per cent of sales (embodied technology import).
Export Intensity	EXPOINT	Exports of goods and services as a per cent of sales.
Inward FDI	FDUM	Assume 1 for firms having foreign promoter ownership of at least 10 per cent, 0 otherwise.
Profit Margin	PROFIT	Profits before tax as a per cent of sales.
Liberalization	LIBDUM1	Assume 1 for years from 1988 to 1992, 0 otherwise.
	LIBDUM2	Assume 1 for years from 1993 to 2002, 0 otherwise.
Product Specialization	ACOM_DUM	Assume 1 for auto component manufacturers, 0 otherwise.
Outward FDI	OFDIDUM	Assume 1 for firms with OFDI, 0 otherwise.
	OFDIDUM_D	Assume 1 for firms with OFDI in developed region, 0 otherwise.
	OFDIDUM_DL	Assume 1 for firms with OFDI in developing region, 0 otherwise.
	OFDI_JV	Assume 1 for firms with OFDI in joint venture form, 0 otherwise.
	OFDI_WOS	Assume 1 for firms with OFDI as overseas wholly-owned subsidiaries, 0 otherwise.
	OFDINT_L1	One period lagged OFDI intensity measured as OFDI stock as a per cent of total assets.
	OFDINT_DL1	One period lagged OFDI intensity in developed region.
	OFDINT_DLL1	One period lagged OFDI intensity in developing region.
	OFDINT_JVL1	One period lagged OFDI intensity in overseas joint ventures.
	OFDINT_WOSL1	One period lagged OFDI intensity in overseas wholly-owned subsidiaries.

Note: Two period lagged OFDI intensity variables are defined similarly.

Table 5: Tobit results on outward FDI status and R&D performance of Indian automotive firms

Independent Variables	Dependent Variable: R&D Intensity (%)				
	Coefficients (Robust z-value)				
	Total	Regional Dimension of OFDI		Ownership Structure of OFDI	
		Developed	Developing	JV	WOS
AGE	0.017452*** (11.17)	0.017880*** (11.49)	0.017780*** (11.39)	0.017388*** (11.12)	0.018045*** (11.60)
SIZE	0.000007*** (5.18)	0.000008*** (5.11)	0.000007*** (4.74)	0.000006*** (4.37)	0.000008*** (5.41)
DISTECH	0.140785*** (3.60)	0.135630*** (3.54)	0.137675*** (3.54)	0.138718*** (3.57)	0.134412*** (3.51)
EMTECH	-0.003251 (1.58)	-0.003265 (1.63)	-0.003201 (1.62)	-0.003153 (1.60)	-0.003257* (1.65)
EXPOINT	0.004991** (2.40)	0.005293** (2.55)	0.006234*** (3.02)	0.006101*** (2.96)	0.005861*** (2.82)
PROFIT	0.000098 (1.59)	0.000096 (1.55)	0.000096 (1.56)	0.000098 (1.59)	0.000095 (1.53)
FDUM	0.691080*** (9.19)	0.697354*** (9.23)	0.658417*** (8.80)	0.682994*** (9.08)	0.672392*** (8.94)
LIBDUM1	-2.106310*** (11.12)	-2.085800*** (11.03)	-2.112569*** (11.16)	-2.142829*** (11.27)	-2.084146*** (11.02)
LIBDUM2	-0.254612*** (3.66)	-0.247283*** (3.52)	-0.272907*** (3.94)	-0.284149*** (4.11)	-0.256963*** (3.66)
ACOM_DUM	-0.512255*** (5.19)	-0.576839*** (6.16)	-0.573119*** (5.99)	-0.546013*** (5.63)	-0.600038*** (6.48)
OFDIDUM	0.633528*** (5.13)				
OFDIDUM_D		0.614130*** (4.51)			
OFDIDUM_DL			0.518022*** (2.92)		
OFDIDUM_JV				0.730703*** (4.46)	
OFDIDUM_WOS					0.339435** (2.35)
Constant	-0.885317*** (7.08)	-0.838319*** (6.89)	-0.806261*** (6.67)	-0.825398*** (6.75)	-0.802334*** (6.66)
Log-likelihood	-3106.34	-3109.06	-3113.64	-3108.50	-3114.80
Wald chi ² (11)	598.49	544.40	567.28	588.56	522.93
Prob > chi ²	0.0000	0.0000	0.0000	0.0000	0.0000
Cragg & Uhler R ²	0.182	0.180	0.178	0.180	0.177

Notes: Number of observations having R&D and without R&D: 1,134 and 2,603. JV – joint ventures; WOS – wholly-owned subsidiaries; * significant at 10%; ** significant at 5%; *** significant at 1%.

predicted positive sign. The OFDIDUM emerges with a positive consistently significant coefficient indicating that the firms having overseas presence through OFDI are likely to conduct more domestic R&D than other firms. This is expected as the outward investing Indian automotive firms get proximity to innovation centres and innovative competitors in foreign countries, and the higher their own R&D, the more they are likely to appropriate the global knowledge spillovers.

Both OFDIDUM_D and OFDIDUM_DL capturing the locational geography as the host developed and developing region play a significant positive role in the R&D performance of the Indian automotive firms. Hence, irrespective of the location of their outward investment, the foreign presence appears to be a promoting factor for in-house R&D. The Indian automotive firms seem to be learning from not just innovative developed countries, but also from emerging countries like China, South Korea, Malaysia, Indonesia, Singapore and South Africa that have long industrial tradition and concentration of R&D within the developing region. However, the estimated coefficient of developed region OFDI is larger than that of developing region OFDI, indicating greater knowledge flows from the former. This is as expected before since, on the whole, the developed region is traditionally more innovative than developing region.

The OFDIDUM_JV and OFDIDUM_WOS dummies capturing the joint ownership and wholly-owned subsidiary ownership mode of outward investing firms come up with statistically significant effect at 1 per cent and 5 per cent level. This suggests that the Indian automotive firms are generally benefiting in terms of more domestic R&D due to their OFDI presence, irrespective of their choice of ownership pattern. Since the joint venture OFDI dummy achieves relatively more significant and larger coefficient than wholly-owned subsidiary OFDI dummy, there is some indication that the R&D promoting effect of OFDI is better in the case of joint venture.

There are a number of other independent variables that are significantly affecting the R&D activities of the Indian automotive firms. The variables AGE, SIZE, DISTECH, EXPOINT and FDUM all have significant positive coefficients throughout. Other factors being equal, the R&D intensity of Indian automotive firms increases with age; the-age associated accumulation of knowledge seems to encourage greater in-house R&D activities. Large-sized Indian automotive firms appear to have significantly higher R&D intensity than the small-sized firms. The export intensity also comes out as an important factor for a deeper R&D involvement of the Indian automotive firms, as global buyers generally impose stringent quality and efficiency requirements on the part of the Indian automotive suppliers. Foreign affiliates in the Indian automotive sector show relatively greater R&D performance than their domestic counterparts, holding other factors constant.

Our findings on DISTECH suggest that the disembodied technology purchase, rather than substituting, has actually been promoting firm-level in-house R&D. Among the Indian automotive firms those having larger purchases of disembodied technologies also seem to spend more on in-house R&D relative to the other firms. However, our dataset used here does not permit us to investigate if this additional R&D is for minor adaptation of purchased technologies or for major technological improvement(s) based thereon. In the regressions including an OFDI dummy, the embodied technology purchase EMTECH coefficient has an unexpected negative sign, though weak (marginally significant at 10 per cent in one case).

As expected, the liberalization dummies, namely LIBDUM1 and LIBDUM2 both have significant negative coefficients; also the former coefficient is quite large in absolute terms. These findings corroborate the hypothesis that progression of policy measures from a relatively restrictive phase (1988-1992) to a liberalized one (1993-2002) and then further to a strategically proactive one (2003-2008) has successively pushed up the R&D intensity in the Indian automotive sector. ACOM_DUM comes out with a negative coefficient that achieves statistical significance at 1 per cent level. This implies that in general, the R&D performance of automotive component producers is on lower side as compared to that of vehicle manufacturers. The variable PROFIT has a positive effect; it consistently fails to achieve any acceptable level of significance, though the Z-value is above unity, indicating that the R&D activities in the Indian automotive firms are not systematically depending upon their current (short-term) profitability performance.

4.4 Impact of OFDI Intensity

As discussed above, Table 5 reports the effect of the firm (simply) being an outward investor as a 1-0 dummy. In order to further explore the link between the OFDI and R&D for the Indian automotive firms, we have employed instead the OFDI intensity to re-estimate all the regressions. The idea is to examine whether the in-house R&D also gets affected when the firm increases its OFDI intensity. As the R&D intensity has been found to be a contributory factor for OFDI of the Indian manufacturing firms (Pradhan, 2004), including the variable OFDI intensity contemporaneously raises the issue of bi-way causality. Therefore, we have included the OFDI intensity alternatively in one year and two year lagged form in the estimation. These findings are summarized in Table 6 and Table 7, respectively.

The empirical findings on lagged OFDI intensities corroborate that the Indian automotive firms appear to enjoy a special advantage in conducting in-house R&D when they enhance the magnitude of their total OFDI. OFDINT_L1 (one year lagged OFDI intensity) and OFDINT_L2 (two year

Table 6: Tobit results on one year lagged OFDI intensity and R&D performance of Indian automotive firms

Independent Variables	Dependent Variable: R&D Intensity (%)				
	Coefficients (Robust z-value)				
	Total	Regional Dimension of OFDI		Ownership Structure of OFDI	
		Developed	Developing	JV	WOS
AGE	0.015561*** (9.99)	0.015532*** (9.97)	0.015597*** (10.01)	0.015541*** (9.96)	0.015602*** (10.02)
SIZE	0.000008*** (5.54)	0.000008*** (5.90)	0.000008*** (5.69)	0.000009*** (6.15)	0.000008*** (5.29)
DISTECH	0.152863*** (3.33)	0.150567*** (3.31)	0.151050*** (3.32)	0.150742*** (3.31)	0.150460*** (3.31)
EMTECH	0.002486 (0.81)	0.002357 (0.77)	0.002586 (0.84)	0.002619 (0.85)	0.002433 (0.80)
EXPOINT	0.005599*** (2.60)	0.005550** (2.58)	0.005963*** (2.77)	0.005987*** (2.78)	0.005768*** (2.68)
PROFIT	0.000226 (1.20)	0.000227 (1.20)	0.000226 (1.20)	0.000226 (1.21)	0.000226 (1.20)
FDUM	0.627594*** (8.23)	0.629540*** (8.27)	0.622558*** (8.17)	0.629446*** (8.25)	0.621142*** (8.17)
LIBDUM1	-1.998320*** (9.79)	-1.983747*** (9.67)	-2.003924*** (9.81)	-2.014318*** (9.85)	-1.985884*** (9.68)
LIBDUM2	-0.215859*** (3.07)	-0.216795*** (3.08)	-0.223815*** (3.19)	-0.229107*** (3.27)	-0.217535*** (3.09)
ACOM_DUM	-0.559983*** (5.96)	-0.577642*** (6.22)	-0.570346*** (6.07)	-0.551605*** (5.76)	-0.591511*** (6.39)
OFDINT_L1	0.177300*** (3.85)				
OFDINT_DL1		0.291341*** (4.22)			
OFDINT_DLL1			0.153099*** (2.69)		
OFDINT_JV1				0.212343*** (3.17)	
OFDINT_WOSL1					0.150270** (2.52)
Constant	-0.724089*** (5.92)	-0.70220*** (5.81)	-0.709344*** (5.80)	-0.725050*** (5.86)	-0.689264*** (5.72)
Log-likelihood	-2992.79	-2994.42	-2994.71	-2994.34	-2995.28
Wald chi ² (11)	494.03	505.00	467.52	466.93	485.15
Prob > chi ²	0.0000	0.0000	0.0000	0.0000	0.0000
Cragg & Uhler R ²	0.156	0.155	0.155	0.155	0.155

Notes: Number of observations having R&D and without R&D: 1,114 and 2,194. JV – joint ventures; WOS – wholly-owned subsidiaries; * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 7: Tobit results on two year lagged OFDI intensity and R&D performance of Indian automotive firms

Independent Variables	Dependent Variable: R&D Intensity (%)				
	Coefficients (Robust z-value)				
	Total	Regional Dimension of OFDI		Ownership Structure of OFDI	
		Developed	Developing	JV	WOS
AGE	0.013722*** (8.51)	0.013659*** (8.48)	0.013735*** (8.52)	0.013661*** (8.47)	0.013728*** (8.53)
SIZE	0.000008*** (5.44)	0.000008*** (5.67)	0.000008*** (5.52)	0.000009*** (5.92)	0.000008*** (5.36)
DISTECH	0.210102*** (5.22)	0.206366*** (5.14)	0.208309*** (5.18)	0.208330*** (5.17)	0.206113*** (5.13)
EMTECH	0.009900* (1.70)	0.009814* (1.68)	0.009956* (1.70)	0.010024* (1.71)	0.009834* (1.68)
EXPOINT	0.005963*** (2.58)	0.005923** (2.56)	0.006300*** (2.73)	0.006338*** (2.75)	0.006145*** (2.66)
PROFIT	0.000218 (1.19)	0.000218 (1.18)	0.000218 (1.19)	0.000218 (1.19)	0.000218 (1.18)
FDUM	0.588634*** (7.83)	0.591469*** (7.88)	0.584445*** (7.78)	0.592261*** (7.88)	0.583326*** (7.77)
LIBDUM1	-1.701759*** (7.64)	-1.677325*** (7.48)	-1.705345*** (7.66)	-1.717994*** (7.69)	-1.679823*** (7.49)
LIBDUM2	-0.178399** (2.48)	-0.179292** (2.49)	-0.183778** (2.56)	-0.188279*** (2.62)	-0.180178** (2.50)
ACOM_DUM	-0.534678*** (5.58)	-0.552484*** (5.81)	-0.541749*** (5.65)	-0.524817*** (5.39)	-0.562660*** (5.92)
OFDINT_L2	0.175519*** (3.67)				
OFDINT_DL2		0.274548*** (3.01)			
OFDINT_DLL2			0.159813*** (2.85)		
OFDINT_JVL2				0.219356*** (3.29)	
OFDINT_WOSL2					0.128607** (2.21)
Constant	-0.679598*** (5.47)	-0.65551*** (5.33)	-0.668941*** (5.38)	-0.682922*** (5.45)	-0.646257*** (5.27)
Log-likelihood	-2795.64	-2797.69	-2796.94	-2796.39	-2798.36
Wald chi ² (11)	421.13	426.16	403.18	406.82	410.90
Prob > chi ²	0.0000	0.0000	0.0000	0.0000	0.0000
Cragg & Uhler R ²	0.139	0.137	0.138	0.138	0.137

Notes: Number of observations having R&D and without R&D: 1,067 and 1,812. JV – joint ventures; WOS – wholly-owned subsidiaries; * significant at 10%; ** significant at 5%; *** significant at 1%.

lagged OFDI intensity) show significant positive impacts in their respective estimations. A consistent favourable impact of the lagged OFDI intensity is found across different regressions over host regions and level of equity participation in OFDI projects. Therefore, it is not just the OFDI presence in foreign countries that is encouraging the R&D intensity of the Indian automotive firms, but also the degree of their OFDI involvement is an important conducive factor.

The performances of other predictors AGE, SIZE, DISTECH, EXPOINT, PROFIT, FDUM, LIBDUM1, LIBDUM2 and ACOM_DUM across these estimations are generally in line with the findings obtained in the case of estimations involving the OFDI dummy variable. EMTECH is a slight exception with sensitivity over different specifications. While it has largely an insignificant negative coefficient in regressions with OFDI dummy variable, it has an insignificant positive coefficient and a moderately significant (10 per cent) positive coefficient in regressions with one year lagged and two year lagged OFDI intensities respectively.

5. Concluding Remarks

The Indian automotive sector has been experiencing a phase of fast growth and capability formation in recent years. With the Indian policy regime on the industry expansion, inward FDI, technology and trade evolving from a restrictive phase in pre-1990s to a facilitative one in the 1990s and then to a more strategic one in the 2000s, both the vehicle and component manufacturers have been rapidly upgrading their competitive prowess. Concurrently these Indian automotive firms are also aggressively transnationalizing their business through strategic alliances, exports and outward FDI. The phenomenon of rising outward investment from the Indian automotive sector presents an interesting case of cross-border knowledge flows led by developing country enterprises having OFDI. Our focus is on the knowledge flows to the investing firms.

Analyzing the determinants of R&D intensity of the Indian automotive firms during 1988-2008, we explore the role of OFDI by the firm, alternatively as being an outward investor and of lagged OFDI intensity. The empirical findings strongly support the postulation that the OFDI is an important determinant of the domestic R&D performance of the Indian automotive firms. With OFDI the Indian automotive firms appear to be gaining access to technological and market information in foreign countries which motivates them to undertake higher in-house R&D. The favourable effect of OFDI on R&D is found for both developed and developing host regions, interestingly stronger in the former case. The OFDI, be it a joint venture or a wholly-owned subsidiary, tends to encourage R&D at home, relatively more in the case

of joint venture. The other significant explanatory variables that positively affect R&D intensity of the Indian automotive firms are the firm age, size, purchase of disembodied technologies, export intensity, foreign ownership and liberalization. Auto component producers have lower R&D intensity as compared to vehicle manufacturers.

A number of policy observations and lessons can be deduced from this study. Given the fact that the outward FDI operations of firms tend to be instrumental in improving their domestic R&D, a strategic OFDI policy should be adopted by the home developing countries. The government should particularly facilitate the strategic asset-seeking OFDI, as is being done in China.¹⁰ While the OFDI regulations have been liberalized in India, a focused policy is required to strengthen the multinational operations of Indian firms, with targeted national champions being supported through information, finance and other support services (Pradhan, 2008b). Earlier Singh (2007) has recommended that the government needs to support and encourage outward FDI (even the setting up of overseas R&D centres), say through special investment tax credit scheme for business fixed investment abroad in plant & equipment and buildings, also for acquisitions. We may add that the scheme of 150% weighted average deduction of R&D expenses from the taxable income of automotive firms in India should also be extended to their initial capital expenses for setting up/acquiring overseas R&D/technical/engineering centres. Encouraging such overseas centres and R&D collaborations, with or without manufacturing abroad, would add to the augmentation of strategic assets of the overseas investing Indian firms. It is also important to create a collaborative platform involving both the automotive industry associations SIAM and ACMA to synergize the OFDI by vehicle and auto component producers from India.

The R&D by the Indian automotive firms can also be encouraged by facilitating the firms' access to foreign technical collaborations and enhancing export-supporting infrastructure. Also since the size variable has a positive impact on R&D intensity, and the Indian automotive firms are relatively small by international standard, measures to mitigate small size disadvantage, like clusters upgradation and common testing facilities, could be very helpful in pushing up automotive R&D.

Notes

1. For details pertaining to this Section see Pradhan and Singh (2008) and Singh (2007).
2. Based on ACMA and SIAM data for auto component and vehicle sectors respectively. The size of the organized (factory segment of the) Indian automotive sector in terms of production value grew per annum by 21.7 per cent during

- 1980-81 to 1989-90 and by 27.9 per cent during 1990-91 to 2002-03 (Pradhan and Singh, 2008).
3. For example, many global automotive OEMs ask their Tier-1 suppliers to sign joint product liability clauses. Like vehicle producers, auto component manufacturers too fall in the high risk category of product liabilities; any defects in the components may sometimes become known only after the loss of lives or grievous injuries, after the installation in thousands of vehicles – largely sold to educated customers. See *Auto Monitor*, “Important defence in their war to capture global markets”, FEATURES Section, February 19, 2007.
 4. A reduction in lead time for deliveries is possible even with an OFDI for having a warehouse or simple assembly of semi-finished products.
 5. For details on individual OFDI projects and companies see Pradhan and Singh (2008).
 6. In empirical estimation, we did test for non-linearity by including a squared term of the firm size, but consistently the squared size did not achieve any significant level. Therefore, we have included only the firm size in the final estimation.
 7. For the Indian pharmaceutical firms Narayanan and Thomas (2007) find a positive but insignificant partial effect of the outward FDI on R&D intensity; the average R&D intensity is, however, significantly higher for the outward investors group than the other firms set. Measuring the outward investment as “foreign exchange earnings from dividends, interest, technology receipts, etc.” as ratio to sales, Kumar and Aggarwal (2005) find a favourable effect on the R&D intensity among local firms.
 8. All estimations are conducted with the help of STATA version 8.1. The estimated standard errors are robust to the problem of heteroscedastic errors. Using the Cook’s Distance the influential observations were excluded from the estimated sample.
 9. http://www.bseindia.com/shareholding/sharehold_search.asp
 10. In China there is a strong support for the firms’ globalization in general – starting with the Chinese government ‘go global’ strategy announced in October 2000 – and for them to acquire the strategic assets in particular (Deng, 2007; Rui and Yip, 2008); the targeted State-owned enterprises are encouraged to engage in overseas FDI and are offered the tax benefits, investment insurance and subsidized loans from the State financial institutions. In certain sectors there is an intense domestic competition between the foreign and domestic firms. The Chinese firms view the foreign acquisitions as a fast way of obtaining a complete set of new capabilities. Earlier in the 1990s in several emerging Asian nations, e.g. Singapore, Malaysia and Taiwan, the government has encouraged the strategic asset-seeking OFDI (Sim and Pandian, 2007).

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