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Abstract

We examine the importance of a firm's R and D activity, technology import and intra-sectoral R and D spillovers on the decision to export and export intensity using firm level panel data for the Indian automobile sector from 2000-2014. R and D and technology import activities are found to be important determinants of export activity. There is evidence that R and D spillovers exert positive effects on firms' export intensity and decision to export. In addition to these results, firm age and size are nonlinearly related to export decision and export intensity. Energy efficiency plays important role in export behavior for firms that are continuously exporting and those who are exporting at least for one year.

KEYWORDS: *Decision to export, Export intensity, Indian automobile sector, R and D intensity, Technology import intensity*

JEL CODES: *L10, L21, L22, L62*

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INTRODUCTION

It is generally recognized that the expansion of a nation's exports has positive effects on growth of the economy as a whole as well as on individual firms. Inter-country difference in technological capabilities is one of the important determinants of the direction of trade (Krugman, 1979). The evolutionary theorists (Dosi et al. 1992) assert that these differences emanate at the level of the firm itself, which eventually accumulates into inter-country differences in capabilities. Interest in firm heterogeneity and firm internationalization has grown exponentially since the path-breaking work of Bernard et al. (1995), which established that exporters perform better than non-exporters. There are two sides to export behavior, with one side suggesting that productive firms get induced to export. On the other side, policy makers believe that firms can learn to be more productive by exporting. In literature, the role of technological efforts in determining competitiveness of firms is well established.

Strong export base is generally regarded as a key component for economic growth. Exporters are usually considered to be high-performance firms at least for two reasons. First, when competing in foreign markets exporting firms generally incur higher trade barriers and face different consumer tastes and tougher competition. And second, exporting additionally makes firms more easily aware of potential innovations taking place abroad and they may assimilate these in order to improve their position both in domestic and foreign markets. This learning by competing effect may also spread over to and benefit other local firms. However, in order to compete successfully in foreign markets and avail of the benefits, firms must first acquire the appropriate knowledge and technological capability, for example, through a firm's own Research and Development (R and D) activities or spillovers arising from other firms, both domestic and foreign (Barrios et al. 2003).

In this paper, we examine (1) a firm's decision of whether or not to export and (2) the determinants of the export intensity using a rich firm level dataset for Indian Automobile industries from 2000-2014. Besides providing evidence for the Indian case, this paper extends the existing literature not only considering the decision to export but also, the importance of export behavior of firms and their determinants. Our empirical analysis provides evidence to substantiate this conjecture. India arguably provides an interesting case study in these regards. The rest of the paper is structured as follows. In section-2 and 3 we describe the review of literature and theoretical background; section-4 describes the dataset and provides the summary statistics. The econometric analysis of export activity is contained in section-5, while section-6 presents the conclusion of the study.

REVIEW OF LITERATURE

While there is a fairly large literature on the importance of innovation and R and D on exports, few studies have examined the importance of spillovers from multinational enterprises (MNEs) on firms' export performance (see Bleaney and Wakelin, 2002; Sterlacchini, 2001; Wakelin, 1998; Narayanan, 1998 and Fagerberg, 1988 for firm level analyses). There is, however, a large literature examining the effect of spillovers from MNEs on domestic firms' productivity (see Gorg and Strobl (2001) and Blomstrom and Kokko (1998) for concise review of this literature). For example, Aitken et al. (1997), in a study of Mexico, find that export activities of MNEs have positive effects on the probability of whether a firm located in the same sector, either foreign or domestic, is an exporter. However, the authors only examine the decision of whether or not to export and not the extent of exporting, and consider only export spillovers specifically arising from MNEs. Bernard and Jensan (2001) examine for the US if sectoral export activity has any effects on whether US firms are exporters or not and do not find any strong evidence for such, although they do not distinguish between export

activity in MNEs and domestic firms. Hirsch (1971), in a study of Danish 36 Dutch, and Israeli firms, concluded that foreign entry is more hazardous than domestic selling. Tesar (1975) found that the "light exporters" in the sample perceived more risk from exporting than did "heavy exporters". Using firm level panel data for the UK; Greenaway et al. (2004) investigated whether spillovers affect a firm's export intensity. They consider two channels for MNE spillovers, viz., MNEs' export activities and MNEs' R and D activities in the sector. They find that MNEs' exports have a positive effect on domestic firms' probability of being exporters but do not find evidence that such spillovers impact on the export ratio of domestic firms. On the other hand, there are R and D spillovers from multinationals to domestic firms that affect positively both the decision to export and the choice of export intensity.

The motivation for exporting is distinct from, though often related to, the initiation of exporting. Some firms are pushed into exporting by an external change agent (e.g., a foreign customer); some simply take advantage of export opportunities that come their way with no evident objective in mind, while others are motivated to initiate exporting deliberately. Analyses of export motivation apply primarily to the latter group of firms. Many analysts regard a firm's size as critical for its propensity to export, yet empirical findings on this issue have been mixed. Some studies found positive cross-sectional relationship between firm size and the percent of firms that export (Perkett, 1963; Tookey, 1975). There are some studies that also found no meaningful relationship (Doyle and Schommer, 1976; Bilkey and Tesar, 1975). Some studies also concluded that very small firms tend not to export, that beyond some point exporting is not correlated with size, and that between these two points exporting is correlated with firm size (Hirsch, 1971; Cavusgil, 1976). The latter proposition seems capable of reconciling the other analysts' divergent findings; however, the relationship is complicated by a possible inter correlation of firm size with the quality of management.

The extent to which an inter correlation exists could alone cause firm size to vary directly with a firm's propensity to export.

In studying competitiveness of Indian automobile sector, Kathuria (1996) notes that the time-bound indigenization programme for commercial vehicles in the 1980s facilitated the upgradation of vendor skills and modifying vehicles to suit local conditions, which demand functional efficiency, overloading capabilities, fuel economy, frequent changes in speed and easy repair and maintenance. Kathuria also mentioned that the choice between vertical integration and subcontracting crucially depends on the policy regime; in a liberal regime, vertical integration may not work. Narayanan (1998) attempted to analyze the effects of deregulation policy, introduced in India during the mid 1980s, on technology acquisition and competitiveness in the Indian automobile industry during the 1980s. Following evolutionary theoretical framework, he argues that asymmetry among firms in terms of technology acquisition explain much of the firm level differences in competitiveness. Asymmetry in technology acquisition is largely due to differences in the firms' ability to bring about technological paradigm and trajectory shifts. The results of the econometric exercise support the view that, even in an era of capacity licensing, development of competitive skills crucially depended upon the ability to build specific technology trajectory advantages. This is achieved by successfully complementing imported technology with in-house technological efforts. Competitiveness in a deregulated regime would, however, depend upon the ability of the firm to bring about technological paradigm shifts. New firms who depended on intra-firm transfer of technology and firms with in-house R and D efforts, to accomplish paradigm shifts, appear more successful. Furthermore, in a liberal regime, advantages of vertical integration also appear to be important determinants of competitiveness.

Pingle (2000) reviews the policy framework of India's automobile industry and its impact on its growth. While the ties between bureaucrats and the managers of state-owned enterprises played a positive role especially since the late 1980s, ties between politicians and industrialists and between politicians and labour leaders have impeded the growth. The first phase of 1940s and 1950s was characterized by socialist ideology and vested interests, resulting in protection to the domestic auto industry and entry barriers for foreign firms. There was a good relationship between politicians and industrialists in this phase, but bureaucrats played little role. Development of ancillaries segment as recommended by the L.K. Jha Committee report in 1960 was a major event that took place towards the end of this phase. During the second phase of rules, regulations and politics, many political developments and economic problems affected the auto industry, especially passenger cars segment, in the 1960s and 1970s. Though politicians picked winners and losers mainly by licensing production, this situation changed with oil crises and other related political and macro-economic constraints. Pingle also argues that state intervention and ownership need not imply poor results and performance, as demonstrated by Maruti Udyog Limited (MUL). Further, the non-contractual relations between bureaucrats and MUL dictated most of the policies in the 1980s, which were biased towards passenger cars and MUL in particular. However, D'Costa (2002) argues that MUL's success is not particularly attributable to the support from bureaucrats. Rather, any firm that is as good as MUL in terms of scale economies, first-comer advantage, affordability, product novelty, consumer choice, financing schemes and extensive servicing networks would have performed as well, even in the absence of bureaucratic support.

Piplai (2001) examines the effects of liberalisation on the Indian vehicle industry, in terms of production, marketing, export, technology tie-up, product upgradation and profitability. Till the 1940s, the Indian

auto industry was non-existent, since automobile were imported from General Motors and Ford. In early 1940s, Hindustan Motors and Premier Auto started, by importing know-how from General Motors and Fiat respectively. Since the 1950s, a few other companies entered the market for two-wheelers and commercial vehicles. However, most of them either imported or indigenously produced auto-components, till the mid-1950s, when India had launched import substitution programme, thereby resulting in a distinctly separate auto-component sector. Narayanan (2004) analyses the determinants of growth of Indian automobile firms during three different policy regimes, namely, licensing (1980-1981 to 1984-1985), deregulation (1985-1986 to 1990-1991) and liberalisation (1991-1992 to 1995-1996). Narayanan (2004) uses two-way fixed effects estimation of the firm growth as a function of variables capturing technology, such as R and D expenditure as a proportion of sales, foreign equity participation and import of capital goods. Role of technology depends on the technological regime in which the firm operates. In a licensed regime, firms with foreign equity grow faster because of better access to resources and technology. In a deregulated regime, import of capital goods has been the technology-related variable that triggered growth. In a liberal regime, growth is positively influenced by the intra-firm technology transfer.

Narayanan (2006) analyses the determinants of export intensity of Indian automobile firms using a Tobit model, taking the variables discussed in Narayanan (1998) and Narayanan (2004) as the determinants. This study was based on the premises that there is a systematic difference in the characteristics and performance between the firms that export and those which sell in the domestic market, mainly in terms of technology acquisition, which in turn depends on the policy regime. Technology acquisition, firm size, vertical integration, capital intensity, imports of components and policy regime are found to be the main determinants of export competitiveness, by his analysis. Narayanan

(2006) also finds that vertical integration plays a positive role in a regulated regime, while it is not conducive for export competitiveness in a liberal regime.

Sharma (2006) analyses the performance of the Indian auto industry with respect to the productivity growth. Partial and total factor productivity of the Indian automobile industry have been calculated for the period from 1990-1991 to 2003-2004, using the Divisia Tornquist index for the estimation of the total factor productivity growth. The author finds that the domestic auto industry has registered a negative and insignificant productivity growth during the last one and a half decade. Among the partial factor productivity indices only labour productivity has seen a significant improvement, while the productivity of other three inputs (capital, energy and materials) haven't shown any significant improvement. Labour productivity has increased mainly due to the increase in the capital intensity, which has grown at a rate of 0.14 percent per annum from 1990-1991 to 2003-2004. Saripalli (2008) analyzed the differences in the export behavior of domestic and multinational firms in the Indian auto component industry. Three types of firms are identified according to ownership: purely domestic and licensees, domestic joint ventures and joint ventures with majority stakes by the multinationals. Although all the types of firms face the same labor costs, any difference in export performances could arise because of higher productivity of labor. This paper tests whether this is true for the domestic firms and the multinational firms in the Industry. It finds that only in the case of the multinational firms, it is not just cheap labor in terms of low wage rate per worker, but low wage in relation to productivity of that labor which leads to comparative cost advantage in exports. The domestic firms are competing based on low wage cost more than the productivity of the labor. Among other factors discussed, of the reasons is the low value added nature of the components that are being exported. The role of other factors like, size, import- intensity and

distribution expenses are also examined, followed by an analysis of the scope for domestic firms to become a part of the global supply chain.

Ray (2012) estimated the economic performance of Indian automobile industry in terms of capacity utilization at an aggregate level. In view of identifying several factors that influence capacity utilization, the result suggests that coefficient of export-intensity variable, import penetration ratio are negative which indicate that capacity utilization was relatively lower in firms belonging to industry characterized by high export-intensity and import penetration. A positive relationship is found between size and capacity utilization and similarly between market share and capacity utilization.

Based on the inputs from the review of literature, this paper attempts to understand the export decisions of firm in automobile sector in India and also tries to understand the extent of export and their determinants. In order to arrive at robust result and understanding of export behavior, this paper also tries to estimate determinants of export intensity for the full sample and firms grouped by export behavior. This attempt of differentiating firms based on export behavior and factors explaining decision to export tries to fill in the gap in literature for the Indian economy context.

THEORETICAL BACKGROUND

This section provides a simple theoretical framework, based on Rosa and Mohnen (2103) and Barrios et al. (2003) to motivate the empirical analysis. To begin with, we assume the cost function of each firm to be decomposable into two components: production costs, h, and distribution costs, m. All output is produced in the home country (d) but can be sold on the domestic market or abroad (countries d and f). The total cost function can be expressed as:

$$C = h(q_d + q_f) + m_d(q_d) + m_f(q_f) \quad (1)$$

Where q represents the quantity sold in each market. Since this approach is based on cost function we do not consider explicitly the possibility that innovating firms would create a new product and start exporting it. Instead, we focus on the effect of innovations and potential spillovers on firms' productivity efficiency for already existing products. This assumption may not be too unreasonable given the time span covered in this study. Most of the firms in the sample are established firms and it is unlikely that start-up firms' create new products and are able to export it over the period. Aitken et al. (1997) also argue that the presence of MNE in a sector affects distribution costs. However, it is not clear how this spillover effect works and we, therefore, do not include it herein but focus on the two channels of spillovers, namely export activity and R and D. As in Aitken et al. (1997) and further in Barrios et al. (2003), we assume that distribution costs in foreign markets f are a decreasing function of total export activity (Γ_{EX}) in each sector.

$$\frac{\partial m_f(q_f)}{\partial \Gamma_{EX}} \leq 0 \quad (2)$$

In contrast to Aitken et al. (1997), and similar to Barrios et al. (2003) we assume distribution costs in d and f to be decreasing functions of R and D expenditure at the sector level (Γ_R):

$$\frac{\partial m_f(q_f)}{\partial \Gamma_R} \leq 0 \quad (3)$$

$$\frac{\partial m_d(q_d)}{\partial \Gamma_{EX}} \leq 0 \quad (4)$$

Equation (3) implies that firms benefit from the technology and knowledge intensity of other firms in the same sector in order to gain access to foreign markets. Sector level R and D expenditure is not considered as a direct link to foreign markets, but we assume it provides a way to improve product quality and general knowledge in order to compete successfully in foreign markets. In that sense, sector-level R and D also benefits local sales as shown in equation (4). The overall effect of Γ_R is thus ambiguous for the ratio of export to total sales, as we shall see below. One may also assume that R and D and export spillovers affect not only distribution costs but also production costs. We, therefore, assume that production costs are decreasing functions of R and D and export activities at the sector level which are identical to Barrios et al. (2003):

$$\frac{\partial h(q_f + q_d)}{\partial \Gamma_R} \leq 0 \qquad (5)$$

$$\frac{\partial h(q_f + q_d)}{\partial \Gamma_{EX}} \leq 0 \qquad (6)$$

The rationale for considering production costs to be a decreasing function of R and D expenditure in equation (5) relates to the extensive literature concerning the positive effect of R and D on firm efficiency (Griliches, 1992). In addition, several authors have shown that exporting firms tend to have higher productivity levels than non-exporting firms either because of a market selection process or through learning by exporting as shown by Delgado et al. (2002), Girma et al. (2004) and Bernard and Jensen (1999). These efficiency advantages may spill over to other firms via exporting activity in the sector. We consider this possibility through the negative impact of export spillovers on production costs as in equation (6). We assume that export and R and D activity in a sector affects a firm's distribution costs regardless of whether this activity

is undertaken by MNEs or domestic firms in the sector. The positive effect from MNEs may, however, be stronger than from domestic firms for both channels of spillovers. In terms of export activities, multinationals, because of their very nature, can be assumed to have better knowledge of foreign markets and therefore may be more beneficial to other firms deciding to export. Also, multinationals are usually considered to be more technology intensive than domestic firms (Markusen, 1995) and may therefore also provide a better source for R and D spillovers. Using simple quadratic functions, the terms of the cost function in equation (1) can be expressed as follows:

$$h(q_d + q_f) = \frac{1}{2} a(q_d + q_f)^2 + g(q_d + q_f) \tag{7}$$

$$m_i(q_i) = \frac{1}{2} bq^2 + c_i q_{i,} \qquad \text{with } i = d, f \tag{8}$$

Where *a*, *b* are scalars and *g* and c_i ($i = d, f$) are function of cost variables for the production and distribution cost functions, respectively. Specifically, *c* and *g* can be expressed as:

$$g = g(X, \Gamma_{EX,} \Gamma_R) \tag{9}$$

$$c_d = c_d(X, Z_{d,} \Gamma_R) \tag{10}$$

$$c_f = c_f(X, Z_{f,} \Gamma_{EX,} \Gamma_R) \tag{11}$$

Where *X* is the production cost incurred both in the home and foreign markets and *Z* are the distribution costs in the home and foreign markets assuming $Z_d \leq Z_f$. We consider distribution costs in foreign markets to be higher than distribution costs in local markets. The former include higher transport costs (for example tariff and non-tariff barriers), the product has to be adapted to foreign tastes and market conditions,

export channels have to be set up and firms have to compete with established firms. The definition of *X* and *C* are given in the empirical section. The maximization problem of the representative producer located in h is:

$$\max_{q_d, q_f} \; p_d q_d + p_f q_f - h(q_d + q_f) - m_d(q_d) - m_f(q_f), \qquad (12)$$

Assuming that $q_{d,} q_f \geq 0$, the first-order solutions give

$$q_d = \frac{1}{a+b}(p_d - aq_f - g - c_d) \qquad (13)$$

$$q_f = \frac{1}{a+b}(p_f - aq_d - g - c_f) \qquad (14)$$

We consider two dependent variables: (1) the decision whether or not to export and (2) the ratio of total exports to net sales. Expression in equation (14) provides the equation for the decision to export when $q_f = q^*_{f,}$ where q^*_f is the optimal value given by the maximization of equation (12) and the solution of equation (14). The ratio of the value of exports to total sales can be expressed using the solution given by equation (13) and (14) and multiplying each quantity by their relevant price. After rearranging we obtain the following expression for the export intensity (EI):

$$EI = \frac{p_f q_f}{p_h q_h + p_f q_f} = \frac{p_f(p_f - aq_d - g - c_f)}{p_f(p_f - aq_f - g - c_f) + p_d(p_d - aq_f - g - c_d)} \qquad (15)$$

Equation (12) – (15) can be rewritten in order to get estimable expressions for a typical firm *i* belonging to a sector *j* for domestic and MNE firms:

$$q_{d,ij} = \alpha_1 p_d + \alpha_2 q_{f,ij} + \alpha_3 X_{ij} + \alpha_4 Z_{d,ij} + \alpha_5 \Gamma_{Rj} + \alpha_6 \Gamma_{EXj} + u_{d,ij} \quad (16)$$

$$q_{f,ij} = \beta_1 p_f + \beta_2 q_{d,ij} + \beta_3 X_{ij} + \alpha_4 Z_{f,ij} + \alpha_5 \Gamma_{Rj} + \alpha_6 \Gamma_{EXj} + u_{f,ij} \quad (17)$$

$$EI_{ij} = \gamma_1 p_f + \gamma_2 X_{ij} + \gamma_3 Z_{f,ij} + \gamma_4 P_d + \gamma_5 Z_{d,ij} + \gamma_6 \Gamma_{Rj} + \gamma_7 \Gamma_{EXj} + \varepsilon_{ij} \quad (18)$$

We assume $u_{d,ij}$, $u_{f,ij}$ and e_{ij} to be normally distributed error terms with zero mean and constant variance. Equations (16) and (17) form a system of simultaneous equations. We focus our analysis on the decision to export represented by equation (17) and the export intensity represented by equation (18). Further transformation of equation (17) is needed in order to obtain an estimable equation. The decision to export can be represented by a dummy variable y_{ij}.

$$\begin{aligned} &y_{i,j} = 1 \text{ if } q_f > 0, \\ &y_{i,j} = 0 \ otherwise \end{aligned} \quad (19)$$

Accordingly, the probability for firm *i* to export can be expressed as follows:

$$\Pr\left(y_{i,j}=1\right) = \Pr\left[\begin{array}{l} \beta_1 p_f + \beta_2\left(\alpha_1 p_d + \alpha_4 Z_{d,ij}\right) + \beta_4 Z_{f,ij} + \\ \left(\beta_2\alpha_3 + \beta_3\right) X_{ij} + \left(\beta_2\alpha_6 + \beta_6\right)\Gamma_{EX,ij} + \\ \left(\beta_2\alpha_5 + \beta_5\right)\Gamma_{R,ij} + \upsilon_{ij} \end{array}\right] > 0 \quad (20)$$

where $\upsilon_{ij} = \beta_{2,} u_{d,ij} + u_{f,ij}$ given the assumption on $u_{d,ij}$ and $u_{f,ij}$. Equation (16) shows that export spillovers through their positive effect on

firms' efficiency can also improve firms' positions in their local market. However, the coefficients of Γ_{EX} in equation (20) will still display positive signs provided that the positive effect on exports outweighs the positive effect on domestic sales. The probability to export will rise when the positive effect on exports of R and D spillovers exceeds the positive effect on domestic sales.

The model, thus, assumes that R and D spillovers improve both local and foreign market positions by raising firms' efficiency and product quality. When R and D spillovers arise, firms belonging to R and D intensive industries tend to adopt these new technologies. If we assume that foreign markets are more competitive than domestic markets then the effect of R and D spillovers will be likely to have a greater marginal impact on firms' sales abroad than in their home market, as firms have to be more competitive and technologically advanced to penetrate markets abroad. The resulting impact of Γ_R on EI would then be positive. The technological level in the export intensity also matter in addition to the above discussions.

Apart from the above stated variables of interest, the question also rises on the export behavior of firms, meaning the years of exporting. To capture this we estimated export participation classified in different groups. Once, we get an idea of why firms export based on the technology import, and R and D, we also focus on the export intensity; how much a firm export. In the empirical strategy we have followed (1) probit model and (2) tobit model of estimations. In case (1) the estimate gives the differences of firms' probability to export. Case (2) finds the export ratio and the determinants of export intensity at firm level. In the empirical estimation we consider equation (18) for the test of the determinants of export intensity and equation (20) for the test of the probability to export and inter group probability to export. As an improvement to Barrios et al. (2003), we also add some more

independent firm characteristic such as energy intensity, ISO certification that explain the export behavior of firms. In addition to the full sample analysis, we also analyze for different export behavior based on years of exporting for the sample of firms.

DATA AND VARIABLES

The empirical estimation uses data from the Center of Monitoring Indian Economy[1] (Prowess) online corporate database from 2000-2014. The sample covers around 56% of the Automobile firms at 4-digit based on National Industrial Classification 2008 (NIC-2008). From the collected data for automobile firms in Indian economy, 64% of the firms got deleted because of the misreporting of major variables of interest; that includes net sales, firm age etc. The unit of observation in this case is the firm. The total number of firms for which we have data is 3398 over the period 2000-2014. This sample includes firms in (1) manufacture of rubber tyres and tubes for motor vehicles, motorcycles, scooters, three-wheelers, (2) manufacture of passenger cars, (3) manufacture of commercial vehicles, (4) manufacture of motor vehicles, and (5) manufacture of motorcycles, scooters, mopeds etc.

The variables of interest provided by the CMIE Prowess are firm age, firm size, capital intensity, labour intensity, energy intensity, advertisement and packaging intensity, R and D Intensity, Multinational

[1] Centre for Monitoring Indian Economy or the CMIE, is a leading business information company. Established in 1976, it straddles the entire information food-chain from primary data collection through analytics and forecasting. It provides services to the entire spectrum of business information consumers that includes governments, academia, financial markets, business enterprises, professionals and the media. CMIE produces economic and business databases and develops specialized analytical tools to deliver these to its customers for decision making and for research (for detail see http://www.cmie.com)

affiliation[2], technology import and ISO 14001 Certification[3]. As noted earlier, one of our main variables of interest is R and D and technology import intensity. R and D and technology import concerns scientific activities, technological information, normalization and quality control.

Table 1: Description of the Sample

Sl. No.	NIC-2008	Observations	No. of Exporters	Exporters in Sample
1	2211	251 (6.29)	187 (6.82)	74.50
2	2910	179 (4.48)	152 (5.54)	84.92
3	3091	3513 (87.98)	2366 (86.26)	67.35
4	3092	50 (1.25)	38 (1.39)	76.00
5	Full Sample	3993 (100)	2,743 (100)	68.70

Note: Figures in the brackets are presented in percentage terms related to the full sample. Last column of the table the figures are in percentage terms related to number of firms in each sub-sector to exporting firms. The numbers in the table are firm-year observations. Source: Authors calculation from CMIE Prowess Data.

Further, the variable advertisement and packaging intensity concerns marketing and publicity and design of new products. This information arguably reflects the technological activity as well as the effort made by firms in designing and promoting new products. Finally, all monetary variables were deflated using sectoral price indices, where

[2] Foreign participation is in most cases higher than 20-30%

[3] In the case of innovative technologies, standards can reduce the time to market of products and services based on them, create global interest and develop a critical mass of support to ensure the economic success of such technologies. ISO has already developed standards with an impact on climate change for areas such as building environment design, energy efficiency of buildings and sustainability in building construction, intelligent transport systems, solar energy, wind turbines, nuclear energy and hydrogen technologies. ISO's proactive stance on energy and climate change matters has resulted in the initiation of ISO work on energy. As one indicator of the use of ISO 14000, up to the end of December 2009, more than 223149 ISO 14001 certificates of conformity had been issued to private and public sector organizations in 159 countries and economies.

each firm's economic activity was classified into one of four digit nomenclature NIC-2008, which gives the industrial classification for the Indian industries by the Center for Statistical Organization, Government of India[4].

Table 2: Export Behavior of Firms in the Sample

Sl. No	Export Behavior/ NIC-2008	2211	2910	3091	3092	Total
1	Exporting for full sample period (15 years)	6.31	3.81	88.45	1.43	31.30
2	Exporting for 7 to 14 years	5.85	5.92	86.76	1.46	21.04
3	Exporting for 2 to 6 years	4.7	4.91	89.32	1.07	35.94
4	Exporting at least for 1 year	7.36	3.12	88.56	0.96	11.72

Note: The first row of the table depicts the subsectors based on the NIC 2008 classification. Figures in the table are presented in percentage for different categories of export behavior of firms, Source: Authors calculation from CMIE Prowess Data

Table 1 describes the sample in terms of export participation. As mentioned earlier, the sample is classified based on National Industrial Classification 2008 (NIC-2008). The four digit classification and related information on the subsectors are given in the table. For instance, we can observe that the sample consists of 251 firm-year observations for the manufacture of rubber tyres and tubes; retreading and rebuilding of rubber tyres sub-industries. Out of which 74.50 percent are exporters.

[4] The Central Statistical Organisation of the Ministry of Statistics and Programme Implementation being nodal statistical authority is vested with the responsibility of setting up standards for collection, compilation and dissemination of statistical data. The official statistical data are required to be collected and presented according to classification designed to facilitate their use for national economic policy and for international comparison. Comparability of statistics available from various sources, on different aspects of the economy, and usability of such data for economic analysis are prerequisite for standardization of a system of classification.

Maximum observations are present for the manufacture of motorcycle segment (87.98 percent), of which 84.92 percent are participating in export market during the study period.

The export behavior of firms, are not similar. Hence, we have tried to map the export behavior of firms in this segment of manufacturing firms in Indian economy. The exercise is given in table 2. Table 2 classifies the firm-year observations to four categories. The maximum years of exporting is found to be 15 years (full study period). Further, we have classified in different intervals to see the export behavior of sample firms. We can observe that parallel to table 1, manufacture of motorcycles segment of the sample is dominated in case of the export participation across years. For example, out of 31.3 percent exporting firms, this segment presents 88.45 percent of firms those are exporting for 15 years. Hence, the sample for the empirical analysis has higher number of firm-year observations for this segment. Given the sample size is less for all other subsectors of firms in automobile industries in our sample, the share of export participation ranges more than 86 percent for manufacture of motorcycle segment alone. From the table is can also be seen that the highest firm-year observations are those firms that are exporting for minimum one year to six years followed by firms exporting for 15 years continuously.

Table 3 shows that between 2000 and 2014 there has been an increase in export activity in Indian automobile industries with overall export ratios rising in 8.17 percent to 13.35 percent for the full sample where increase has happened in 4 out of 7 sub-sectors. At the same time, number of exporters has also increased in most of the automobile sub-sector, except one. These two similar trends went hand-in-hand with an increasing presence of multinationals in 5 out of 7 sub-sectors for the automobile sector. Whether the changes in export activity at the firm level are to some degree due to spillovers arising from MNEs is the main

focus of the empirical analysis of this paper. One of the other observations from the table 3 is related to the technology import and R and D intensity. Both R and D intensity and technology import intensity have increased from 2000 to 2014 in all most all the sub-sectors except few.

Table 3: Exports, R and D, and Technology Import Intensity and Presence of MNEs

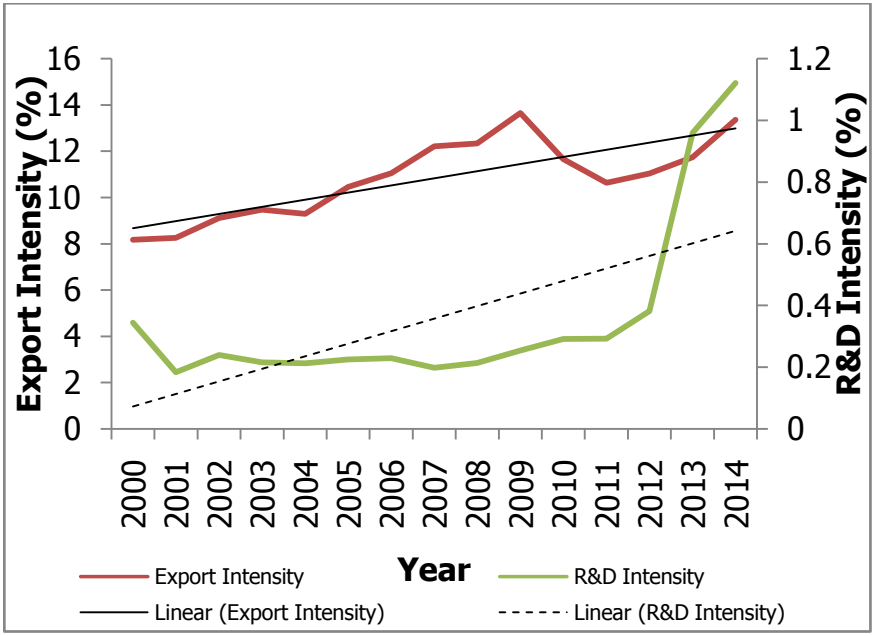
Sl. No.	NIC-2008	Export Intensity		No. of Exporters		R and D Intensity		Technology Import Intensity		MNE Presence	
		2000	2014	2000	2014	2000	2014	2000	2014	2000	2014
1	2211	6.89	15.74	14	20	0.19	0.40	0.11	0.24	5.02	7.63
2	2910	4.97	3.08	12	16	1.67	7.34	0.40	0.16	4.30	9.32
3	3091	7.45	11.11	248	266	0.30	0.49	0.58	0.47	88.89	83.05
4	3092	7.00	3.09	5	3	0.02	0.01	0.01	0.01	1.79	4.24
5	Total	7.31	10.80	279	305	0.35	1.12	0.53	0.42	100.00	100.00

Note: 2000 and 2014 (the second row of the table) refer to years of analysis; export intensity, R and D intensity and technology import intensity are given as intensity form; number of exporters, are in numbers and MNE presence is presented in percentage. Source: Authors calculation from CMIE Prowess Data

For a better understanding on the export intensity and R and D intensity we have plotted both the variables across time and presented in figure 1. From the figure, it is clear that both the variables are showing increasing trends. However, R and D intensity has increased much faster than that of export intensity from 2012 to 2014. From 2010, export intensity for the sample had shown a decrease in the intensity; however from 2010 export intensity has increased till 2014. Given this variable a ratio between the net sales and export there is a higher possibility that higher sales might have recorded for the domestic market and hence, the ratio has shown a decreasing trend from 2010 to 2013. For R and D intensity the decreasing trend was only visible for 2001, hereafter the R and D intensity is wither consistent or reporting an increasing trend. The

behavior of export intensity, R and D intensity and the increase in presence of multinational may explain this phenomenon.

Figure 1: Trends in export and R and D intensity across year



Source: Authors calculation from CMIE Prowess Data.

ECONOMETRIC ANALYSIS AND RESULTS

In our estimates of (18) and (20) we consider both firm and sector-specific variables, which are assumed to impact on the production costs X and/or distribution costs Z_f and Z_d. These costs are, of course, not observed; we therefore have to choose a set of variables that may be considered reasonable proxies. Our choice of variables is guided by the

existing empirical literature on the determinants of exports[5]. Our analysis of firms' export activity is static and does not take into account the importance of sunk costs in exporting and past exporting performances, as in Roberts and Tybout (1997) and Bernard and Jensen (2001). This is due to the nature of our data with only 15 years, where firms exporting continuously for 15 years are relatively less. This also implies that, theoretically, we expect the effect of all explanatory variables to be instantaneous. However, a separate model is also presented for the firms that are continuously exporting for 15 years, 8-14 years, 2-7 years and for firms that are exporting at least for one year. In this case the objective is to find out the similarities or differences between those set of firms and determinants of participation of export. We choose variables that are assumed to impact on firms' efficiency, interpreting efficiency in terms of cost efficiency. Accordingly, firm level determinants considered in the empirical estimation are age, size, productivity, skill intensity, and R and D intensity; detailed definitions of which are given in table 4.

We follow Roberts and Tybout (1997) and Narayanan (2004) by including age and size (measured in terms of natural log of net sales) as independent variables. As is frequently found in the empirical industrial organization literature, older and larger firms are more likely to be better performers, i.e. be more efficient, and may therefore, also be more likely to have higher export activity than other firms (Bernard and Jensen, 1999). In addition, older firms tend to be more efficient if learning by doing economies, are present. The basic assumption lying behind this hypothesis is that knowledge may explain a great part of firms' performance and that the best way to accumulate knowledge is to

[5] While equation (17) and (18) include both domestic and foreign prices we do not include price indices in the empirical estimations for three reasons. Firstly, empirically it would be recommendable to use firm-level prices indices since the use of industry-level price indices may introduce aggregation bias in our estimates. Second, since nominal variables were deflated with these indices, the use of price indices as additional explanatory variables may introduce co-linearity problems. Thirdly, ideally we would need export prices in order to consider relative prices; however, such data are not available to us. Note that these will also apply to an estimation of equation (13).

acquire it through experience[6]. A large number of studies show that learning through experience may explain a substantial part of firms' heterogeneity in terms of production costs (Berndt, 1991). The use of firms' age is thus likely to be a good proxy for both production and distribution costs as those described in equations (7) and (8) of our model. The impact of age and size is not necessarily linear however. For example, in the study of the impact of age on US plant productivity, Power (1998) discovered that after a certain threshold, firms' experience ceases to exert a positive influence on their efficiency and, at best, has no influence once a certain level is reached. As a consequence, we also allow the effect of age and size to be non-linear by including both variables squared. However, the empirical results vary for both the variables. For instance, even the empirical literature argues that both the variables are non-linearly related; our findings are true for the firm age.

An additional indicator of firm efficiency is productivity, which also features in the empirical model of Bernard and Jensen (2001). Furthermore, we include skill intensity, as in Bleaney and Wakelin (2002) and Bernard and Jensen (2001). The rationale of using this variable as an indicator of skills' intensity rests on Mincer's (1974) human capital earnings function, which derives a regression relationship between earnings, education and experience based on human capital theory. The firm characteristic of most interest to us is the firm's R and D intensity. This variable is measured as the ratio of R and D expenditure over net sales. We would expect that the higher the R and D intensity, the higher the firm's export activity will be (Bleaney and Wakelin, 2002; Wakelin, 1998). We also include sector-specific variables that we assume to impact on firms' efficiency. Our choice of sector-specific variables is based on measures of R and D spillovers by making the distinction between foreign

[6] Different terms have been used in the literature to represent this phenomenon like 'learning curve', 'progress ratio' or 'learning by doing'. They all, more or less, refer to the same process by which firms become more efficient by accumulating knowledge, either through lower costs or higher productivity.

and domestic firms' activities. First, as in Greenaway et al. (2004), we consider R and D undertaken by multinationals in the same sector. The rationale for this is based on the descriptive statistics reported in table 1.

In the theoretical literature, it is generally assumed that the largest part of R and D by multinationals is undertaken in the home country. Foreign affiliates then exploit the R and D services provided by the headquarters at a low marginal cost. Those R and D services are akin to a public good within the firm that benefits the different affiliates around the world (Markusen, 1995). As a consequence, domestic firms' and foreign affiliates' R and D activities may have different effects on other firms' innovative activities and export performance. For R and D spillovers, we allow the MNEs related spillover variables to have different impacts on domestic and foreign firms by including interaction terms that are set to zero if firm i is domestic and equal to the MNE spillover variable if the firm is foreign owned. The rationale behind this is that one may expect foreign firms to be better able to assimilate the spillovers emanating from MNEs either because they are 'better', i.e. more efficient than domestic firms (Doms and Jensen, 1998) or have a better absorptive capacity than their domestic counterparts.

In the empirical estimation we have also included three other proxies for technology variables. One of the technology variables is energy intensity at firm level. We assume that to minimize the cost function, firms can go for cost minimization in energy sources by adopting efficient energy source in production. Further, by minimizing production cost and becoming energy efficient, firms can get into the export market. Similarly, in case of Indian economy, only in-house R and D or multinational affiliation do not necessarily increase the technological components for the firms in production; but technology import also plays major role. Here the meaning of technology import implies sum of both embodied and disembodied technology imports of the firm from abroad.

This might go along with the multinational affiliation or only for the domestic firms in increasing the capability of technology and innovation process. Therefore, this variable might play major role in either decision to export or for the export intensity for the Indian firms.

Table 4: Description of Variables

Variables	Description
Productivity	Value added/salaries and wages
Skill Intensity	Ratio between salaries and wages to net sales
Size and size^2	Natural log of net sales (current period)
Advertisement and Marketing Intensity	Advertisement and marketing expenses/net sales
Energy intensity	Ratio between energy consumption to net sales
R and D intensity	R and D expenditure/net sales
Technology Import Intensity	Technology import/net sales
R and D interaction to domestic exports	R and D intensity × (dummy = 1), if firm is domestic owned and exporting, else 0
R and D intensity of domestic firms	R and D expenditure of domestic firms in sector j/net sales by domestic firms in j
Age and Age^2	Current year – year of incorporation as recorded in CMIE Prowess database
ISO Certification	Dummy variable = 1, if firm has obtained ISO-14001 certification

The third variable of interest is ISO-140001 certification that necessarily relates to international standard of technology learning and related to the environmental issues at firm level. Getting this certification leads a firm forward in the international market and increases the possibility of export and hence decision to export. However, the number of firms attaining this certification for the sample here are very limited. Hence, the result of this experimentation is not clear at this stage. However, we would like to experiment with this variable to check the

model outcome. The other variable of interest is expenses related to advertisement, marketing, packaging and distribution of final output. This variable is important in the view of export behavior as this activity at firm level, helps firms in wider market may it be domestic or foreign. Hence, the probability of getting into the export market becomes easy for the firms. Finally, the empirical model includes a set of industry dummies to control for time invariant sectoral effects. The variables and their definition are presented in table 4.

Table 5 presents the average export, R and D and technology import for the sample from 2000 to 2014. Here we have tried to compare these three variables between the beginning of the study period and the end of the period. We can observe that export intensity for domestic firms in the sample has increased from 2000 to 2014 not only for the full sample but also for the sub-samples, except for the manufacture of bicycles and invalid carriages segment where the export intensity has decreased from 8.55 percent to 3.09 percent. For the MNE affiliation firms export intensity has also increased from 7.72 percent in 2000 to 11.51 percent for 2014. An increase in the export intensity is also reported for sub-industries in the MNE affiliated firms except for the manufacture of bicycles and invalid carriages. Only this sector has reported a decrease in export intensity in our sample. Otherwise there is an increase of 47.62 percent in export intensity for the domestic firms against 49.09 percent increase in export intensity for the MNE affiliated firms. These figures indicates that during 2000 to 2014 export intensity for the automobile sector of India has increased except for the manufacture of bicycles and invalid carriages segment.

When we see the changes in R and D intensity of firms in the sample in the same classification (domestic and MNE affiliated) we can observe that domestic firms R and D intensity has increased from 0.39 percent to 1.11 percent during the study period, where as for the MNE affiliated firms R and D intensity has increased from 0.21 percent to 0.49

percent. A close look into the subsector narrates that except for (1) manufacture of motorcycles and (2) manufacture of bicycles and invalid carriages other firms in the domestic classification of the sample has increased R and D intensity.

However, in the MNE affiliation firms (1) manufacture of rubber tyres and tubes; retreading and rebuilding of rubber tyres and (2) manufacture of motorcycles have reported less R and D intensity during the study period. One closer look in to the table revels that R and D intensity of domestic firms in manufacture of motor vehicles segment has drastically increased from merely 1.83 percent in 2000 to 11.86 percent in 2014. However, for the full sample there is a positive change in R and D intensity in the study period. Unlike export and R and D intensity, technology import intensity has not majorly shifted upward in the study period. For the domestic firms, the technology import intensity has declines from 0.47 percent to 0.42 percent and for the MNE affiliated firms technology import intensity has remained at 0.35 percent for both the years. The detail information is given in table 5.

Table 6 presented the descriptive statistics of the variables. From the table, we can observe that the firm-year mean in export intensity is 10.82 percent with standard deviation of 16.93. Maximum export intensity is calculated at 96.70 percent where there are also firms with no export participation. In case of productivity, we can see that the productive firm in the sample has the ratio of 81.40 percent with mean productivity of 16.59 percent. In case of skill intensity the maximum is at 9.93 percent with mean skill intensity of 0.13 and standard deviation of 0.46. Similarly, energy intensity is found maximum at 0.53 for the sample with mean energy intensity of 0.04. The youngest firm is at the age of one year compared to the oldest firm of 109 years of old. There are firms with no advertisement intensity with firms having advertisement intensity maximum at 0.27.

Table 5: Average Export, R and D and Technology Import Intensity by Affiliation of Firms

Export Intensity					R and D Intensity				Technology Import Intensity			
NIC-2008	Domestic		Foreign		Domestic		Foreign		Domestic		Foreign	
	2000	2014	2000	2014	2000	2014	2000	2014	2000	2014	2000	2014
2211	7.42	18.18	3.69	4.73	0.17	0.29	0.31	0.05	0.54	0.24	0.00	0.35
2910	4.69	2.20	6.35	5.75	1.83	11.86	0.90	1.85	0.91	0.37	0.00	0.50
3091	7.25	10.70	7.99	12.33	0.34	0.33	0.19	0.41	0.44	0.45	0.37	0.34
3092	8.55	3.09	0.78	5.06	0.02	0.00	0.05	0.10	0.38	0.00	0.00	0.00
Total	7.16	10.57	7.72	11.51	0.39	1.11	0.21	0.49	0.47	0.42	0.35	0.35

Note: In third row, 2000 and 2014 represents the year of study. First column represents sub-industries based on NIC-2008 classification. Export, R and D and Technology import intensity are presented in intensity form. Source: Authors calculation from CMIE Prowess Data.

Table 6: Descriptive statistics of variables

Variables	Mean	SD	Min	Max
Export Intensity	10.827	16.930	0.001	96.700
Productivity	16.592	12.583	1.644	81.408
Skill intensity	0.130	0.461	0.014	9.933
Energy Intensity	0.044	0.053	0.004	0.533
Research and Development Intensity	0.003	0.008	0.000	0.142
Technology Import Intensity	0.005	0.010	0.000	0.098
R and D Intensity of Domestic Firms	0.002	0.008	0.000	0.142
Firm Age	25.062	17.677	1.000	109.000
Firm Size	6.912	1.813	0.405	12.435
Advertisement and Marketing Intensity	0.043	0.036	0.000	0.274

Note: SD represents standard deviation. Source: Authors calculation from CMIE Prowess Data.

From the table it's clear that the firms in the automobile sector in the sample have heterogonous characteristics among variables. Hence, the factors explaining the decision to export or determinants of export intensity shall be different based on the decision to entry in export market. Table 7 presents the correlation matrix of the variables with the covariance. From the table it is clear that the estimated probit model (probability to export) is positively related to all the variables included in the estimation. This matrix is a post estimation exercise after the probit regression. However, correlations among the independent variables coefficients are having different signs. The details of the estimated results are given in table 7. After arriving at the results of the probit estimations, we have tried to check the sensitivity and the goodness of the test results. The details are given in table 8. In the earlier model the status variable is export participation; and the explanatory variables are given in the table. Table reports the observed coefficient and the bias of estimation with the bootstrap strand error. For instance, some of the coefficient of the independent variables such as productivity, research

and development intensity, technology import intensity, R and D intensity of domestic firms, R and D interaction and advertisement and marketing intensity of firms are negatively biased in the estimate however, other variables are positively biased in the estimation.

Table 7: Correlation Matrix of Coefficients of Probit Model

Variables	Productivity	Skill	EI	RDI	AGE	SIZE	ADVT	TI
Productivity	1.000 (0.001)							
Skill	0.115 (0.001)	1.000 (0.017)						
EI	0.063 (0.003)	-0.265 (-0.018)	1.000 (0.285)					
RDI	0.008 (0.009)	0.001 (0.001)	-0.007 (-0.043)	1.000 (155.119)				
AGE	0.102 (0.004)	-0.034 (-0.002)	-0.085 (-0.017)	0.011 (0.001)	1.000 (0.001)			
SIZE	0.042 (0.003)	0.225 (0.002)	0.118 (0.005)	0.013 (0.013)	-0.001 (-0.004)	1.000 (0.001)		
ADVT	0.033 (0.002)	0.022 (0.002)	-0.028 (-0.011)	0.040 (0.355)	-0.032 (-0.009)	0.097 0.510)	1.000 (0.004)	
TI	0.003 (0.001)	-0.003 (-0.001)	0.034 (0.033)	-0.011 (-0.248)	0.065 (0.046)	0.010 (0.008)	0.006 (0.002)	1.000 (3.352)

Note: Covariances are presented in brackets. EI, RDI, AGE SIZE, ADVT and TI refer to energy intensity, R and D intensity, Firm Age, Firm Size, Advertisement and Marketing Intensity and Technology Import Intensity respectively. Source: Authors calculation from CMIE Prowess Data.

The area under the Receiver Operating Characteristic (ROC)[7] curve has been estimated to be 0.809 which is considered to be above acceptance region. Hence, the model is well explained in terms of accuracy and biasness. Similarly the sensitivity of the model is 90.70

[7] A receiver operating characteristic (ROC), or ROC curve, is an analysis illustrates the performance of a binary classifier system as its discrimination threshold is varied. The curve is created by plotting the true positive rate against the false positive rate at various threshold settings. The ROC curve is thus the sensitivity as a function of fall-out. In general, if the probability distributions for both detection and false alarm are known, the ROC curve can be generated by plotting the cumulative distribution function (area under the probability distribution from +∞ to -∞) of the detection probability in the y-axis versus the cumulative distribution function of the false-alarm probability in x-axis. ROC analysis provides tools to select possibly optimal models and to discard suboptimal ones independently from (and prior to specifying) the cost context or the class distribution. ROC analysis is related in a direct and natural way to cost/benefit analysis of diagnostic decision making.

percent; predictive capacity of the model is more than 79 percent positively and more than 70 percent negatively. The model is correctly specified up to 77.41 percent and the goodness of fit is statistically significant.

Table 8: ROC Bootstrap Results, Sensitivity and Goodness of Fit Test

Status Variable- Export Participation			
Classifiers	**Observed Coefficient**	**Bias**	**Bootstrap Std. Err.**
Productivity	0.478	-0.0004	0.026
Skill Intensity	0.519	0.0006	0.026
Energy Intensity	0.482	0.0008	0.024
Research and Development Intensity	0.504	-0.0012	0.026
Technology Import Intensity	0.318	-0.0002	0.020
R and D Intensity of Domestic Firms	0.392	-0.0008	0.024
R and D Interaction to Domestic Exports Intensity	0.123	-0.0006	0.015
Firm Age	0.668	0.0002	0.024
Firm Size	0.739	0.0001	0.022
Advertisement and Marketing Intensity	0.689	-0.0008	0.024
Area under ROC Curve	0.809		
Sensitivity of the model	90.70%		
Positive predictive value	79.36%		
Negative predictive value	70.28%		
Correctly classified	77.41%		
Goodness-of-fit test Pearson chi^2 (3979)	4104.88**		
AIC	-1924.282		
Number of observations	3993		
Replications	1000		

Note: *** denotes statistical significance at 1% level. Source: Authors calculation from CMIE Prowess Data.

As discussed in the theoretical section, we measure the export activity of firm i in two ways. The first measure is a dummy variable that is equal to one if the firm is an exporter at time t (zero if not) which the second is the firm's export ratio, defined as exports as a percentage of net sales by firm i in time t. We first report results of the probit estimation for the determinants of whether a firm is an exporter in table 9. Column (i) in table 9 presents results of the probit estimation using the full sample where observations are pooled over the 15 years. The number of observations used is not equal to the total observations as export data are missing for some firms and years. Since, the data are missing randomly this should not lean to any selectivity problems. However, if there are significant unobserved, time invariant firm specific effects that are correlated with the explanatory variables, then the simple pooled regression may produce biased and inconsistent estimates. In order to control for the possibility of the presence of such effects we also estimated a random effects probit model (Guilkey and Murphy, 1993), the results of which are reported in column (ii). The likelihood ratio test reported in the table indicates that the panel-level variance component is not unimportant and, hence, the pooled estimation is not identical to the panel estimation. However, overall, the results of the pooled probit and random effects probit are reasonably similar in terms of magnitudes and statistical significance of the coefficients. Inspection of the results shows that, as expected, firms are more likely to be exporters the older and larger they get; a finding that is in line with the results obtained by Roberts and Tybout (1997) in their analysis of the decision to export by the Colombian firms. In our case, however, we allow the effects of age and size to be non-linear and our statistically significant coefficients provide support for this assumption. In line with Bernard and Jensen (2001) we also find that more productive and more skill intensive firms are more likely to be exporters. Also our study finds that energy efficiency is an indicator of export participation when the pooled probit analysis results are considered.

Table 9: Results of Probit Estimations

Variables	Pooled Probit Regression		Panel Probit Regression	
	Std. Err.	Coef.	Std. Err.	Coef.
Productivity	0.002	0.003*	0.002	0.004**
Skill intensity	0.161	0.246*	0.205	0.228*
Energy Intensity	1.186	-1.372*	1.461	0.966
Research and Development Intensity	15.857	-11.112	26.698	37.786*
Technology Import Intensity	2.918	0.675	3.474	2.986*
R and D Intensity of Domestic Firms	16.125	14.238	26.867	37.875*
R and D Interaction to Domestic Exports Intensity	0.177	0.395**	0.246	0.259*
Firm Age	0.008	0.035***	0.015	0.083***
Firm Age^2	0.000	-0.000***	0.000	-0.001***
Firm Size	0.150	0.507***	0.206	0.773***
Firm Size^2	0.011	-0.014*	0.015	-0.012*
Advertisement and Marketing Intensity	2.174	8.895***	2.017	14.450***
ISO certification dummy	0.318	0.295	0.382	0.354
Constant	0.556	-3.063	0.723	-5.232
/lnsig2u			0.139	
sigma_u			0.153	
Rho			0.020	
LR test rho=0			1468.820***	
Number of observations	3993			
Wald chi^2(13)	185.850***			
Pseudo R^2	0.225			

Note: All regressions include sectoral and time dummies; standard errors (Sdt. Err.) adjusted for clustering on firm id for the pooled probit estimates; Coef., refers to coefficients; *, ** and *** denotes statistical significance at 10, 5 and 1% level. Source: Authors calculation from CMIE Prowess Data.

In terms of R and D activity we find strong evidence that a firm's own R and D intensity is an important determinants of whether a firm exports. R and D interaction, from multinational firms also appears to encourage export activity by the domestic firms. The interaction term, however, indicates that spillovers from MNEs do benefit foreign firms, i.e. foreign firms benefit from R and D activity of MNEs in the same sector while domestic firms apparently do not. This may not be surprising, given that foreign firms are usually shown to be more efficient and productive than their domestic counterparts (e.g. Doms and Jensen, 1998). The result may also to some extent indicate that foreign firms have a better absorptive capacity to assimilate and utilize the knowledge that spills over from the R and D activity of other MNEs in the same industry. However, R and D intensity of domestic firms also plays major in the decision to export having a positive and significant result. Technology import intensity is also included in the regression equation. The result of this experiment finds that firms with higher technology import intensity encourages firm to participate in the export market.

Another firm characteristic related to export behavior of firms "advertisement and marketing intensity" is also found statistically significant, implying higher advertisement and marketing intensities encourages firms to participate in export markets. However, ISO certification is not arriving as one of the major determinants of decision to export for the sample of firms in automobile industries in India. While many of the variables included in the probit model are statistically significant, their economic significance is not clear. In order to try and assess this we calculate the change in probability (at the mean of the independent variables) associated with a marginal change in the variable for the results reported in column (i). Accordingly, we find that the predicted probability that firms export is 0.58. The coefficient on the R and D interaction term then indicates that a marginal increase in the

domestic R and D presence would lead to an increase in the probability to export for foreign firms by 0.69.

In this paper, we are not only interested in what determines whether a firm exports or not, but also in the determinants of the export ratio, i.e. how much a firm exports[8]. The export ratio, by definition, varies between 0 and 1 and, therefore, OLS estimation is not appropriate. Rather, we employ a tobit model which allows for left and right censoring of the data[9]. As in the probit estimations above, we first estimate a tobit model on the pooled data, ignoring any possible firm specific time invariant effects. These estimations are reported in column (i) of table 10. In order to control for *possible firm specific effects* we also estimated a random effects tobit model, the results of which are presented in column (ii). The likelihood ratio test indicates that the panel estimations are not identical to the pooled tobit model; however, inspection of the results shows that they are roughly similar in terms of size and significance of the coefficients.

As in the probit estimations we find that older and larger firms tend to export more, although these effects are non-linear. Firm size is nonlinearly related to export intensity in the tobit estimates, with opposite sign as compared to the probit model. The results indicates that smaller and bigger sized firms are exporting more compared to the medium sized firms, however, in case of decision to export the relation is opposite and medium sized firms are deciding to export more compared to the small and large sized firms. There is also evidence that more productive and skill intensive firms have higher export intensity.

[8] Note that the export intensity in equation (15) is defines as the share of the value of export over net sales by each firm. Since individual prices are not available to us we cannot, therefore, study potential price and/or quantity effects that could possibly explain variations in the export intensity.

[9] One problem in the estimation of the determinants of the export intensity is that there may be selectivity bias if we were to include only firms with positive exports. The tobit model, however, includes all firms, i.e. also those with zero exports. We also focus on firms that were in the sample in all 15 years, therefore, avoiding selectivity bias due to entry and exit of firms.

In terms of the impact of R and D, our results suggest that higher R and D intensity of firms leads to higher export intensity. This finding is in line with Bleaney and Wakelin (2002) and Wakelin (1998) who analyze the export performance of UK manufacturing plants. In line with the probit estimations, we also find a positive R and D interaction term, implying that R and D spillovers are stronger for the foreign firms than that of the domestic firms. Hence, R and D intensity and R and D interaction not only affect a firm's decision of whether or not to export, it also stimulates firm's to export more. The third variable related to the R and D behavior of firms is R and D intensity of the domestic firms. The result of this variable is statistically significant and positive. The result indicates that domestic firms R and D also have a significant role in explaining export intensity for the sample. Hence, the results on the R and D indicates that not only R and D intensity is related to firms export behavior but R and D intensity of domestic firms and R and D intensity and export interaction are also related in explaining firms export behavior.

Parallel to the results of probit regression, technology import intensity is statistically significant to the export intensity of firms. Hence, technology import intensity not only affects firm's decision to export, it also stimulates firms' to export more. Parallel to the above results we can also see that export intensities are also related to energy intensity. From the results it seems that firms that are energy efficient are exporting more. Energy intensity has emerged as an important variable in explaining export intensity of firms; however, it does not explain the decision to export (as the result of the probit regression is statistically insignificant). This result of export behavior and energy intensity is similar to the earlier study by Sahu and Narayanan (2013) for the technology intensive manufacturing firms in India.

Table 10: Results of Tobit Estimations

Variables	Tobit regression		Random-effects tobit regression	
	Std. Err.	Coef.	Std. Err.	Coef.
Productivity	0.017	0.041***	0.011	0.043***
Skill intensity	2.940	1.048	2.189	1.808*
Energy Intensity	8.949	-13.961*	11.049***	-5.636***
Research and Development Intensity	14.057	17.749	9.050	14.258*
Technology Import Intensity	30.316	94.475	17.635	13.754*
R and D Intensity of Domestic Firms	155.928	74.795	9.616	4.881*
R and D Interaction to Domestic Exports Intensity	1.519	0.040*	0.870	0.653*
Firm Age	0.056	0.343***	0.099	0.560***
Firm Age^2	-0.001	-0.003***	0.001	-0.003***
Firm Size	1.062	6.277***	1.079	-0.159*
Firm Size^2	0.072	-0.355***	0.074	0.070*
Advertisement and Marketing Intensity	10.242	172.247***	9.320	116.968***
ISO certification dummy	3.160	0.204	2.274	0.493
Constant	4.120	-33.059	4.123	-12.980
/sigma	0.302	21.321		
/sigma_u			0.959	22.181
/sigma_e			0.138	9.521
Rho			0.012	0.844
Wald chi2(13)			338.590***	
Log likelihood	-13144.902		-11143.845	
Number of observations	3993		3993	
LR chi2(13)	469.270***			
Pseudo R2	0.018			

Note: All regressions include sectoral and time dummies; standard errors (Std. Err.) adjusted for clustering on firm id for the pooled tobit estimates; Coef., refers to coefficient; *, ** and *** denotes statistical significance at 10, 5 and 1% level. Source: Authors calculation from CMIE Prowess Data.

Further, determinants of export intensity for different export behaving firms are reported in table 11. The results are given for four classifications of export behaving firms. The classifications include firms that are exporting at least for one year, exporting from 1-6 years,

exporting from 7-14 years and continuously exporters (for all 15 years). From the table we can observe that productivity is positively related to all the classifications. Hence, productive firms are those which are exporting more. However, the magnitude of relationship is decreasing. For instance, the coefficient of productivity is ranging from 1 percent to 10 percent statistically. Further, skill intensity is also positive for all the classifications of export behavior. However, energy intensity is negatively related for firms that are exporting for at least for one year, firms that are exporting for 7-14 years and firms that are continuously exporting. Meaning firms that are higher energy efficient are exporting more compared to the energy intensive firms. In case of other classifications (i.e. firms exporting from 2-6 years) the export intensity is however positively related to energy intensity. Meaning firms that are exporting between 2 to 6 years are energy intensive. Hence, in comparison we can conclude that firms that are continuously exporting for minimum 7 years and more are energy efficient. Also, firms that are exporting for at least for one year are energy efficient. But firms that are exporting for 2 to 6 years are the energy intensive firms.

The results of the research and developing intensity are positively related to firms that are exporting at least for 7 years or more. However, for firms those are exporting for minimum for 2 to 6 years are negatively related. Hence, firms R and D intensity is higher and export intensity is higher when they export for minimum for 7 years. Firms that are exporting for less than seven years have lesser R and D intensity. This result is parallel to the results of energy intensity. In comparison we can assume that firms that are exporting more, energy efficient and investing more in R and D intensity are those that are exporting for a minimum for seven years. Technology import intensity is significant for firms exporting for 2 to 6 years and for continuously for 15 years. However, the sign is different. In case of the first one, the relationship is positive and for the continuously exporters the sign is negative.

Table 11: Results of Tobit Estimates for Group of Firms those are Classified in Different Export Behavior Classifications

Variables	At least exporting for 1 year (1)		Exporting for 2-6 years (2)		Exporting for 7-14 years (3)		Exporting for 15 years (4)	
	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.
Productivity	0.017	0.081***	0.020	0.061***	0.026	0.108***	0.097	0.012*
Skill intensity	8.398	20.710***	8.414	2.194*	8.143	33.806***	19.351	7.246*
Energy Intensity	19.935	-82.860***	24.780	2.970	20.242	-70.694***	38.299	139.444***
Research and Development Intensity	16.956	16.437	16.196	-19.404**	12.694	11.948*	6.003	7.070**
Technology Import Intensity	63.217	-9.046	21.349	5.645*	44.153	51.114	87.832	-76.757**
R and D Intensity of Domestic Firms	157.324	110.992	17.668	17.109*	14.860	6.581*	4.229	-5.101*
R and D Interaction to Domestic Exports Intensity	1.497	3.108**	1.616	1.667**	1.435	-0.671	3.210	0.421**
Firm Age	0.165	0.687***	0.188	-0.015*	0.166	-0.803***	0.215	-0.292*
Firm Age^2	0.002	-0.005***	0.002	0.003*	0.002	0.005**	0.003	0.001**
Firm Size	1.982	1.325*	2.275	-1.583*	1.824	-4.000**	3.215	-0.060*
Firm Size^2	0.134	-0.188*	0.160	0.015*	0.119	0.167*	0.217	0.006*
Advertisement and Marketing Intensity	14.828	16.585***	24.004	19.538***	15.456	11.416***	27.633	19.420***
ISO certification dummy	2.977	-3.369	66815.270	-154.981	5.053	0.624	5.302	7.722
Constant	7.503	-18.073	8.591	-27.944	7.084	3.971	12.574	-9.419
/sigma_u	1.241	21.707	2.311	29.846	1.589	23.932	1.572	19.990
/sigma_e	0.240	8.652	0.262	8.157	0.220	8.635	0.409	8.778
Rho	0.015	0.863	0.011	0.931	0.015	0.885	0.026	0.838
Number of observations	1250		840		1435		468	
Wald chi2(13)	195.76***		58.29***		158.94***		56.73***	
Log likelihood	-3428.268		-2395.793		-3955.2156		-1466.0069	

Note: All regressions include sectoral and time dummies; standard errors adjusted for clustering on firm id for the pooled tobit estimates; *, ** and *** denotes statistical significance at 10, 5 and 1% level. Source: Authors calculation from CMIE Prowess Data.

Comparing the results of the R and D intensity we can observe that firms that are continuously exporting have higher R and D intensity and lesser technology import intensity. Meaning these firms are probably doing higher in house R and D compared to the dependency on import of technology. However, for firms exporting between 2 to 6 years the higher export intensity depends on higher technology import intensity. It should be noted that the sample consists of firms both from the domestic and foreign presence. Because there is a difference in the structure of firm in terms of ownership or equity share, the decision to export and the export intensity should be different for the two different classifications of the firms based on the ownership classifications. It will be also interested to check the interaction of R and D with the ownership of firms and see if spillover exists in terms of R and D and firm ownership while looking at the export intensity. To capture this, we have created two types of interaction variables. Of which one captures the export intensity of only domestic firms (for multinational firms the value being 0) and other doing R and D and being domestic in terms of firm ownership (0 for firms doing R and D and multinationals). These interaction variables not only give robust results in terms of determinants of export intensity but also give related information on the R and D behavior of firms.

From the result we can see that R and D intensity of domestic firms are important for the firms that are exporting from 2 years to 14 years. However, firms those are continuously exporters, R and D of the multinational matters compared to the domestic firms. When we consider the decision to do R and D for domestic firms and foreign firms; decision to do R and D for the domestic firms are explaining positively for the firms those are exporting at least for one year to exporting for 6 years. However, for the continuously exporters decision to do R and D of the foreign firms matters compared to the domestic firms. Age of the firm has nonlinear relationship with export intensity across group. However, the relationship is different only for those firms exporting for one year. In

case of this group of firms the medium aged firms are exporting more compared to the older and younger firms. When we discuss the result related to the firm size and export intensity; a non linear relationship do exists across groups. This result is similar to the earlier results of firm age and firm size. Advertising and marketing intensity is positively related to export intensity across groups. Other details of the regression results are presented in table 11.

CONCLUSION

This paper uses a rich firm level dataset for Indian Automobile sector for 2000-2014 to reconsider the importance of firms' own R and D and technology activities and intra-sectoral spillovers on firms' export behaviour. We distinguish four channels for R and D and Technology related indicators, namely (1) R and D intensity, (2) technology import intensity, (3) domestic R and D intensity and (4) spillover of R and D for the domestic firms. We also allow for different indicators measuring input efficiency such as energy intensity, skill intensity and productivity defined in terms of value added to salaries and wages. Our empirical results show that a firm's own R and D related activities and technology import intensity are important determinants of whether or not this firm becomes an exporter, and how much a firm exports. R and D spillovers, either from MNEs or domestic firms, also appear to affect the likelihood of whether domestic firms become exporters, and how much a firm exports. Our results do suggest, however, that R and D spillovers exert positive effects on firms' export ratios for both domestic and foreign firms' based on the export behavior. We do not find strong evidence to suggest that firms benefit from ISO certification for the export activities; however, energy efficiency plays an important role to explain the inter-firm differences in export behavior at firm level.

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