



Received: 16 August 2017
Accepted: 27 March 2018
First Published: 03 April 2018

*Corresponding author: Amarendu Nandy, Department of Economics, Indian Institute of Management (IIM) Ranchi, Suchana Bhawan, Meur's Road 834008, Ranchi, Jharkhand, India
E-mail: amarendu@iimranchi.ac.in

Reviewing editor:
Xibin Zhang, Monash University, Australia

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GENERAL & APPLIED ECONOMICS | RESEARCH ARTICLE

FDI, technical efficiency and spillovers: Evidence from Indian automobile industry

Abhisek Sur¹ and Amarendu Nandy^{1*}

Abstract: Most emerging market economies intend to attract foreign direct investment (FDI), expecting that efficiency spillovers from FDI positively influence the productivity of domestic firms. The Indian automobile industry has been a key beneficiary of FDI, ever since the economy opened up since the early 1990s. Employing a stochastic frontier analysis (SFA), this paper first compares the technical efficiency of foreign firms (FFs) vis-à-vis domestic firms (DFs) in the Indian automobile industry for the period 2001–2014. Second, the paper identifies the key determinants, which explain the differences in technical efficiency between FFs and DFs. Finally, the paper analyses the transmission of spillovers from FFs to DFs in terms of competition, demonstration, and information effects. The results reveal higher technical efficiency (TE) of foreign firms over the domestic firms; that younger firms, both domestic and foreign, were relatively more efficient; and domestic automobile firms did not benefit from exporting activities, mainly due to their inward-orientation. The analysis in this paper suggests that the spillover effects is prominent only through demonstration effect. The competition and information effects are not significant channels for transmission of spillovers from foreign to domestic firms in the Indian automobile industry.

ABOUT THE AUTHORS

Abhisek Sur is a doctoral candidate in the Economics Area at the Indian Institute of Management (IIM) Ranchi. He received his BSc and MSc degrees from University of Calcutta, India. His current research interests include international trade and applied macroeconomics.

Amarendu Nandy is an assistant professor in the Economics Area at the Indian Institute of Management (IIM), Ranchi. He holds a PhD from the Lee Kuan Yew School of Public Policy from the National University of Singapore (NUS), Singapore and MSc and BSc degrees from University of Burdwan, India. His current research interests are in international trade, economic development, and labor economics.

PUBLIC INTEREST STATEMENT

The Indian automobile industry has been a key beneficiary of India's liberalization and globalization process that started in early 1990s. The study investigates whether and how the domestic automobile firms benefitted from the higher levels of foreign direct investment in India's automobile industry. One key finding of the study indicates the inability of the domestic firms to tap the overseas markets, primarily due to their inward-orientation. The results underscore the need for domestic firms to tap newer external markets through collaborations, and strengthen their research and development activities. With India's renewed thrust on boosting domestic manufacturing and entrepreneurial activities, including in the automobile industry, the focus of public policy should be on skill development of the workforce, so that spillover benefits accruing from foreign direct investment maybe better reaped by domestic firms, households, and the economy at large.

Subjects: Industrial Economics; Econometrics; International Trade (incl. trade agreements & tariffs); Manufacturing Industries

Keywords: foreign direct investment; technical efficiency; spillover effect; stochastic frontier analysis; automobile industry; India

JEL classifications: D24; F14; L62

1. Introduction

Over the past three decades, foreign direct investment (FDI) has emerged as a prime source of external financing for the emerging market economies (EMEs). Between 1998 and 2014, total private capital flows to 30 EMEs witnessed a sevenfold increase, with an average growth of 14.3% between 1998 and 2014 (Table 1). In 2014, of the total private capital flows to EMEs, two-thirds was accounted for by direct and portfolio equity flows, while one-third was accounted for by total debt flows (bank and non-bank lending). Table 1 also suggests that FDI explains about three-fifths of the increase in total private capital flows during the same period. It is therefore not surprising that policy-makers in the developing countries have undertaken structural reforms and have made sustained efforts to improve the business environment to attract FDI.

A review of the extant literature, covering aggregate level studies, suggests a fair degree of convergence among researchers regarding the benefits of FDI as a stable source of capital (Berg, Borensztein, & Pattillo, 2005); in stimulating growth (Aizenman, Jinjark, & Park, 2013; Choong, Baharumshah, Yusop, & Habibullah, 2010); in bridging the savings-investment gap; and in addressing the balance of payment (BoP) problems, particularly in emerging economies. Studies have also recognized the role that foreign firms play to boost innovative activities in the host country, directly or indirectly (Lall, 1993) and in positively influencing industrial productivity (Bitzer & Görg, 2009). Tong and Wei (2011) showed that countries with higher FDI flow prior to crisis period developed greater resilience to mitigate the crisis.

However, there has been little convergence on the indirect benefits that accrue to economies attracting FDI. Starting with the seminal work by Caves (1974), several empirical studies have attempted to identify and measure the indirect benefits (spillover effects) of FDI in a variety of geographical and industrial settings. However, the results have yielded no conclusive evidence of positive or

Table 1. Private capital inflows to 30 emerging market economies

Items	1998	2007	2008	2010	2014
A. Total private capital inflows (B+C)	153,953 (100.0)	1,261,256 (100.0)	682,401 (100.0)	1,213,139 (100.0)	1,048,077 (100.0)
B. Total equity flows	156,648 (101.75)	574,313 (45.53)	452,794 (66.35)	668,262 (55.09)	687,187 (65.57)
B.1. FDI	141,115 (91.66)	490,750 (38.90)	535,367 (78.45)	521,227 (42.96)	585,971 (55.91)
B.2. FPI	15,533 (10.08)	83,563 (6.62)	-82573 (-12.10)	147,035 (12.12)	101,216 (9.66)
C. Total debt inflows	-2694 (-1.75)	686,943 (54.46)	229,607 (33.65)	544,877 (44.91)	360,891 (34.43)
C.1. Bank lending	-89175 (-57.92)	442,352 (35.07)	74,880 (10.97)	171,503 (14.14)	175,075 (16.70)
C.2. Non-bank lending	86,481 (56.17)	244,591 (19.39)	154,727 (22.67)	373,374 (30.78)	185,816 (17.73)

Notes: 1. All figure in billion US dollars; 2. Figures in parentheses denotes percentage of total.

Source: Adapted from Igan, Kutan, and Mirzae (2016).

negative spillovers. For example, while Javorcik (2004), Kose, Prasad, and Terrones (2009) and Li and Liu (2005) found substantial productivity gains accruing to the domestic firms from FDI, other studies like Rogers (2010) and Medda and Piga (2014) concluded to the contrary. Various empirical studies have also been conducted to test the viability, extent, and effects of such spillovers in the host economy (Singh & Zammit, 2011; Wade, 1990). These studies pointed out that though quantitatively small, qualitatively FDI played a significant role in economic development. Nevertheless, the extant literature suggests that the benefits of FDI accruing to domestic firms are not equal, rather are contingent upon the conditions in the host country and are often firm-specific as well (Görg & Greenaway, 2004).

Consistent with the trends of inward FDI flows to EMEs, India also attracted substantial FDI flows following the adoption of the New Industrial Policy in 1991, which initiated structural reforms in the Indian economy. Apart from dismantling the license *permit-raj* regime that hindered the growth of domestic industries, the liberalization, privatization and globalization (LPG) policies undertaken since 1991 also liberalized the terms of inward foreign capital flows. This resulted in marked increase in FDI inflows to different sectors of the Indian economy. The automobile industry in India was one such beneficiary, being consistently among the top five industries attracting FDI in India in the post-liberalization era. According to India Brand Equity Foundation (IBEF), the automobile industry attracted FDI of US\$ 16.67 billion between April 2000 and March 2014 (IBEF, 2017). Most of the global automobile giants set their manufacturing or assembling units in the country, giving rise to the possibility of potential spillover benefits accruing to the industry. The motivation of this study is therefore to examine the extent to which the indirect benefits of FDI inflows benefited the domestic firms in the Indian automobile industry and the transmission route of such spillovers. Such studies in the Indian context, as is the focus of this paper, on intra-industry spillovers is scant in the extant literature.

This paper thus contributes to the existing literature in two key aspects. *First*, unlike most of the previous studies in the Indian context, it adopts a disaggregated approach and analyzes the industry-specific impact of FDI. Most of the studies in the Indian context has either focused at the macro level impacts of FDI (Ghosh & Roy, 2013; Kumar & Joseph, 2005) or have investigated the inter-industry linkages or the vertical spillovers using firm level or industry-level data (Behera, 2014; Kuntluru, Muppani, & Khan, 2012). *Second*, this is one of the few studies, which encompasses both the aspects of technical efficiency and spillovers and the only study covering both aspects in the context of the Indian automobile industry.

The major findings of the paper suggest that foreign firms exhibited higher technical efficiency compared to the domestic firms; that younger firms, both domestic and foreign, were relatively more efficient; and that Indian firms did not benefit from exporting activities due to their inward-orientation. Furthermore, the findings that competition from foreign presence did not significantly influence the industry and that demonstration effect proved to be the dominant channel for transmission of spillovers to the domestic firms assumes importance from policy perspectives.

The rest of the paper is organized as follows. Section 2 gives the summary of the extant literature. Section 3 outlines the research objectives, the variable construction, and the econometric strategy. Section 4 outlines the sample and data specifications. Section 5 provides the results and analyses. Section 6 provides the concluding remarks.

2. Literature review

The theoretical models on FDI and spillovers are based on the industrialization theory (Hymer, 1976). The neoclassical theory of capital flows considered the movement of capital only in response to interest rate differentials in expectation of arbitrage and neglected the development aspects of FDI flows (Dunning & Rayman, 1985). On the contrary, Hymer (1976) proposed FDI as a transfer of a “package” of capital, management, and new technology and hence viewed FDI as an international extension of industrial organization theory. This strand of literature was advanced in the works of (Caves, 1971, 1974), and Koizumi and Kopecky (1977) first modeled the relationship between FDI and technology transfer using a partial equilibrium framework.

Other frameworks have also examined the impact of FDI on host economies. For example, the OLI (ownership location and internalization) paradigm (Dunning, 1976) examined how FDI affects productivity, efficiency, wage levels of the host country. According to this paradigm, the MNCs have certain advantages because of the ownership or because they can exploit the host country conditions with the objective of maximizing the returns.

Another set of studies examined the varying effects of FDI on both the home and the host country. Sala- I. Martin (1997) for example, argues that since the cost of imitation is lower than the cost of innovation, the developing nations would benefit by imitating the designs and technology from their advanced counterparts. FDI, according to them provides a channel for the transfer of technology to the developing countries. Grossman and Helpman (1991) state that besides imitation the transfer of technology has a noticeable effect on R&D and innovation in these economies thus enabling increased efficiency and growth.

Findlay (1978) introduced the concept of technology gap and emphasized that greater the technological gap between the host and home country firms, higher is the possibility of potential spillovers to domestic firms. On the contrary, Glass and Saggi (2002) and Kokko, Zejan, and Tansini (2001) considered technological gap as absorptive capacity and hypothesized that the greater the gap, lower is the possibility of spillovers.

Empirical studies have also yielded contradictory results regarding the spillover benefits from FDI. A brief summary of the relevant literature is provided in Table 2. The studies, set in a variety of industrial settings, have found either positive, negative or inconclusive result pertaining to productivity spillovers from FDI. One crucial insight from studies surveyed (Table 2) suggests that spillover effects are very much contingent upon country-specific and industry/firm-specific factors.

Since this paper studies technical efficiency (TE) and effects of FDI in the Indian automobile sector, it maybe useful to provide a brief review of the extant literature in the Indian context. Ray (2004) computed year-specific firm-level TE for 27 industry groups of Indian manufacturing sector for 1991–2001. Among other things, his study finds that foreign firms enjoyed a significantly higher level of TE than domestic firms. Goldar, Renganathan, and Banga (2004) analyzed the effect of foreign ownership along with other factors on the TE of engineering firms in India during the 1990s and found similar results as Ray (2004). However, Patibandla and Sanyal (2005) studying 11 industries, reported that foreign ownership in a firm had no significant impact on productivity. Banga (2004) examined the impact of US and Japanese-owned firms on total factor productivity growth (TFPG) of the firms in the Indian automobiles, electrical and chemical industries and concluded that the presence of Japanese affiliates had a significant positive impact on TFPG in an industry, while the US affiliation had no impact.

Table 2. Productivity spillovers from FDI—Summary findings from empirical studies

Literature	Aggregation level	Results of spillover effects
Javorick (2004), Haddad and Harrison (1993), Suyanto and Salim (2013), Suyanto, Salim, and Bloch(2014)	Firm	Positive
Blomström (1986), Blomström and Wolff (1994), Caves (1974), Globerman (1979), Kokko (1996)	Industry	
Aitken and Harrison (1999), Blomström and Sjöholm (1999), Djankov and Hoekman (2000)	Firm	Negative
Medda and Piga (2014), Rogers (2010)	Industry	
Barrios and Strobl (2002), Flores, Fontoura, and Santos (2000), Girma, Greenaway, and Wakelin (2001)	Firm	Inconclusive

Source: Authors.

Sasidharan and Ramanathan (2007) studying 2,700 firms found foreign firms to be better performers than domestic firms in terms of total factor productivity. Joseph and Reddy (2009) examined the impact of FDI through backward spillovers arising from the buyer-supplier linkages and concluded that domestic firms resorted to exports due to increased competition and crowding-out of the domestic market by foreign firms. They also found that export efficiency of domestic firms did not increase from the foreign association. Kuntluru et al. (2012) analyzed the impact of FDI on export performance of the pharmaceutical industry in India and found a negative impact of foreign ownership on export performance. Behera (2014) examined the technology spillovers from FDI and showed that foreign firms played a significant role in technological diffusion in the host economy, given a certain subsistence level of absorptive capacity of the domestic firms.

The above review suggests that most of the micro-level studies investigated the spillover aspects of FDI from an inter-industry perspective. The results are heterogeneous and vary across industries. Hence, adopting a disaggregated approach and focussing on a particular industry may provide new insights from an intra-industry perspective, and thus contribute to the extant literature. This study fills this gap in the literature by undertaking an intra-industry study of the Indian automobile industry and exploring the aspects of technical efficiency and spillover benefits accruing to domestic firms from foreign presence.

3. Research objectives, variable construction, and econometric strategy

3.1. Research objectives

Given the lack of disaggregated studies pertaining to technical efficiency and spillover effects from the foreign presence in the Indian context, the preliminary focus was on identifying a relevant sector, which received sizeable inward FDI since the Indian economy moved to a liberalized regime from the early 1990s.

There exists sufficient cross-country evidence about the role the automobile industry plays as one of the key drivers of technology, growth, and employment in various countries (Gottschalk & Kalmbach, 2007). This has also been the case in India, particularly in the post-liberalization era. The automobile industry contributes 45% of the country's manufacturing gross domestic product (GDP), 7.1% of the country's GDP, and employs about 19 million people (DIPP, 2017). In continued efforts towards liberalization, the FDI regulations pertaining to the automobile industry were steadily relaxed, and 100% FDI was allowed since 2002. Between 2000 and 2014, this industry has been consistently among the top five sectors attracting inward FDI. During 2014–16, the FDI flows in this sector increased by 72% to USD 5.25 billion from USD 3.05 billion during 2012–14 (IBEF, 2017). The above suggests that the sector has continuously attracted foreign capital with most of the automobile giants setting up manufacturing or assembling units in India.

With the above backdrop, the key research objective of this paper is to investigate the impact of foreign presence in the Indian automobile sector and the spillover benefits accruing to the domestic firms. To do so, we proceed as follows. First, the hypothesis that the foreign firms are technically more efficient than the domestic firms is empirically tested with reference to the Indian automobile sector. If the initial hypothesis stands true, it gives rise to the possibility of potential spillover benefits from the foreign firms to their domestic counterpart. Second, we check whether firm-level characteristics namely age, size, and export orientation have any influence on the technical efficiency of the domestic firms vis-à-vis the foreign firms. Third, we check the transmission of spillover effects of FDI accruing to the domestic firms specifically through the competition, demonstration and information effects.¹

3.2. Econometric strategy

First, employing a stochastic frontier analysis (SFA), we compute the firm and year-specific measure of technical efficiency and compare the technical efficiency of the domestic firms vis-à-vis the foreign firms. In this method, the technical efficiency of a given firm (in a given year) is defined as the

ratio of its mean output to the corresponding mean output if the firm utilized all its resources (inputs) efficiently.

The SFA is a regression-based method, with specific assumptions pertaining to the production function and distribution of the error terms. Two pioneering papers of SFA by Aigner, Lovell, and Schmidt (1977) and Meeusen and van Den Broeck (1977) introduced the concept of a stochastic parametric model involving two distinct error terms, one representing inefficiency and the other measurement errors and statistical noise typical of empirical estimates associated with technical efficiency, which could introduce a potential source of error. The stochastic frontier models allow estimating standard errors and hypotheses testing. The SFA addresses the shortcoming of the DEA technique² of producing biased estimates in the presence of statistical noise.

Following Battese and Coelli (1995), we use the one-stage stochastic frontier production function (SFPF)³ to estimate the production frontier and the technical inefficiency function simultaneously. The model is specified as:

$$Y_{it} = f(X_{it}; \beta) \exp(v_{it} - u_{it}) \quad (1)$$

$$\text{or, } \log(Y_{it}) = X_{it}\beta + (v_{it} - u_{it}) \quad (2)$$

$$u_{it} = z_{it}\delta + w_{it} \quad (3)$$

Here, Y_{it} is the production of i th firm in the t th time period, X_{it} is a $(1 \times k)$ vector of known functions of inputs of production and other explanatory variables associated with the i th firm at the t th observation, β is a $(k \times 1)$ vector of unknown parameters to be estimated, v_{it} is the time-specific stochastic error term which are i.i.d $N(0, \sigma_v^2)$ and independently distributed of the non-negative random variable u_{it} , which are associated with technical inefficiency of production. u_{it} is assumed to be independently distributed such that these are obtained by truncation at zero of the normal distribution with mean $z_{it}\delta$ and variance σ . z_{it} is a $(1 \times j)$ vector of explanatory variables associated with technical inefficiency of production of firms overtime, and δ is an $(j \times 1)$ vector of unknown coefficients. w_{it} is defined by the truncation of the normal distribution with zero mean and variance σ^2 , such that the point of truncation is $-z_{it}\delta$, i.e. $w_{it} \geq -z_{it}\delta$.

The parameters of Equation (2) are estimated to obtain the maximum likelihood estimates (MLE) of the SFPF following Coelli, Rao, O'Donnell, and Battese (2005). We calculate the firm-specific and year-specific estimates of TE, i.e. TE_{it} . The estimates thus obtained are unbiased and efficient.⁴ The TE thus obtained is the ratio of the observed output to the stochastic frontier output, which can be expressed as:

$$TE_{it} = \frac{Y_{it}}{Y_{it}^p} = \exp(-u_{it}) \quad (4)$$

where Y_{it}^p is the potential maximum output for the i th firm in the t th period.

Following Battese and Coelli (1995), the conditional expectation, $E[\exp(-u_{it})]$ is the best estimator of $\exp(-u_{it})$. Hence,

$$TE_{it} = E[\exp(-u_{it} | \varepsilon_{it})] \quad (5)$$

where $\varepsilon_{it} = -u_{it} + v_{it}$

It is further assumed that the production function takes a log-linear form with three production inputs labor, capital, and material in the production process⁵. Thus, the empirical model can be written as:

$$\log Y_{it} = \beta_0 + \beta_1 \ln L_{it} + \beta_2 \ln K_{it} + \beta_3 \ln M_{it} + \beta_4 T + v_{it} - u_{it} \quad (6)$$

where Y_{it} is the output of the i th firm at the t th period. L_{it} , K_{it} and M_{it} are the three input variables labor, capital and material respectively of the i th firm at the t th period and T denotes the time-trend and increases by one for each year.

To measure the year specific and firm-specific measure of output (Y_{it}) we have taken the natural logarithmic value of net income (LNTI) as a proxy measure of output. Capital (K_{it}) should ideally be measured by the current replacement value of the fixed assets of the firm. However, in the absence of relevant data, we have taken the natural logarithmic value of net fixed assets as a measure of firms' capital following Joseph and Reddy (2009). Labor input (L_{it}) is generally measured by man-hours or number of employees. However, due to lack of data on Indian firms, following Bhavani and Tendulkar (2001), we have taken total wages and salaries as a proxy measure for labor input (L_{it}) and adopted its natural logarithmic values. Material input (M_{it}) is one of the most important inputs of production and affects TE. We have taken the natural logarithmic value of raw materials consumed (RMC) by firm in a particular year as a proxy measure of material input. We have further deflated the values by the GDP deflator to account for the changes in prices overtime.

The parameters of the stochastic frontier function are estimated by the maximum likelihood method. As provided by Coelli and Henningsen (2013), R Frontier package (Version 1.1) was used to estimate Equation (6), to derive the firm-specific and year-specific measure of technical efficiency (TE) for the entire sample. The results also help us to compare the TE of foreign firms vis-à-vis domestic firms.⁶

The inefficiency function is captured by the equation:

$$u_{it} = \alpha + \delta_1 z_{1it} + \delta_2 z_{2it} + \delta_3 z_{3it} + \delta_4 z_{4it} + \delta_5 (z_{1it} z_{2it}) + \delta_6 (z_{1it} z_{3it}) + \delta_7 (z_{1it} z_{4it}) + w_{it} \quad (7)$$

Here, z_{1it} denotes foreign presence) = 1, if it is a FF

= 0 otherwise

z_{2it} , z_{3it} , z_{4it} denote age of the firm (AGE_FIRM), size of the firm (NS), and the export orientation (EXP_INT) of the firms, respectively. The effect of foreign presence is captured by the interaction terms ($z_{1it} z_{2it}$), ($z_{1it} z_{3it}$), ($z_{1it} z_{4it}$) and represent FD_AGE_FIRM, FD_NS, and FD_EXP_INT, respectively. Thus,

$$E(u_{it} | z_{1it} = 1, z_{2it} = 1) = \alpha + \delta_1 + \delta_2 + \delta_5 \quad (8)$$

Equation (8) gives the mean effect of foreign presence on the control variable age of the firm (AGE_FIRM). Similarly,

$$E(u_{it} | z_{1it} = 1, z_{3it} = 1) = \alpha + \delta_1 + \delta_3 + \delta_6 \quad (9)$$

$$E(u_{it} | z_{1it} = 1, z_{4it} = 1) = \alpha + \delta_1 + \delta_4 + \delta_7 \quad (10)$$

Equations (9) and (10) imply the mean effect of foreign presence on the control variables, size of the firm (NS) and export orientation (EXP_INT) of the firms respectively.

Thus in the model, δ_1 captures the differential effect of the foreign presence while δ_2 , δ_3 and δ_4 measures the differential impact of the control variables on the technical efficiency. Similarly δ_5 , δ_6 and δ_7 measure the differential effects of the foreign presence on the control variables age of the firm (AGE_FIRM), size of the firm (NS), and the export orientation (EXP_INT) of the firms, respectively.

While specifying a regression model for Equation (7), which captures technical inefficiency, the Tobit model is selected. This is because the efficiency scores are censored, and lie between 0 and 1. Model estimation using OLS method would result in inconsistent and biased estimates, as OLS underestimates the true effect of the parameters by reducing the slope. Hence, the Tobit model is an appropriate tool (Schnedler, 2005).

Age of a firm is measured by the numbers of years of operation and is calculated by the difference between the year of presence in the sample and the year of incorporation. The natural logarithmic value of age (AGE) is taken for the age of the firm. The influence of age on the TE is ambiguous, as evident from the existing literature. For example, while Malerba (1992) found a positive relationship between age and TE, Salim (2008) posit younger firms to be more efficient. In the Indian context, Kathuria (2001), found no significant relationship between age and TE from his study on the Indian manufacturing sector. We hypothesize a positive association between age and TE. It maybe assumed that with age a firm matures and gains experience, which may influence TE favorably.

Size of a firm may also affect efficiency. Large-sized firms may have a distinct advantage over the small size firms by their command over significant amount of resources, economies of scale and scope in production and enhanced bargaining power in assessing the inputs of production from the market. Studies by Girma and Wakelin (2000) found small-sized firms and Sinani and Meyer (2004) found small- and medium-sized firms to benefit most from the spillover effects of FDI. However, Lundvall and Battese (2000) found the association between size and efficiency to vary across sectors from their study on the Kenyan manufacturing firms. Some studies in the Indian context (Aggarwal, 2002; Joseph & Reddy, 2009) have found bigger exporting firms in India to be more efficient. We denote the size of a firm by its sales turnover following Joseph and Reddy (2009) and hypothesize a positive relationship. The underlying assumption is that a larger firm will command greater sales. Sales turnover is approximated by the net sales (NS), which equals gross sales less indirect taxes and excludes other sources of income. We measure the size of the firm by the natural logarithmic value of net sales of a firm in a given year.

Some other studies investigating the export behavior of firms and TE have shown that export-oriented firms to be more efficient compared to firms that focus on the domestic market (Greenaway & Kneller, 2005; Wagner, 2007). Their main conjecture is that domestic firms with export orientation are likely to face stiffer competition in the international market, which may force these firms to mobilize their resources more efficiently leading to enhanced productivity. Moreover, they argue that the export-oriented firms are exposed to technologically superior firms, which in turn enable better learning and skill development. Conversely, some other studies (Blomström & Sjöholm, 1999; Ponomareva, 2000) advance a contradictory view. They find the spillover benefits accrued more to non-exporting firms compared to exporting firms. In the Indian context, Ray (2006) found a positive relationship between TE and export orientation from his study on engineering firms. We intend to test the impact of a firm's export orientation on the TE and hypothesize a positive relation between TE and export orientation. We measure the export orientation (EXP_INT) by the natural logarithmic value of the firm's export earnings.

After comparing the technical efficiency and investigating the three firm-level characteristics potentially influencing the TE, we analyze the competition effect (CEF), demonstration effect (DEF), and information effect (IEF) as mechanisms of spillovers from foreign firms to the domestic firms.

Several studies (Glass & Saggi, 2002; Wang & Blomström, 1992) highlight the role of competition. Direct competition from foreign firms' entry into the product market might compel the domestic

firms to utilize their resources effectively or search for new technology. This increased competition might have a potential positive influence on the productivity of domestic firms. We measure CEF by a particular foreign firms' share of NS in total NS of all foreign firms in the industry scaled by share of all foreign firms NS to NS of all firms in the sample.

Demonstration effect occurs when the domestic firms are encouraged to imitate the advanced technology associated with MNCs, or they develop their own innovations to match the superior technology brought in by the foreign firms (Das, 1987). This could have a positive impact of raising the productivity of domestic firms. We approximate DEF by a particular foreign firm's share of R&D in total R&D expenditure of all foreign firms in the industry scaled by share of foreign firms in R&D expenditure of all firms in the sample.

The third channel of productivity spillovers, IEF, is linked to exports. Domestic firms often adopt the expertise to export from the MNCs to gain access to foreign markets (Aitken, Hanson, & Harrison, 1997). Exporting generally involves fixed costs, which are investments to create distribution networks, learning about customer's tastes and preferences, and the regulatory norms in the foreign market. Since MNCs are already adept with such information, domestic firms often learn from their foreign counterparts. We measure IEF by a particular foreign firm's share of exports in total exports of all foreign firms in the industry scaled by share of all foreign firms' exports to exports of all firms in the sample.

To capture the spillover effects, we run the censored Tobit regression with technical efficiency (TE) as the dependent variable and the three variables identified as channels for spillover effects—CEF, DEF, and IEF as the independent variables, also incorporating the foreign dummy variable.

4. Sample and data specification

The study uses unbalanced panel data drawn from a sample of 67 firms from the Indian automobile industry over the period 2001–2014. The data were sourced from the Prowess database maintained by CMIE.

The period of study assumes significance from various aspects. First, India moved from the FERA to the FEMA regime in 1999 and pursued liberalized policy, particularly concerning capital flows. Second, 2001 marked a year of inflexion with increased FDI inflows. During the period 2001–2014, the automobile sector in India remained one of the major sectors attracting on an average about 5.5% of annual FDI inflows.

Initially, we extracted a list of 91 firms of the Indian automobile sector available in the Prowess database. However, due to non-availability of data on all chosen parameters for the period of study, we were forced to refine our sample set. Only those firms for which data on relevant parameters were available were selected. This left us with a usable sample of 67 firms, comprising of 15 foreign and 52 domestic firms. The selected firms included all major domestic and foreign firms operating in the industry.

The descriptive statistics (Table 3) below reveal that mean output of the foreign firms is significantly higher than the domestic firms. Further, the firms with highest and the lowest output belonged to FF and DF category, respectively. Another salient finding is that the output-input ratios of FFs are higher than the DFs, suggesting the efficient use of resources.

Table 3. Descriptive statistics

Variable	Sample	Mean	Maximum	Minimum	Standard deviation	No. of firms	No. of obs.
Output	Entire	4,110.28	164,478.51	24.02	11,970.57	67	938
	FF	5,925.03	164,478.51	94.38	15,301.98	15	210
	DF	3,617.07	137,940.1	24.02	10,901.83	52	728
Capital	Entire	936.38	50,169.4	2.35	2,910.16	67	938
	FF	1,251.06	35,542.41	20.3	3,321.52	15	210
	DF	847.84	50,169.4	2.35	2,804.41	52	728
Labor	Entire	167.86	7,618.34	2.85	434	67	938
	FF	241.96	3,863.41	8.2	467.64	15	210
	DF	146.43	7,618.34	2.85	425.62	52	728
Raw materials	Entire	2,320.87	95,189.85	10.63	7,078.25	67	938
	FF	3,174.6	95,189.85	18.34	9,081.95	15	210
	DF	2,100.29	68,450.36	10.63	6,443.95	52	728

Note: The above calculations are based on annual data of the sample firms for the period 2001–2014.

5. Results and discussions

5.1. Results from the estimation of SFPF and technical efficiency

The accuracy of estimates of the spillover effects necessitates correct specification of the stochastic production frontier. Table 4 gives the results of the estimates of parameters of SFPF. It is evident that the coefficients of each of the three inputs are statistically significant at 1% level and they together successfully explain about 86% of the variation in total income (TI).

In our model, the estimates of the coefficients also signify the elasticity of output with respect to material, labor, and capital input. The comparison of these elasticities shows that elasticity of output with respect to labor (0.40) is the highest and substantial, followed by the elasticity of income with respect to material input (0.38) and capital input (0.19), respectively. This implies that the Indian automobile industry can be characterized as a labor-intensive industry. A possible reason could be the dominance of low-end passenger vehicle segment employing cheap labor resources due to cost effectiveness. Further, the sum of the three elasticities (0.97), a measure of returns to scale, is close to unity, signifying that the production function approximates constant returns to scale.

Table 5A provides the descriptive statistics on technical efficiency of the foreign and domestic firms for the sample period. The mean analysis for the entire sample reveals that in accordance with our initial hypothesis foreign firms (mean TE 0.338) are more technically efficient than the domestic firms (mean TE 0.264). Our finding is in line with a study on the manufacturing sector by Ray (2004).

Table 4. Estimates of parameters of SFPF (Dependent variable: LNTI)

	Coefficients	Standard error	t-statistic
Constant	1.8806	0.0760	27.7341
LnNFA	0.1929*	0.0293	6.5839
LnRMC	0.3783*	0.0313	12.0851
LnSAL	0.4042*	0.3937	10.2677
R ²	0.8581		
F-statistic	1,874.100*		

*Significance at 1% level.

Table 5A. Descriptive statistics on technical efficiency of foreign and domestic firms

Description		Mean	Max	Min	Standard deviation	No. of firms
Aggregate (Entire Sample)	Entire	0.280	0.975	0.024	0.154	67
	FF	0.338	0.975	0.142	0.207	15
	DF	0.264	0.899	0.024	0.132	52
First Quartile (By Size)	Entire	0.229	0.975	0.099	0.201	17
	FF	0.560	0.975	0.141	0.227	2
	DF	0.185	0.460	0.099	0.200	15
Second Quartile (By Size)	Entire	0.250	0.899	0.063	0.172	17
	FF	0.229	0.249	0.211	0.010	4
	DF	0.256	0.899	0.063	0.172	13
Third Quartile (By Size)	Entire	0.235	0.670	0.024	0.143	17
	FF	0.237	0.364	0.160	0.073	4
	DF	0.234	0.670	0.024	0.142	13
Fourth Quartile (By Size)	Entire	0.416	0.757	0.271	0.137	16
	FF	0.414	0.757	0.274	0.137	5
	DF	0.417	0.687	0.271	0.110	11

Table 5B. Tobit regression estimates of efficiency of foreign vis-à-vis domestic firms

	Coefficients	Standard error	z-statistic
C	0.264359***	0.006648	39.7636
FOR_DUMMY	0.073216***	0.014051	5.210836
S.E. of regression	0.179738	Mean dependent var	0.280751
Log likelihood	280.7526	Sum squared resid	30.2058
Avg. log likelihood	0.29931	S.D. dependent var	0.182055

***Significance at 1% level.

However, looking simply at the magnitude of the efficiencies is not enough. Therefore, we also tested the hypothesis that foreign firms are relatively more efficient than the domestic firms. Since we have panel data with a censored dependent variable, we applied the Tobit regression in this case. The results in Table 5B provide the statistical evidence of the relatively higher efficiency of foreign firms vis-à-vis the domestic firms as the explanatory variable (foreign dummy in this case) is significant at 1% level.

Further, since the firm size varies across the sample, it maybe worthwhile to see whether the above conclusion remains valid for firms of different sizes. To do so, we divided the entire sample of firms into four quartiles based on the size of the firms and compared the average efficiencies for each quartile. This helped us to compare efficiencies for similar-sized firms. The results in Table 5A suggest that the foreign firms in the first and third quartiles are more efficient than their domestic counterparts, while the domestic firms in the second and fourth quartiles are relatively more efficient. Therefore, the mean efficiencies do vary according to firm-size.

However, as year-wise comparison of TE of foreign vis-à-vis domestic firms (Table A1) suggest relatively higher efficiencies of foreign firms throughout the sample period, and the overall hypothesis holds (Table 5B), we conclude that foreign firms are on an average more efficient than the domestic firms.

5.2. Estimating the influence of firm-level characteristics on technical efficiency

We estimated Equation (7) using censored Tobit regression and calculated the estimates of the corresponding coefficients. The z values and the corresponding p-values are also obtained with the help of the EVIEWS 9 software package.

The coefficient of the foreign dummy was found to be significant and positive. The coefficient of AGE, which represents the age of the firm, is significant and negative although the value of the coefficient is very small (Table 6). This implies a negative relationship between age and TE although the impact would be much less. The results are in accordance with the results obtained by Chen and Tang (1987), who found a negative relationship between age and efficiency from their study on Taiwanese electronics industry. However, the results contradict the study by Kathuria (2001) on Indian manufacturing sector, which did not find any significant relationship between age and efficiency. This is indicative of the fact that the new age firms in the automobile industry are more adept compared to their older counterparts in adopting the modern technology, which can possibly explain the difference in efficiencies.

However, the coefficient of size (NS) is significant at 1% level of significance. The coefficient of NS is positive, implying size is positively related with TE, i.e. as a firm's capacity increases its TE also increases. This might be because large size firms may have a distinct advantage over the small size firms by its command over a large number of resources, economies of scale and scope in production, and enhanced bargaining power in assessing the inputs of production from the market. While this result is a departure from the findings in Girma and Wakelin (2000) and Sinani and Meyer (2004), it is consistent with Indian studies on exporting firms (Aggarwal, 2002; Joseph & Reddy, 2009).

Similarly, export orientation does not have any significant impact on the productivity of domestic firms. Although the sign is positive, it is not statistically significant. The results are in contradiction with the results of Ray (2006), who found a positive relationship between TE and export orientation from his study on Indian engineering firms.

Next, we compare the influence of the control variables on TE of FFs employing interaction dummy as explained in Section 3.2. The results, reported in Table 6, reveal that all the three variables

Table 6. Tobit regression estimates of determinants of technical efficiency

	Coefficients	Standard error	z-statistic
Constant	0.211418**	0.014187	14.90215
AGE_FIRM	-0.000832	0.000386	-2.158209
NS	0.00000518**	0.000000	16.46431
EXP_INT	0.014996	0.045325	0.330845
FD*AGE_FIRM	-0.003095**	0.000678	-4.563015
FD*NS	-0.000000875*	0.000000	-2.039696
FD*EXP_INT	0.763035**	0.067222	11.3509
FOR_DUMMY (FD)	0.108137**	0.026159	4.133893
S.E. of regression	0.120003	Mean dependent var	0.220366
Log likelihood	662.242800	Sum squared resid	13.378320
Avg. log likelihood	0.706016	S.D. dependent var	0.140243
Likelihood ratio test		Wald's test	
Test statistic	Value	Test statistic	Value
Likelihood ratio	245.8121**	F-statistic	117.1950**
		χ^2	703.1703**

*Significance at 5% level.

**Significance at 1% level.

influence the TE of FFs, and are statistically significant. While age and export orientation is significant at 1% level, size of a firm (foreign) is significant only at 5% level of significance. Although size and age have a negative relationship with TE, the coefficients are very small signifying the impact to be minimal. However, unlike the previous case, export orientation not only affects the TE of the FFs positively but also is significant at 1% level. The interaction effect which captures the effect of being an export-oriented foreign firm is much stronger compared to an export-oriented domestic firm.

From the above analysis, we can conclude that although statistically significant, age and size of a firm have a negligible influence as evident from the size of the coefficients. However, export orientation, has a more significant impact, favorably influencing the TE of foreign firms only. This is perhaps because the domestic automobile firms have been laggards in technology adoption and in complying with stringent regulatory norms prevalent in global markets, and hence can capture these markets in a very limited way. This is corroborated by the fact that as of 2016, only two domestic players featured in the list of top ten car exporters from India. Further, Mexico, Nepal, UK, and South Africa being the top export destinations suggests limited reach of the players in more competitive and demanding US and European markets.

5.3. Estimation results of spillover analysis

Estimation of spillover effects from foreign firms to domestic firms reveals that the estimated coefficients of CEF and DEF are significant at 10 and 1% level of significance, respectively. However, IEF is not significant (Table 7). Thus, it can be concluded that the spillover benefits accrue to the DFs primarily through demonstration effect. The MNCs are the prime transmitters of advanced technology as their operations have significant spillover effects to DFs and demonstration effect proves to be an important channel and source of technological externalities to the local firms in the Indian automobile sector. However, the competitive pressure exerted on the existing domestic firms from the entry of the FFs with superior technology appears to have only a weak impact, as the coefficient of CEF is significant only at 10% level. One possible reason for weak competition effect maybe the large and growing⁷ domestic automobile market, which ensures minimal effect on individual market share, despite an increase in the number of players in the industry.

The information effect comes out to be insignificant indicating that domestic firms are unable to extract benefits from exposure to the overseas markets. Indian automobile firms are focused primarily towards catering the domestic market and have limited collaboration with foreign players, resulting in insignificant information spillovers about nature and scope of the foreign markets. This finding strengthens our earlier finding that domestic firms did not gain from export-orientation.

Table 7. Tobit regression estimates of spillover effects

	Coefficients	Standard error	z-statistic
Constant	0.198098**	0.016647	11.89988
CEF_FD	3.289685*	2.065796	1.592454
DEF_FD	3.236731**	1.142881	2.832081
IEF_FD	-0.002692	0.002157	-1.247782
S.E. of regression	0.131886	Mean dependent var	0.220366
Log likelihood	43.24643	Sum squared resid	1.078429
Avg. log likelihood	0.645469	S.D. dependent var	0.141226
Likelihood ratio test		Wald's test	
Test statistic	Value	Test statistic	Value
Likelihood ratio	13.3326**	F-statistic	18.080790**
		χ^2	54.242360**

*Significance at 10% level.

**Significance at 1% level.

6. Concluding remarks

In this study, we empirically examined the technical efficiency and the resulting spillovers from FDI in the context of the Indian automobile industry for the period 2001–2014. Employing a stochastic frontier analysis, we found that on the average the foreign firms were more efficient than their domestic counterparts. This maybe attributed to the foreign firms' access to new advanced technology and the adoption of best practices. Further, the new age firms were found to be more efficient, indicating that the new age firms are more adept at acquiring new technology compared to the older firms. Size of a firm though statistically significant, had negligible influence on the technical efficiency of both domestic and foreign firms. However, export orientation, had a significant positive influence on the TE of foreign firms only, suggesting inward orientation of the majority of the domestic firms.

The results of spillover effects suggest that information effect did not prove to be a significant channel indicating the lack of know-how of Indian firms about export markets and their access strategies due to limited collaboration with foreign players. Competition from the presence of foreign firms was insignificant as well. This is because, the large and growing automobile market in India has not only served as a cushion against foreign competition but has also refrained the domestic firms from venturing overseas, as their market share remained almost unaffected by the influx of foreign players. Only demonstration effect emerged as a major channel for transmission of spillover effects to the domestic firms. This is a crucial finding implying that India must encourage FDI with technological diffusion to ensure the spillover benefits of FDI are passed on to the domestic firms.

The findings of the paper underscore the scope for further research. For example, it maybe worthwhile to understand the role that absorptive capacity of the domestic firms could play in efficiency gains due to foreign presence. Further, a comparative study on the effects of foreign presence on both technical efficiency and production can be undertaken to see whether FDI has more impact on technical efficiency or production function.

Nevertheless, the findings of this study have certain policy imperatives. The untapped opportunities for entrepreneurial activities provided by the large and growing Indian automobile market are evident. The recent government initiatives like Make in India, Automotive Mission Plan 2026 and the National Electric Mobility Mission Plan 2020 has the potential to catapult India into an auto-manufacturing hub, and are steps in the right direction. However, as the study suggests, the inability of the local firms to capture overseas market seems to be a concern and needs to be addressed with right earnest. Encouraging collaborations and joint ventures between domestic and foreign players can have significant benefits in accessing new markets, besides improving the efficiency of domestic firms through stronger spillovers. This, of course, will have to be supplemented by a stronger focus on R&D activities and skill development, which can ensure efficient transmission of spillovers from foreign presence.

Acknowledgements

We are grateful to the anonymous referees of the journal for their constructive and very useful comments, which helped us to improve the paper substantially. However, the authors remain solely responsible for any errors and omissions that may remain in the paper.

Funding

The authors received no direct funding for this research.

Author details

Abhisek Sur¹
E-mail: abhisek.sur15fpm@iimranchi.ac.in
Amarendu Nandy¹
E-mail: amarendu@iimranchi.ac.in
ORCID ID: <http://orcid.org/0000-0002-7513-5415>

¹ Department of Economics, Indian Institute of Management (IIM) Ranchi, Suchana Bhawan, Meur's Road 834008, Ranchi, Jharkhand, India.

Citation information

Cite this article as: FDI, technical efficiency and spillovers: Evidence from Indian automobile industry, Abhisek Sur & Amarendu Nandy, *Cogent Economics & Finance* (2018), 6: 1460026.

Notes

1. Since, this study focuses on a particular (automobile) sector, the intra-industry or horizontal spillovers is only considered as the inter-industry or vertical spillovers are out of scope of this study.
2. DEA is a widely used technique in productivity analysis and is a non-parametric method based on linear programming technique. It uses the envelopment technique and calculates the efficiency as the distance from the frontier. For a detailed exposition of DEA and SFA methodologies, see Zhu (2014) and Kumbhakar, Wang, and Horncastle (2015).
3. As pointed out by Wang and Schmidt (2002) the two-stage approach, is likely to yield biased estimates

- as the technical efficiency might be correlated with the production inputs. Furthermore, the OLS method becomes inappropriate in the two-stage method as the TE is assumed to have a one-sided distribution. Hence, the one-stage approach is preferred over the two-stage approach.
- The complete description of Battese-Coelli model and derivation of the log-likelihood function and the variance parameters is given in Battese and Coelli (1993).
 - Though the trans-log form of production function is a popular choice in today's empirical studies, for this paper, we choose the log-linear model primarily due to its simplicity in usage and interpretation. Although this confines the analysis to one particular form of the production function, studies by Kopp and Smith (1980), Krishna and Sahota (1991) and Driffield and Kambhampati (2003) suggest that other functional specifications vis-à-vis the log-linear form have negligible influence on the measured efficiency. More recent empirical studies, using stochastic frontier analysis in the context of manufacturing sector in Indonesia like Suyanto et al. (2014) has not reported any significant difference in the results obtained. Further, as the sum of factor elasticities is close to unity (Table 4), it signifies the production function exhibits constant returns to scale.
 - Since there exists no consensus in literature regarding the minimum proportion of share capital for classifying a firm as a foreign firm, we adopt the classification as given in the Centre for Monitoring Indian Economy (CMIE) Prowess database and match the classification with the Bloomberg database.
 - Since the beginning of this century, the Indian economy has witnessed some impressive growth figures, with 2004–08 recording one of the highest growth phases in the history of the Indian economy. Indian economy was also not majorly affected by the global financial crisis of 2007–08. According to Society of Indian Automobile Manufacturers (SIAM), the automobile industry witnessed a compounded annual growth rate of 9.4% during the period FY2006–16. This provided an increasing consumer base to the automobile firms, reducing the impact of CEF.

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Appendix

Table A1.

Year-wise technical efficiency of foreign and domestic firms

Year	Entire sample	Foreign firm	Domestic firm
2001	0.2707	0.3274	0.2544
2002	0.2722	0.3290	0.2559
2003	0.2738	0.3305	0.2574
2004	0.2753	0.3321	0.2589
2005	0.2768	0.3336	0.2604
2006	0.2784	0.3352	0.2620
2007	0.2799	0.3367	0.2635
2008	0.2810	0.3383	0.2651
2009	0.2830	0.3398	0.2666
2010	0.2845	0.3414	0.2681
2011	0.2861	0.3430	0.2697
2012	0.2876	0.3446	0.2712
2013	0.2892	0.3461	0.2728
2014	0.2908	0.3477	0.2743



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