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Export Versus FDI in Services

Rudrani Bhattacharya, Ila Patnaik and Ajay Shah

National Institute of Public Finance and Policy

1. INTRODUCTION

THE Helpman, Melitz and Yeaple (HMY; 2004) model for understanding the choice between exporting and undertaking horizontal FDI is rooted in the interplay between firm heterogeneity, the fixed cost of FDI and the transportation cost of exporting. It finds that when firm productivity is above a certain threshold, it is optimal for the firm to pay the fixed cost of FDI to avoid paying the cost of transportation. The model predicts that the most efficient firms would undertake FDI. A substantial empirical literature has found support for these predictions (Head and Ries, 2003, 2004; Girma et al., 2004a, 2004b; Kimura and Kiyota, 2006; Tomiura, 2007).

In recent years, FDI in services has gained prominence. In this paper, we focus on certain IT-oriented services where telecommunications networks result in near-zero transportation cost. While the HMY model has been useful in explaining the global structure of production in goods, it faces limitations in this setting, where one essential element of the model (transportation cost) has been eliminated. If transportation costs are zero, then there is little incentive to pay the fixed costs of FDI, since foreign customers can be served by producing at home. This prediction, of zero FDI in certain IT-oriented services, is clearly contradicted by the evidence.

To understand this situation, we extend the HMY model by introducing a unique feature of services: when the consumer of services is at a considerable distance away from the producer, he faces risk of service quality. Under these conditions, low-productivity firms find that it is efficient to incur the fixed cost of FDI. But high productivity firms are able to obtain the highest profits by both exporting and investing abroad. Thus, under conditions of high risk but zero costs of transportation, the model predicts a reversal of the traditional

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productivity ordering of the HMY model. In the absence of this risk, our model predicts the familiar case.

We go on to test this model using data from two highly globalised sectors in India: the chemicals sector (which has features akin to the traditional HMY model) and the software sector (where the cost of transportation is low and risk is high). We obtain an estimate of the productivity of each firm in each year using frontier analysis. This permits testing for stochastic dominance of the productivity of exporting companies versus FDI companies. Our empirical analysis supports the predictions of the model. Stochastic dominance is seen in most, though not all years, of the analysis. Further, when FDI firms are broken into low-FDI and high-FDI groups, the predicted productivity ordering emerges.

The remainder of this paper is organised as follows: Section 2 describes our theoretical framework. Section 3 describes the data and the issues in productivity measurement using firm data. Section 4 shows the results of this measurement, first for chemicals and then for software. Finally, Section 5 concludes.

2. THEORETICAL FRAMEWORK

a. *The HMY Setting*

In this section, we construct a model in the HMY framework (Helpman et al., 2004) to explain export versus FDI decisions of a firm. The conventional HMY framework is the following: consider an open economy where a continuum of differentiated goods is consumed. The representative consumer's utility is defined over a composite good Q given by $U = Q$. The composite good Q is defined by a C.E.S function:

$$Q = \left[\int_{i \in \Omega} q(i)^{\varepsilon} di \right]^{(1/\varepsilon)} \quad 0 < \varepsilon < 1, \tag{1}$$

where i represents the type of a differentiated good and the measure of the set Ω denotes the mass of available goods. The elasticity of substitution between any two goods is $\sigma = 1/(1-\varepsilon) > 1$. The associated overall price index as shown by Dixit and Stiglitz (1977) is

$$P = \left[\int_{i \in \Omega} p(i)^{1-\sigma} di \right]^{\frac{1}{1-\sigma}}, \tag{2}$$

where $p(i)$ is the price of ith differentiated good. The maximisation of utility subject to the budget constraint by the consumer yields demand for the ith commodity as

$$q(i)^d = YP^{\sigma-1}p(i)^{-\sigma}, \tag{3}$$

where Y denotes income of the representative household.

There is a continuum of monopolistically competitive firms, each producing a differentiated product i. The production technology uses only one factor, labour l, and exhibits constant marginal cost and fixed overhead cost. Labour used by the producer of ith good is thus a linear function of output $q(i)$:

$$l(i) = F_D + q(i)/A_l. \tag{4}$$

All firms share the same fixed cost $F_D > 0$ but have different productivity levels. To enter the industry, a firm needs to pay the fixed costs of entry F_E, measured in labour units. An entrant then draws a productivity level from a distribution $G(A)$. Upon observing this draw, a firm may decide to exit and not produce. If it chooses to produce, however, it bears the additional fixed labour costs F_D to produce at home. However, it bears additional fixed costs F_X to export in a foreign market. On the other hand, if it chooses to serve a foreign market via FDI, it bears additional fixed costs F_I. As Helpman et al. (2004) interpret these costs, F_X captures the costs of forming a distribution and servicing network in a foreign country where similar costs for the home market are included in F_D. The fixed costs, F_I, include these distribution and servicing network costs, as well as the costs of forming a subsidiary in a foreign country and the duplicate fixed production costs embodied in F_D.

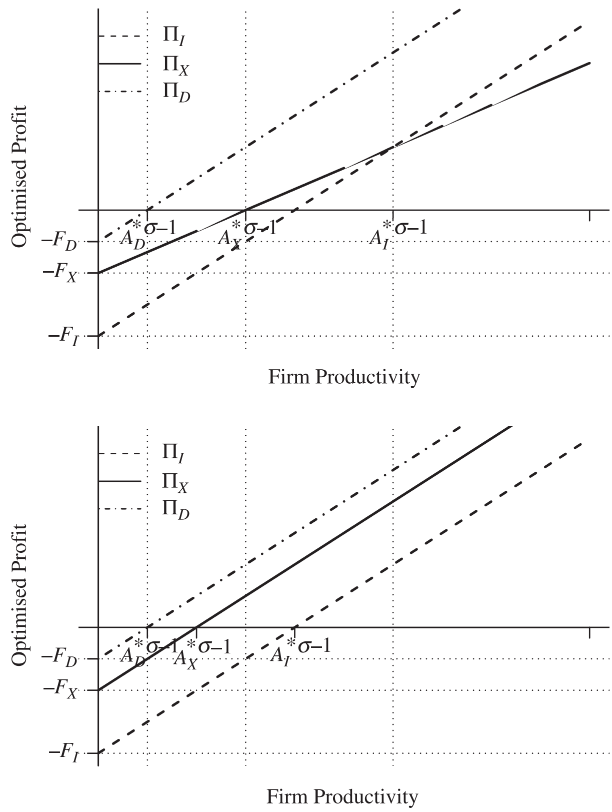
Helpman et al. (2004) further assume per unit export costs modelled in the standard iceberg formulation, whereby τ ($\tau > 1$) units of a good must be produced and shipped in order for 1 unit to arrive at destination. Thus, the labour allocation function of the exporter of ith commodity becomes $l(i) = F_D + \tau q(i)/A_i$. Given this set up of the model and the following inequality, the cost of domestic production is lower than that for export which is again lower than the cost of producing abroad, $F_D < \tau^{\sigma-1}F_X < F_D$, and the main prediction of HMY model is

$$A_D^{*\sigma-1} < A_X^{*\sigma-1} < A_I^{*\sigma-1}. \tag{5}$$

This implies that the most productive firms invest abroad. Less productive firms export, while the least productive ones serve their domestic markets.

The upper panel of Figure 1 depicts the profit functions of various types of firms under the basic HMY framework. In Figure 1, operating profit (depicted along the vertical axis) of a firm is represented as a function of the productivity level A. It is a linear function of $A^{\sigma-1}$ represented along the horizontal axis. The operating profit of domestic firms is shown by $\prod_D = YP^{\sigma-1}(i - \varepsilon)$

FIGURE 1
Prediction of the HMY Model



$\varepsilon^{\sigma-1}A^{\sigma-1} - F_D$. Similarly, profit of the exporting firms is represented by $\prod_X = \tau^{1-\sigma}YP^{\sigma-1}(1-\varepsilon)\varepsilon^{\sigma-1}A^{\sigma-1} - F_X$, while that of FDI firms is given by $\prod_I = YP^{\sigma-1}(1-\varepsilon)\varepsilon^{\sigma-1}A^{\sigma-1} - F_I$. All three profit functions are linearly increasing implying more productive firms are more profitable in all three activities. The profit functions Π_D and Π_I are parallel. However, the profit function Π_X is flatter than both Π_D and Π_I because of the transportation cost component $\tau^{1-\sigma}$. Given the inequality 5, Figure 1 indicates that for firms with productivity A, where $A_D^* < A \leq A_X^*$ it is profitable to serve the domestic market only. Firms with productivity A such that $A_X^* < A \leq A_I^*$, choose to serve the foreign market through exports. For firms with productivity $A > A_I^*$, it is efficient to do FDI. Moreover, operating profits from exporting exceed that from FDI for some positive range of productivity. This ensures that some firms will opt for exporting to serve foreign customers.

One major implication of the HMY framework is that if no transportation cost is associated with exporting, so that $\tau = 1$, the line depicting $\prod_X$ will become parallel to both $\prod_D$ and $\prod_I$ and will always lie above $\prod_I$ as shown in the lower panel of Figure 1. This would then imply that when transport cost of exporting is zero, exporting is always more profitable than FDI. Given this implication, the standard HMY model is incapable of explaining FDI in certain type of services such as software services where transportation cost is effectively zero. If the only reason for FDI was to avoid the cost of transportation, there should be no FDI by services companies.

b. Addressing this Puzzle

We focus on the question of the quality of service provided. In a commodity such as steel, there are objective technical standards that define a certain grade of steel. The buyer of steel is confident in the steel that he has purchased, once it has passed certain technical tests, regardless of the nationality of the producing firm or the location of production. In contrast, services have intangible characteristics. There is significant uncertainty about the true characteristics of the services that are being purchased.

Lee and Tan (2003) compared consumer choice on e-retailing versus physical retailing in an experimental economic set-up. They found that on average, consumers' perceived risk of product failure is higher under e-retailing than under in-store shopping. In a similar vein, we assume that the risk perceived by customers is greater when services are purchased from a foreign company, as opposed to purchase from a local provider.

We focus on outbound foreign direct investment (ODFI) activities in a sector where transport cost is effectively zero, software services being an example. We also restrict our analysis to exporting and FDI firms because the nature of risk discussed earlier is applicable for firms serving the foreign market only.

Owing to the risk of product quality, the foreign demand faced by a firm is

$$q(i)^d = \begin{cases} 0; & \text{with prob } \gamma_j \\ YP^{\sigma-1}p(i)^{-\sigma}; & \text{with prob } 1-\gamma_j \end{cases} \quad j = X, I, \tag{6}$$

where j denotes firm's global status. The subscript $j = X$ indicates that the firm is an exporting one, while $j = I$ denotes that the firm has opted for FDI as the mode of serving foreign customers. The firm faces zero demand with the probability γ_j and positive demand with the probability $1-\gamma_j$.

We assume that physical proximity of the provider reduces the risk perception of the consumer. Hence, the probability of a positive demand realisation is higher for an FDI firm when compared with an exporting firm, that is, $\gamma_X > \gamma_I$.

The production structure is same as in the basic HMY framework. However, we assume zero transportation cost associated with export activities. Firms are assumed to be risk neutral. Taking the demand for a differentiated product as given, that is, $q(i) = q(i)^d$, the firm chooses a price to maximise expected profit:

$$E(\Pi_{ij}) = (1 - \gamma_j)[q(i)p(i) - l(i)] + \gamma_j[-l(i)]. \tag{7}$$

Solving the above, we obtain the expected profit for the exporting and FDI firms in the foreign market as

$$E(\Pi_X) = YP^{\sigma-1}A_X^{\sigma-1}\frac{1}{\sigma-1}\left(\frac{\sigma}{(1-\gamma_X)(\sigma-1)}\right)^{-\sigma} - F_X. \tag{8}$$

$$E(\Pi_I) = YP^{\sigma-1}A_I^{\sigma-1}\frac{1}{\sigma-1}\left(\frac{\sigma}{(1-\gamma_I)(\sigma-1)}\right)^{-\sigma} - F_I. \tag{9}$$

The threshold productivity levels for a firm to start exporting and to become a FDI firm can be obtained by equating the right-hand side of the above expressions to zero:

$$A_X^{*\sigma-1} = \frac{F_X(\sigma-1)(\frac{\sigma}{\sigma-1})^{\sigma}}{YP^{\sigma-1}(1-\gamma_X)^{\sigma}}. \tag{10}$$

$$A_I^{*\sigma-1} = \frac{F_I(\sigma-1)(\frac{\sigma}{\sigma-1})^{\sigma}}{YP^{\sigma-1}(1-\gamma_I)^{\sigma}}. \tag{11}$$

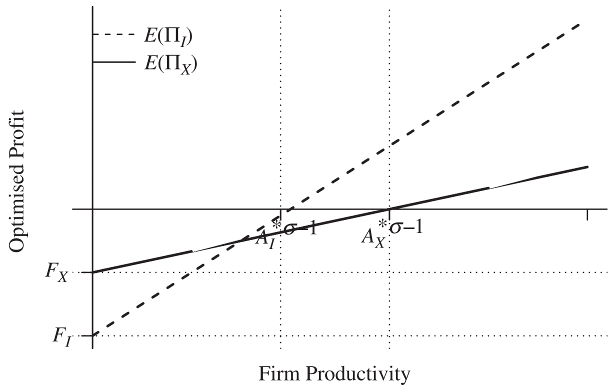
Under the assumption that the fixed cost of exporting is lower than the cost of producing abroad, $F_X < F_I$, equations (10) and (11) show that for a finite γ_I, $A_X^* > A_I^*$, if

$$\gamma_X > 1 - \left(\frac{F_X}{F_I}\right)^{1/\sigma}(1-\gamma_I). \tag{12}$$

If the probability of realisation of zero demand is sufficiently higher for exporters compared with the FDI firms, the threshold productivity for exporting is higher than that for FDI. Thus, when the risk perception associated with export is large, the exporting firm that endogenises the risk of facing zero demand has to be more productive than a firm that does FDI. Internalising the risk of zero demand realisation by firms reduces the mark up over marginal cost and hence profitability of the firm. Hence, a higher productivity level is needed for the realisation of nonnegative profit. Since the risk associated with exports is higher than that with FDI, more productive firms can afford to export while the less productive ones opt for FDI.

As the fixed cost of marketing abroad, that is, F_X is embedded in the fixed cost of producing abroad (F_I), a firm with productivity level beyond the threshold A_X^* can undertake both activities by incurring just F_I. Such a firm's expected profit from both activities in the same market,

FIGURE 2
Export versus FDI: Services with Zero Transport Cost and Uncertainty of Demand Realisation



$$YP^{\sigma-1}A^{\sigma-1}\frac{1}{\sigma-1}\left(\frac{\sigma-1}{(\sigma)}\right)^{\sigma}[(1-\gamma_X)^{\sigma}+(1-\gamma_I)^{\sigma}]-F_I,$$

is always greater than the expected profit from only FDI activities,

$$YP^{\sigma-1}A^{\sigma-1}\frac{1}{\sigma-1}\left(\frac{\sigma-1}{(\sigma)}\right)^{\sigma}(1-\gamma_I)^{\sigma}.-F_I.$$

Thus, less productive firms will do FDI, while the more productive firms will opt for both FDI and exporting.

Figure 2 illustrates the relationships depicted by the equations (8) and (9). Since $\gamma_X > \gamma_I$ $E(\Pi_X)$ will be flatter compared with the line depicted by $E(\Pi_I)$ Given the inequality in equation (12), it is always efficient for firms with productivity levels $A > A_I^*$ to serve foreign market via FDI. Thus, even if the cost of transporting the product to foreign country is negligible, it will be always efficient for the firms with productivity level higher than A_I^* to do FDI. However, if FDI is not viable because of some other exogenous factors, such as regulations, a much higher productivity level A_X^* will be needed for the firms to be able to export in the same market. This is the opposite prediction for a product with zero transportation cost compared with the prediction under the standard HMY framework.

While the standard HMY framework pertains to a product subject to low risk and low/moderate transportation cost, our model attempts to predict the production organisation by a firm in foreign market, when the good is subject to high risk but low transportation cost.[1]

[1] If transport cost is prohibitive, it will always be profitable to do FDI irrespective of the extent of risk.

3. TESTING THIS PREDICTION

We now turn to testing this prediction using data from India in two sectors: chemicals (a conventional HMY setting) and software (where product quality is not certain and where the cost of transportation is zero).

a. The Indian Software Industry

The Indian software industry experienced a spectacular rise in the 1990s. A substantial fraction of the output and services of the software industry are exported to advanced economies, particularly the US (Arora and Gambardella, 2004). This industry has primarily focused on customised software services rather than products. Many types of services, such as those involved in the maintenance of data or legacy systems, are low-value services. The Indian software industry has for the most part specialised in these relatively low-value activities (Athreye, 2005).

Along with exporting, Indian software services firms also started FDI. Firms in the Indian software and communication sectors accounted for about 56 per cent of total FDI approvals given out by the government in the service sector and 30 per cent of overall FDI, in the late 1990s (Pradhan, 2007). After 2001, the IT sector accounts for the largest number of acquisitions by Indian firms (Athukorala, 2009). These acquisitions are concentrated in Europe, UK and US.

b. The Data

Our analysis is based on a firm level database maintained by Centre for Monitoring Indian Economy (CMIE) which reports the exports and the stock of FDI for each firm year. We focus on the period after 2000, when capital controls were eased and include in the analysis all firms who serve foreign customers, whether through export or FDI or both. We exclude firms who serve the domestic market exclusively.

We define the set of exporting firms as those firms where exports on goods and services exceeds 1 per cent of sales. Similarly, the FDI status of a firm is defined by requiring that the firm's FDI outside India is above 1 per cent of total assets. Productivity measurement relies on estimation of the production function. Hence, we consider the subset of firms for which positive values for output and inputs are observed.

(i) The chemicals dataset

Our starting point is an examination of the predictions of the Helpman et al. (2004) model in a conventional setting in terms of transportation costs. Since

TABLE 1
Number of Non-FDI and FDI Firms Over Time in Chemicals

Year	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*
Non- FDI	436	506	496	578	591	559	517	503	430
FDI	5	27	37	46	52	65	80	92	93

productivity measurement is best done within one narrow industry, we focus on the manufacturing subindustry (at a two-digit classification level) with the highest outward FDI: chemicals.

In this industry, we observe 5,027 firm years from 965 distinct firms over the period 2000–08. Table 1 shows the dynamics of the number of non-FDI and FDI firms over time. While in 2000, there were only five firms in this sector with assets abroad, this number had risen to 93 in 2008.

(ii) The software services dataset

Unlike in the case of chemicals where most foreign investors have a small percentage of total assets held abroad, we find that some software firms have much higher levels of overseas assets as compared with others. We conjecture that at a certain low level of overseas assets, overseas activities are oriented towards business development with a prime emphasis on exporting based on home production; that significant production abroad is taking place at high levels of overseas assets. Hence, we also define a 'high-FDI' category, comprising of firms having over 25 per cent of their total assets overseas,[2] whether or not they are exporters. It is fairly likely that high-FDI firms are engaged in *production* in their overseas operations.

Table 2 shows the time series of the number of exporting software services companies, and the number of software services companies that are classified as low FDI and high FDI. We see a sharp rise in the number of companies that had FDI in 2001 and 2002, immediately after the capital controls against

TABLE 2
Software Services: Number of Firms Engaging in FDI Over Time

Year	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*
Non-FDI	94	113	89	111	102	91	104	95	73
Low FDI	17	52	60	68	73	76	74	66	68
High FDI	4	8	24	22	30	32	37	50	49

[2] This cut-off, where 'high-FDI' firms are identified based on an overseas assets to total assets ratio of above 25 per cent, is based on the 75th percentile of the distribution of FDI to total assets.

overseas investment were eased. After that also, there has been a steady shift of the industry towards greater FDI.

c. *Measuring Productivity*

We seek to compare the productivity of FDI firms against that of non-FDI firms. Stochastic frontier analysis (henceforth SFA) was developed by Aigner et al. (1977) and extended to panel data by Battese and Coelli (1992, 1995). For each firm, a technological frontier is postulated, which expresses the maximum output that a firm can produce using a certain vector of inputs. The frontier is subject to random shocks that are outside the control of the firm. The output of a firm falls *inside* the frontier owing to inefficiencies of the firm. Frontier analysis is able to uncover an estimate of the productivity for each firm in each year. However, it requires assumptions about the parametric form of the error terms.

We use the 'efficiency effect SFA model' (Battese and Coelli, 1995), where unobserved inefficiencies vary with explanatory variables that express firm characteristics, the macroeconomic environment, etc. This involves estimating a model of the form:

$$Y_{it} = \exp(x'_{it}\beta + v_{it} - u_{it}), \quad u_{it} \geq 0. \tag{13}$$

$$u_{it} = z_{it}\,\delta + w_{it}, \quad w_{it} \geq -z_{it}, \tag{14}$$

where Y_{it} denotes output and x_{it} are inputs in logs. The noise v_{it} is a conventional error term: it is i.i.d. $N(0, \sigma_v^2)$ and represents fluctuations of the technological frontier, which are not under control of the firm.

The component u_{it} reflects the extent to which the firm fails to produce the maximal output $\exp(x'_{it}\beta + v_{it})$, owing to its own inefficiency. It is assumed that u_{it} follows a truncated normal distribution $N^+(z_{it}\delta, \sigma_u^2)$; it can only attain positive values, and bigger values of u_{it} denote greater inefficiency by firm i at time t. The efficiency effect SFA model goes on to relate inefficiency to firm characteristics z_{it} through equation (14). The restriction ensures that u_{it} is a nonnegative truncation of the $N(z_{it}\delta, \sigma_u^2)$ distribution.

All the parameters are simultaneously estimated using maximum likelihood, assuming that each firm year is independent. The technical efficiency for firm i at period t is the extent to which the firm is away from the frontier:

$$TE_{it} = \frac{\exp(x'_{it}\beta - u_{it} + v_{it})}{\exp(x'_{it}\beta + v_{it})} = \exp(-u_{it}). \tag{15}$$

This framework is well suited to the problem at hand. The prediction of the Helpman et al. (2004) model is that high-productivity firms choose to serve foreign customers through FDI rather than export. Hence, the firm characteristic of interest is the exporting versus FDI status of the firm. In equation (14), in addition to many firm characteristics associated with inefficiency, we include a dummy variable for the FDI status of the firm at time *t*. A positive relationship will then indicate that firms with higher inefficiency self-select themselves to invest abroad.

For the estimation of the production function, we proxy output by sales. We assume software services firms use labour and capital as inputs. The expenditure on wages and salaries is used as a measure of labour. The gross fixed assets of the firm, net of land and building assets, are used as a measure of capital. We estimate two models. In one, we explore how technical efficiency depends on whether the firm exports or is engaged in FDI. In our second specification, we differentiate between low- and high-FDI status based on the definitions described in Section 3.

Other firm specific characteristics that may affect technical efficiency, drawn from the productivity literature, are age, size, the investment rate, stock market listing and market power. Age is proxied by the difference between the year in which a firm is observed and the year of incorporation.

The investment rate is measured by the ratio of the cash outflow on fixed assets of the year to the stock of fixed assets (net of land and building assets): high-investment firms are expected to be more efficient.

A dummy variable represents whether the firm is listed. The scale effects can be captured through market power. We proxy market power by market share – the ratio of the sales of an individual firm over the sectoral sales by year.

While productivity estimation for chemicals includes raw material expenditure, for software firms, we assume that there are no expenses on buying raw materials.

Going beyond the ML estimates for equation (14) which reflect a summary statistic about the overall dataset, we examine technical efficiency in the entire distribution of firms, by testing for stochastic dominance between one FDI category and another through the Kolmogorov-Smirnov test.

4. RESULTS

The second and third columns of Table 3 report efficiency effects SFA analysis for chemicals and software services industries. We find that for the chemicals industry, the FDI dummy is associated with reduced inefficiency, that is, higher technical efficiency. This is a statistically strong result, with an FDI dummy coefficient of −1,531.7 and a standard error of 522.4. This supports the prediction of the Helpman et al. (2004) model.

TABLE 3
Stochastic Frontier Analysis

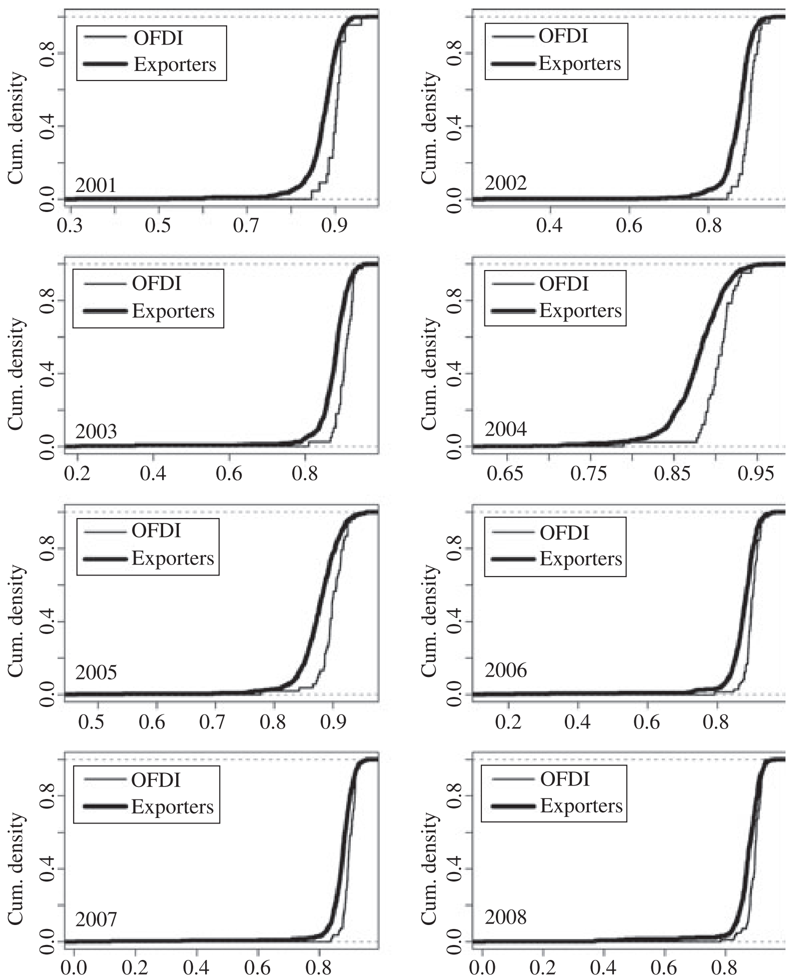
Variable	*Chemicals*		*Software Services: Model 1*		*Software Services: Model 2*	
	Estimate	*t Statistic*	*Estimate*	*t Statistic*	*Estimate*	*t Statistic*
Production function (equation 13)						
Intercept	1.5378	76.45	1.8854	27.6751	1.8880	25.8500
Log wages	0.3524	58.81	0.4945	35.3460	0.4939	36.4298
Log capital	0.0400	6.53	0.3888	21.7545	0.3885	23.2060
Log raw material expenses	0.6420	115.68				
Inefficiency (equation 14)						
Intercept	−3449.38	−2.93	0.2071	3.4574	−0.0338	−0.3200
FDI dummy	−1531.77	−2.93	0.2693	7.0679		
High FDI dummy					0.3118	5.2387
Low FDI dummy					0.2451	4.6263
Age	10.6370	2.92	−0.0026	−1.0206	−0.0023	−0.71
Investment rate	−1424.79	−2.96	−0.9895	−10.0383	−0.9839	−7.76
Listed dummy	−995.0121	−2.93	0.2296	6.1424	0.2343	4.5600
Market share	−2.0137	−2.88	0.0119	2.5721	0.0117	2.1600
$\frac{\sigma_u^2}{\sigma_u^2+\sigma_v^2}$	0.9998	15147.18	1.5186e−7	4.9651	2.0679e−5	10.4455
Number of firms	965		375		375	
Number of firm years	5027		1677		1677	

TABLE 4
Testing for Stochastic Dominance

Year	*Chemicals: FDI*		*Software Services: FDI*		*Software Services: Low FDI*		*Software Services: High FDI*	
	KS Statistics	*p-Value*	*KS Statistics*	*p-Value*	*KS Statistics*	*p-Value*	*KS Statistics*	*p-Value*
2000	0.70	0.02	0.27	0.26	0.21	0.35	0.03	0.99
2001	0.46	0.00	0.21	0.12	0.14	0.39	0.36	0.15
2002	0.42	0.00	0.23	0.02	0.15	0.24	0.52	0.00
2003	0.45	0.00	0.28	0.00	0.20	0.05	0.65	0.00
2004	0.48	0.00	0.30	0.00	0.23	0.02	0.56	0.00
2005	0.42	0.00	0.41	0.00	0.30	0.00	0.51	0.00
2006	0.40	0.00	0.24	0.01	0.17	0.13	0.50	0.00
2007	0.39	0.00	0.26	0.00	0.14	0.30	0.45	0.00
2008	0.35	0.00	0.24	0.02	0.17	0.19	0.42	0.00

The estimates also show other interesting cross-sectional heterogeneity of firm efficiency. Old firms have lower technical efficiency. Firms with a bigger pace of fixed investment tend to be more efficient. Being listed on a stock

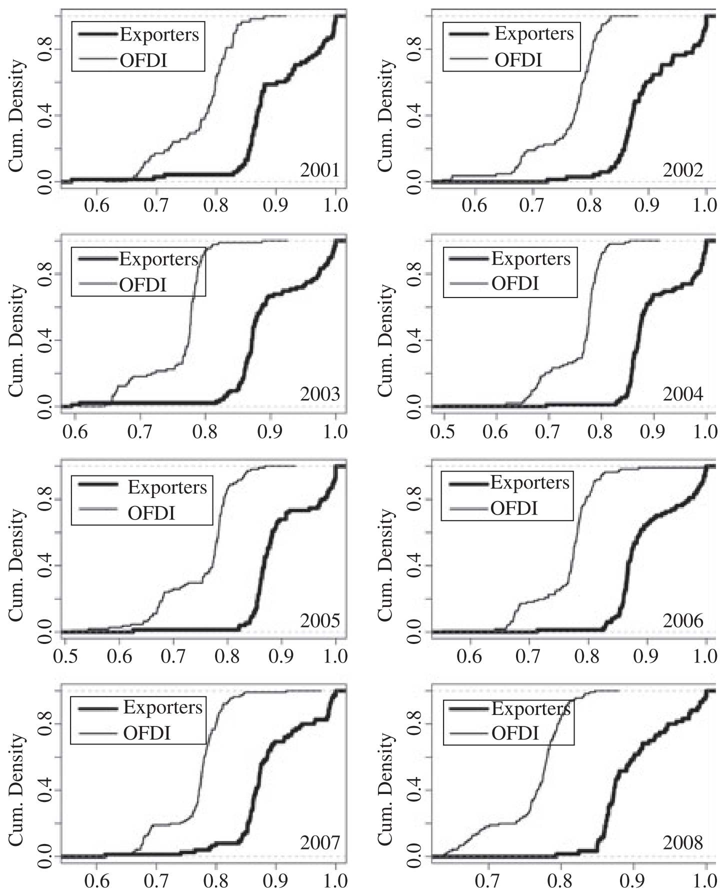
FIGURE 3
Stochastic Dominance of Technical Efficiency: FDI versus Exporters in Chemicals



exchange is associated with increased technical efficiency. Firms with higher market power tend to have higher efficiency. The coefficient of $\sigma_u^2/(\sigma_u^2+\sigma_v^2)$ is very high, near 1 and highly significant. This indicates that the inefficiency effects are highly significant.

We test the stochastic dominance of the estimated productivity level of FDI firms over the non-FDI firms. The results of the tests are reported in the second and third columns of Table 4, with associated graphs in Figure 3. In all years, the CDF of the productivity of FDI firms lies to the right of the CDF of the productivity of non-FDI firms, as predicted by the Helpman et al. (2004) model.

FIGURE 4
Stochastic Dominance of Technical Efficiency: Exporters versus FDI Firms in Software Services

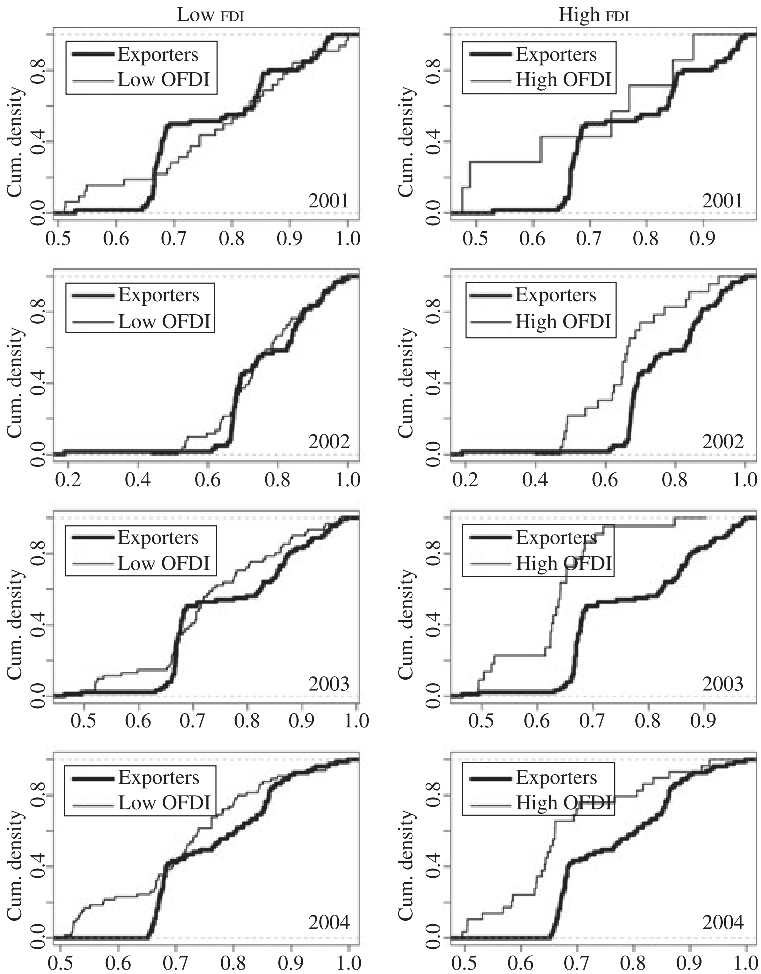


The rejection of the null hypothesis indicates the validation of the standard Helpman et al. (2004) predictions.

We now turn to an analysis of the software industry using the identical database and estimation strategy. The results of the efficiency effect SFA in explaining differences in technical efficiencies across exporting and FDI firms are reported in the fourth to seventh columns of Table 3. Two models are presented. With Model 1, we differentiate FDI firms against exporters. Model 2 distinguishes high- and low-FDI firms from non-FDI firms.

From both the specifications, we find that technical efficiencies are lower for FDI firms. The point estimates suggest that high-FDI firms are somewhat more inefficient than the low-FDI firms.

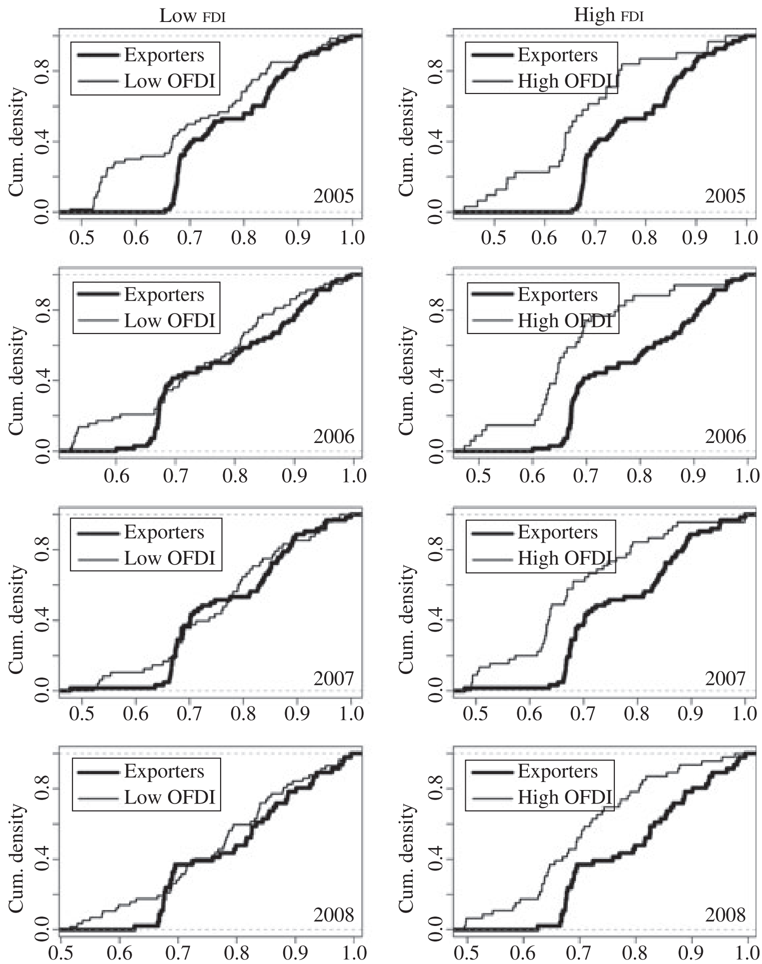
FIGURE 5
Stochastic Dominance of Technical Efficiency: Exporters versus Low- and High-FDI Firms in Software Services



We also find that technical efficiency increases with age; that is, older firms are more efficient. Our estimates suggest that investment activity by the firm tends to reduce inefficiency. Inefficiency increases with market power and public listing. The coefficients of $\sigma_u^2/(\sigma_u^2+\sigma_v^2)$ for both the specifications are low but significant. This indicates the effect of inefficiency.[3]

[3] If the null of zero variance ratio cannot be rejected, it implies that the variance of the inefficiency effects is zero; the model then reduces to a traditional mean response function in which the firm characteristics are included in the production function.

FIGURE 6
Stochastic Dominance of Technical Efficiency: Exporters versus Low- and High-FDI Firms in Software Services



As with our analysis for chemicals, we now test for stochastic dominance of the entire distribution. These results, which are analogous to those shown for the chemicals industry, are also shown in Table 4.

The fourth and fifth columns of the table show test statistics and p-values of stochastic dominance tests of exporters over FDI firms. The sixth and seventh columns present test statistics and p-values of stochastic dominance tests of exporters over low-FDI firms. The eighth and ninth columns present test statistics and p-values of stochastic dominance tests of exporters over high-FDI firms. While comparing between exporters over FDI firms, the p-values generally show support for the predictions of our model. Moreover, the support for predictions of our theoretical model is more evident for exporters versus high-FDI firms.

Figures 4–6 show stochastic dominance of exporters over FDI firms in terms of TFP levels over the period of analysis. Here also, in most situations, we find support for the predictions of our model.

5. CONCLUSION

Trade and foreign investment in tradable services have not been as well analysed in the empirical and theoretical literature as trade in goods. This study contributes towards this larger goal. We have extended the framework for exports of goods and FDI by firms to the case of tradable services. When buyers perceive that services which are produced far away involve greater risk, the model predicts that *less* productive firms would do FDI. This prediction is supported by data from Indian software services industry.

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