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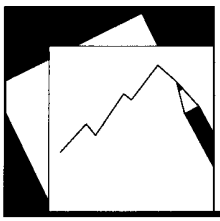

IMF Working Paper

Export versus FDI in services

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Export versus FDI in services

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Abstract

In the literature on exports and investment, most productive firms are seen to invest abroad. In the Helpman et al. (2004) model, costs of transportation play a critical role in the decision about whether to serve foreign customers by exporting, or by producing abroad. We consider the case of tradable services, where the marginal cost of transport is near zero. We argue that in the purchase of services, buyers face uncertainty about product quality, especially when production is located far away. Firm optimisation then leads less productive firms to self-select themselves for FDI. We test this prediction with data from the Indian software industry and find support for it.

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Contents

1 Introduction

Theoretical and empirical work on understanding trade and investment has focused on the export and production of goods. In this paper we extend this framework to understand exports and outbound investment in tradable services.

A milestone in understanding outbound foreign investment was the Helpman *et al.* (2004) model, which argued that firms rationally choose between serving domestic or foreign customers, and between serving foreign customers through exports or through outbound FDI ('OFDI'). Heterogeneity in firm productivity lies at the heart of the decision to serve foreign customers through exports or OFDI. In equilibrium, firms self-select themselves so that more efficient firms export, and the most efficient firms do OFDI. The predictions of the model have found support in the empirical evidence presented by Head and Ries (2003, 2004); Kimura and Kiyota (2006); Tomiura (2007); Girma *et al.* (2004b,a).

In recent years, export of tradable services through the offshoring model, as well as foreign investment in such services, have gained prominence. The proximity-concentration tradeoff in the Helpman *et al.* (2004) model is critically related to transport costs. If transportation costs are zero, then there is little incentive to pay the fixed costs of OFDI, since foreign customers can be served by producing at home. Services such as software services can be transported over telecommunications networks at near-zero cost, and existing models meant to explain exports and OFDI in goods, in which transport costs play a crucial role in the proximity-concentration tradeoff, would predict zero OFDI by software companies, all other aspects of the model remaining the same. However, we see significant OFDI in such sectors. This poses a puzzle.

In this paper, we model export and OFDI in tradable services. The crucial feature of this model, located in the Helpman *et al.* (2004) framework, is that the consumption of a service produced far away induces risk in the utility function of the consumer. If this risk is zero, and if transport-costs are non-zero, this model reduces to the the Helpman *et al.* (2004) model: the most productive firms would engage in outbound FDI. But once costs of transportation are zero, and there is risk in buying services from a distant supplier, the model predicts that the least productive firms would invest abroad.

We test the model for Indian software companies. We start the empirical

analysis with the conventional goods setting: OFDI by Indian firms in the Chemicals industry. Our results show that in this case, firms that do OFDI are indeed more productive. This is a conventional result, in line with the literature which has explored the empirical implications of the Helpman *et al.* (2004) model. This shows that there is nothing special about the Indian setting which takes us away from the mainstream results of this field. Similar results are found in (Pradhan, 2004, 2006b; Kumar, 2007; Demirbas *et al.*, 2009).

We then turn to Indian software companies, and find support for our model: *less* productive software companies do outbound FDI. This suggests that uncertainty about the quality of goods produced far away does influence consumption decisions, and hence, in equilibrium, decisions of the firms.

The remainder of this paper is organized as follows. Section 2 describes our theoretical framework. Section 3 describes the data. Section 3.3 discusses 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 How services producers serve foreign customers

Firms choose between serving foreign customers through exports versus serving them by producing abroad. In the theoretical framework of Helpman *et al.* (2004) they face a 'proximity-concentration trade-off', between the fixed costs of FDI versus the costs of transportation encountered in exporting. Assuming that the fixed cost of setting up a new production unit abroad is higher than the per-unit transportation cost and fixed cost of marketing associated with export, Helpman *et al.* (2004) predict that the most productive firms invest abroad. Less productive firms export, while the least productive ones serve their domestic markets.

In a world with tradable services, firms choose between exporting, i.e. the offshoring model, and investing abroad. This choice differs from that of firms that choose between export or ofdi for goods in two key ways. The first is the issue of transportation cost. Transportation cost is roughly zero for offshoring. If the only reason to do FDI was to avoid the cost of transportation, and marketing and advertising costs are not higher than the set up cost abroad, there should be no outbound FDI by services companies.

The second issue is 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 fully 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 myriad 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 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.

This uncertainty dimension encourages services companies to do FDI, while the transportation cost dimension discourages FDI. In order to understand the interplay between productivity, uncertainty and costs of transportation, we setup a model of the optimisation of the firm.

Consider an open economy where a continuum of differentiated goods are 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:

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

where the measure of the set Ω denotes the mass of available goods and the elasticity of substitution between any two goods is $\sigma = 1/(1-\epsilon) > 1$.

There is a continuum of firms, each producing a differentiated product. The production technology uses only one factor, labor l, and exhibits constant marginal cost and fixed overhead cost. Firm productivity is heterogeneous. We assume that firms are productive enough to operate in the domestic market, and focus on their choice about the mechanism for serving the foreign market.

We assume that in services production, certain aspects of the quality are intrinsic to the producer of services, and cannot be tested by the customer before purchase: in contrast with goods where all aspects of the product can be tested by the prospective buyer before purchase. Owing to this risk, the foreign demand faced by a firm is:

$$q(i) = \begin{cases} 0, & \text{with prob} \quad \gamma_j \\ Dp(i)^{-\sigma}, & \text{with prob} \quad 1-\gamma_j \end{cases} \qquad j = X, I \tag{2}$$

where D is exogenously given from an individual firm's perspective and $j = X, I$. 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 OFDI firm when compared with an exporting firm, i.e. $\gamma_X > \gamma_I$.

Production involves fixed cost. The fixed cost of exporting in terms of labor F_X includes production costs as well as advertisement and marketing cost. The fixed cost of operating abroad in terms of labor F_I includes both a set up cost and production cost. The production function is defined as

$$q(i) = A_j[l(i) - F_j], \quad j = X, I \tag{3}$$

depending on whether the firm is exporting or investing abroad. Here j stands for export versus OFDI status of the firm. The parameter A_j denotes the productivity of the firm. Exports do not involve any transportation cost.

Firms are assumed to be risk-neutral. Taking the demand for a differentiated product as given, the firm chooses a price in order to maximise expected profit:

$$E(\Pi_X) = (1-\gamma_X)[q(i)p(i) - wl_X(i)] + \gamma_X[-wl_X(i)] \tag{4}$$
$$E(\Pi_I) = (1-\gamma_I)[q(i)p(i) - wl_I(i)] + \gamma_I[-wl_I(i)] \tag{5}$$

where $l_X(i) = q(i)/A_X + F_X$ and $l_I(i) = q(i)/A_I + F_I$. It is assumed that wages are identical, and that the wage rate is normalised to one. Making use of Equation 2 in 5, we solve for the price of ith variety from the first order condition. Substituting this price back into 5 yields the expected profit for the exporting and OFDI firms:

$$E(\Pi_X) = DA_X^{\sigma-1}\frac{1}{\sigma-1}\left(\frac{\sigma}{(1-\gamma_X)(\sigma-1)}\right)^{-\sigma} - F_X$$

$$E(\Pi_I) = DA_I^{\sigma-1}\frac{1}{\sigma-1}\left(\frac{\sigma}{(1-\gamma_I)(\sigma-1)}\right)^{-\sigma} - F_I$$

Firms maximise $E(\Pi)$ and if the optimized profit in a certain activity is negative, they do not undertake that activity. The threshold productivity level associated with zero expected profit from exporting services and OFDI are derived by equating the right hand side of the above expressions to zero:

$$A_X^{*\,\sigma-1} = \frac{F_X(\sigma-1)(\frac{\sigma}{\sigma-1})^{\sigma}}{D(1-\gamma_X)^{\sigma}} \quad (6)$$

$$A_I^{*\sigma-1} = \frac{F_I(\sigma-1)(\frac{\sigma}{\sigma-1})^{\sigma}}{D(1-\gamma_I)^{\sigma}} \quad (7)$$

As in Helpman *et al.* (2004), we assume that the cost of exporting is lower than cost of producing abroad, $F_X < F_I$,. Under this assumption, Equation 7 shows that for a finite γ_I, $A_X^* > A_I^*$, if $\gamma_X > 1-\left(\frac{F_X}{F_I}\right)^{1/\sigma}(1-\gamma_I)$. That is, if the probability of realisation of zero demand is sufficiently higher for exporters of software services compared to the OFDI firms, the threshold productivity for exporting is higher than that for outward FDI.

Figure 1 illustrates these relationships. When the risk perception associated with offshore production of a service is high, the firm that endogenises the risk of facing zero demand has to be more productive than a firm that does outbound FDI.

3 Testing this prediction

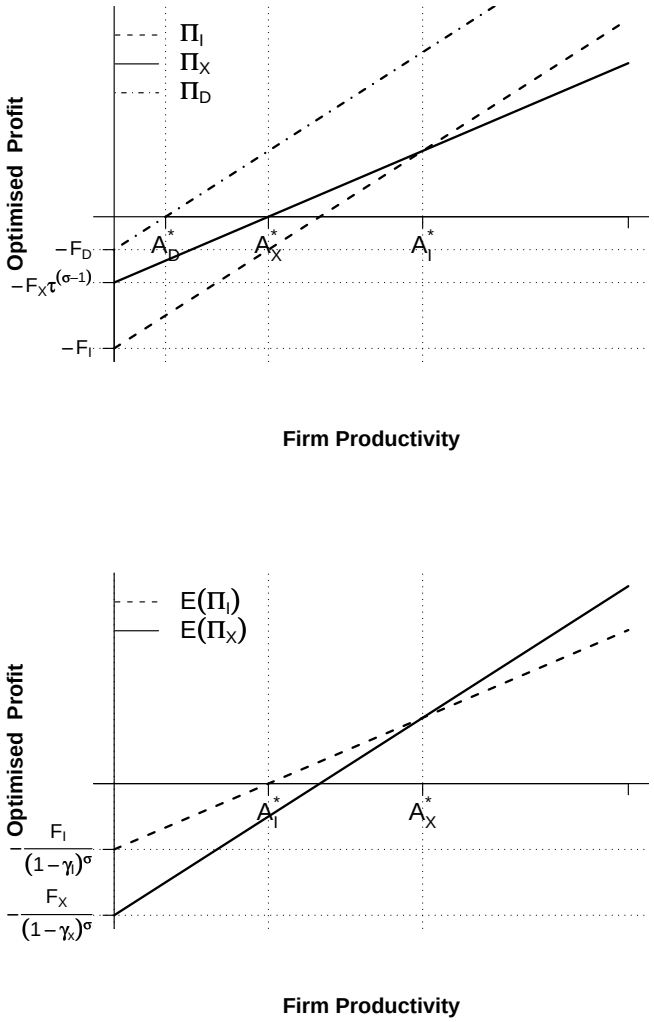
We now turn to testing this prediction using a rich dataset: data from India for export versus FDI in the software industry. As a baseline calculation, we analyse data for the Chemicals industry, which is a traditional setting involving export of goods where transport costs are present, where a conventional result is expected. This measurement strategy is then applied to software companies.

3.1 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

Figure 1 Contrasting Predictions: Goods and services

This figure shows the optimized profit (on the y axis) associated with alternative values of firm productivity (on the x axis).
The upper panel shows the prediction of Helpman *et al.* (2004) framework for goods. Firms below and at the lowest productivity threshold A_D^*, are not operational. Firms with productivity higher than A_D^* and below and at the productivity threshold A_X^*, choose to serve the domestic market only. Firms with productivity above A_X^* and up to the threshold A_I^* choose to serve the foreign market through exports. For firms with productivity above A_I^*, it is efficient to do outbound FDI.
The lower panel depicts the prediction of our model for tradable services under zero transport cost and uncertainty about realisation of foreign demand. It is efficient for firms with productivity level higher than A_I^* and up to the threshold A_X^* to do outbound FDI, while firms above the threshold A_X^* choose exports as the mode of serving foreign market.



is exported to advanced economies, particularly the U.S. (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 specialized in these relatively low-value activities (Athreye, 2005).

Software services exports from India started as Indian firms rented out programmers to the American clients, sending them to work for the client in the U.S.(Arora, 2006). In the early years of the software services industry in India, export projects involved jobs such as rewriting code to migrate applications from mainframes to the then newly emerging client-server platforms, maintaining new systems and applications changed over to by the clients and later, a few data conversion projects such as Y2K. However, a substantial business area consisted of merely providing temporary programmers according to the client's demand. After this, the offshoring model emerged, where domestic firms started developing software in India for offshore clients, managed by the Indian firm. The cost advantage of cheap engineering talent, along with Indian firms' capabilities of managing software projects executed in India for overseas clients, played the major role in the growth of the industry.

Along with the exporting through the offshoring model, Indian software services firms also started doing OFDI. Firms in the Indian Software and Communication sectors accounted for about 56 per cent of total OFDI approvals given out by the government in the service sector, and 30 per cent of overall OFDI, in the late 1990s (Pradhan, 2006a). In 2004, there was a further easing of the capital controls; firms were allowed to invest up to 100% of their net worth abroad. After 2001, the IT sector accounts for the largest number of acquisitions by Indian firms (Athukorala, 2009). These acquisitions are concentrated in Europe, U.K. and U.S.

3.2 The data

Our analysis is based on a firm level database maintained by Centre for Monitoring Indian Economy (CMIE). India has a long tradition of sound accounting standards. CMIE has a well developed methodology for standardisation of definitions of accounting data, so as to obtain a high degree of inter-year and inter-firm comparability. This database has enabled an emerging empirical literature, including papers such as Khanna and Palepu (2000); Bertrand *et al.* (2002); Ghemawat and Khanna (1998); Gopalan *et al.* (2007). The

Table 1 Number of non-OFDI and OFDI firms over time in Chemicals

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

database contains detailed information on 23,000 firms, including all companies traded on stock exchanges and numerous others. The firms contained in the database account for 75 per cent of all corporate taxes, and over 95 per cent of the federal VAT; thus these firms make up the bulk of the economy. The exact set of firms who make up the dataset fluctuates from year to year, given birth and death processes, and non-observation by CMIE.

In addition to traditional accounting data, the database reports the exports and the stock of OFDI for each firm-year. In this paper, we focus on the period after 2000, when capital controls were eased, and Indian multinationals emerged. Our dataset consists of all firms who serve foreign customers, whether through export or outbound 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 one percent of sales. Similarly, the OFDI status of a firm is defined by requiring that the firm's FDI outside India is above one percent 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.

3.2.1 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 transportion costs. Since productivity measurement is best done within one narrow industry, we focus on the manufacturing sub-industry (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 to 2008. Table 1 shows the dynamics of the number of non-OFDI and OFDI firms over time. While there were only 5 MNCs in 2000, this number had risen to 93 in 2008.

Table 2 shows summary statistics about these firms. On average, MNCs have bigger values for total assets, gross fixed assets and the exports to sales ratio. However, the average sales is higher for non-OFDI firms. Export intensity is

Table 2 Summary statistics about Chemicals companies: 2000-2008

		Extent of OFDI	
	Units	Non OFDI	OFDI
Sales	Bln. Rs	8.80	7.07
Total Assets	Bln. Rs	5.88	10.81
Gross Fixed Assets	Bln. Rs	4.105	5.87
Exports to sales ratio	Percent	28.10	34.02
OFDI to total assets ratio	Percent		9.12

Table 3 Software Services: Number of firms engaging in OFDI over time

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

somewhat higher for the OFDI firms. In the class of OFDI firms, on average, foreign assets were 9.12 per cent of total assets.

3.2.2 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-OFDI' category, comprising of firms having over 25% per cent of their total assets overseas,[1] whether or not they are exporters. It is fairly likely that high-OFDI firms are engaged in *production* in their overseas operations.

Table 3 shows the time-series of the number of exporting Software Services companies, and the number of Software Services companies that are classified as Low- and High-OFDI. We see a sharp rise in the number of companies which had OFDI in 2001 and 2002, immediately after the capital controls against overseas investment were eased. After that also, there has been a steady shift of the industry towards greater OFDI.

Table 4 shows summary statistics about the three categories of firms. Three

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

Table 4 Summary statistics about Software Services companies: 2000-2008

		Extent of OFDI		
	Units	None	Low	High
Sales	Bln. Rs.	1	5.34	0.77
Total assets	Bln. Rs.	1.09	6.12	20
Gross fixed assets	Bln. Rs.	0.474	1.779	0.312
Exports to sales	Percent	65.33	69.56	55.08
OFDI to total assets	Percent		9.87	38.11

measures of size – gross fixed assets, total assets and sales – show the biggest values for low-OFDI companies. In addition, the exports to sales ratio is also the highest for low-OFDI companies. Low levels of OFDI might thus be an element of a strategy of serving foreign customers through exports.

3.3 Measuring Productivity

We seek to compare the productivity of OFDI firms against that of non-OFDI 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 which are outside the control of the firm. The output of a firm falls *inside* the frontier owing to inefficiencies of the firm.

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

$$Y_{it} = \exp(x_{it}^{'}\beta + v_{it} - u_{it}), \quad u_{it} \geq 0 \tag{8}$$

$$u_{it} = z_{it}\delta + w_{it}, \quad w_{it} \geq -z_{it}\delta \tag{9}$$

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 unique feature of frontier analysis is the component u_{it}, which 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 9. The restriction ensures that u_{it} is a non-negative 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, t is the extent to which the firm is away from the frontier:

$$TE_{it} = \frac{\exp(x_{it}^{'}\beta - u_{it} + v_{it})}{\exp(x_{it}^{'}\beta + v_{it})} = \exp(-u_{it}) \tag{10}$$

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 OFDI rather than export. Hence, the firm characteristic of interest is the exporting versus OFDI status of the firm. In Equation 9, in addition to many firm characteristics associated with inefficiency, we will have a dummy variable for the OFDI status of the firm at time t. A positive relationship will then indicate that firms with higher *in*efficiency 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 OFDI. In our second specification, we differentiate between low and high OFDI status based on the definitions described in Section 3.

Other firm specific characteristics which 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 or not. We proxy market power by market share, the ratio of the sales of an individual firm over the sectoral sales by year.

Table 5 Stochastic frontier analysis: Chemicals

Variable	Estimate	t statistic
Production function (Equation 8)		
Intercept	1.5378	76.4552
Log wages	0.3524	58.8155
Log capital	0.0400	6.5360
Log raw material expenses	0.6420	115.6850
Inefficiency (Equation 9)		
Intercept	−3449.3874	−2.9344
OFDI dummy	−1531.7724	−2.9322
Age	10.6370	2.9205
Investment rate	−1424.7911	−2.9619
Listed dummy	−995.0121	−2.9332
Market share	−2.0137	−2.8877
$\frac{\sigma_u^2}{\sigma_u^2+\sigma_v^2}$	0.9998	15 147.1863
Number of firms	965	
Number of firm-years	5027	

Size is potentially associated with productivity. The total assets, i.e. the balance sheet size, is a good measure of size. However, a part of total assets, namely gross value added less land and building assets is used in the production function as the measure of capital. Hence, total assets and capital measures are highly correlated. Hence, total assets is not used as an explanatory variable. Size, and scale economies, can enter the results through scale effects (the sum of the coefficient of capital and labour going beyond 1) and through market power.

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

Going beyond the ML estimates for Equation 9 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 OFDI category and another through the Kolmogorov-Smirnov test.

Table 6 Testing for stochastic dominance: Chemicals

Year	KS statistics	p-value
2000	0.70	0.02
2001	0.46	0.00
2002	0.42	0.00
2003	0.45	0.00
2004	0.48	0.00
2005	0.42	0.00
2006	0.40	0.00
2007	0.39	0.00
2008	0.35	0.00

4 Results

4.1 Chemicals

Table 5 reports efficiency effects SFA analysis for Chemicals. We find that the OFDI dummy is associated with reduced inefficiency, i.e. higher technical efficiency. This is a statistically strong result, with an OFDI dummy coefficient of -1531.7 and a standard error of 522.4. This supports the prediction of the Helpman *et al.* (2004) model.

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 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 OFDI firms over the non-OFDI firms. The results of the tests are reported in Table 6, with associated graphs in Figure 2. In all years, the CDF of the productivity of OFDI firms lies to the right of the CDF of the productivity of non-OFDI firms, as predicted by the Helpman *et al.* (2004) model. The rejection of the null hypothesis indicates the validation of the standard Helpman *et al.* (2004) predictions.

This analysis of the Chemicals industry – the part of Indian manufacturing where the largest number of firms with outbound FDI are found – thus yields results which are consistent with the predictions of Helpman *et al.* (2004) hypothesis. Our empirical implementation with the CMIE database, coupled

Table 7 Model explaining inefficiency with stochastic frontier analysis: Software Services

	Model 1		Model 2	
Variable	Estimate	t statistic	Estimate	t statistic
Production function (Equation 8)				
Intercept	1.8854	27.6751	1.8880	25.8500
Log wages	0.4945	35.3460	0.4939	36.4298
Log capital	0.3888	21.7545	0.3885	23.2060
Inefficiency equation (Equation 9)				
Intercept	0.2071	3.4574	−0.0338	−0.3200
OFDI dummy	0.2693	7.0679		
High OFDI dummy			0.3118	5.2387
Low OFDI dummy			0.2451	4.6263
Age	−0.0026	−1.0206	−0.0023	−0.71
Investment rate	−0.9895	−10.0383	−0.9839	−7.76
Listing status dummy	0.2296	6.1424	0.2343	4.5600
Market share	0.0119	2.5721	0.0117	2.1600
$\frac{\sigma_u^2}{\sigma_u^2+\sigma_v^2}$	1.5186×10^{-7}	4.9651	2.0679×10^{-5}	10.4455
No. of firms	375		375	
No. of observations	1677		1677	

with the strategy of productivity measurement using stochastic frontier analysis, has yielded results that are broadly consonant with the literature.

4.2 Software Services

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 OFDI firms are reported in Table 7. Two models are presented. With Model 1, we differentiate OFDI firms against exporters. Model 2 distinguishes high and low OFDI firms from non-OFDI firms.

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

We also find that technical efficiency increases with age. That is, older firms are more efficient. Our estimates suggests 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

Figure 2 Stochastic dominance of technical efficiency: OFDI vs. non-OFDI firms in Chemicals

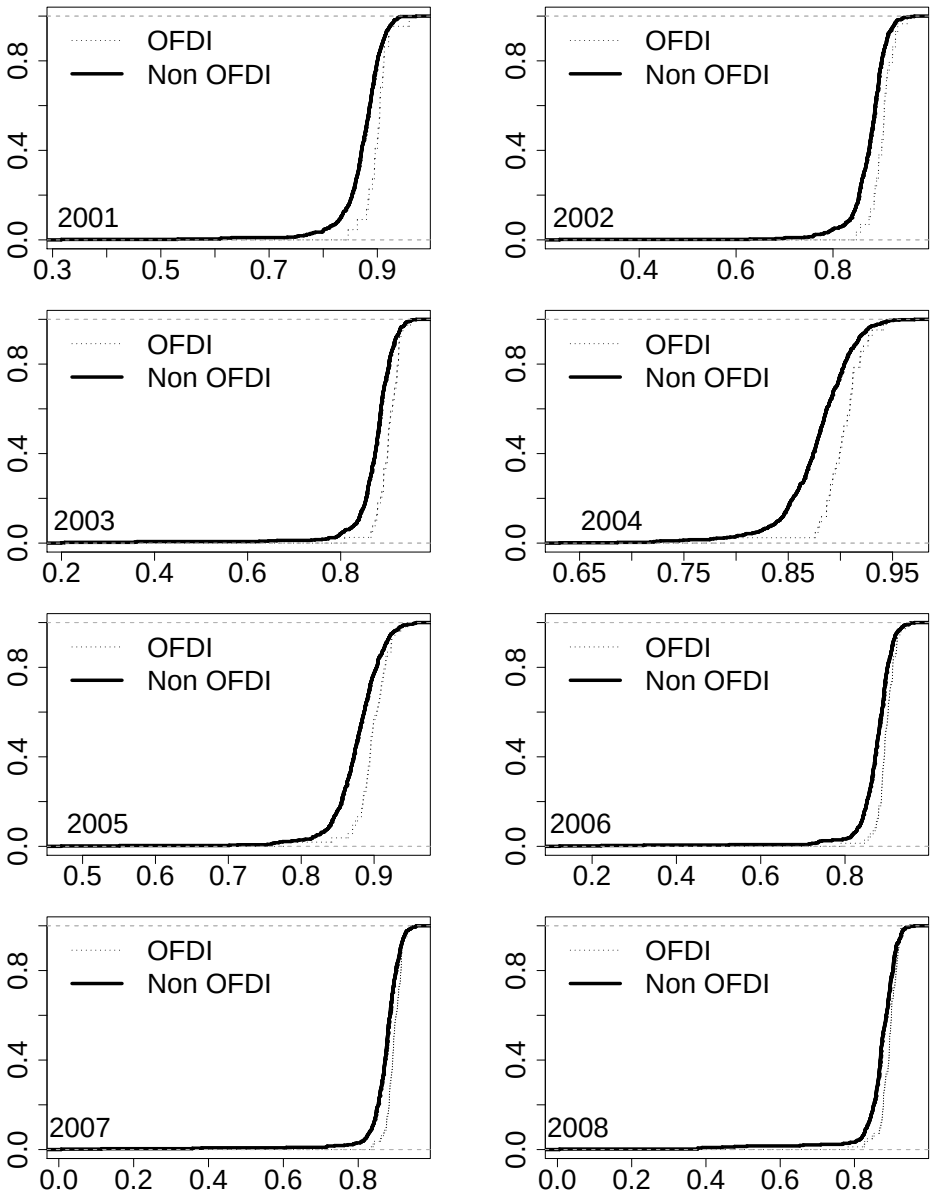


Table 8 Testing for stochastic dominance: Software Services

Year	OFDI		Low OFDI		High OFDI	
	KS statistics	p-value	KS statistics	p-value	KS statistics	p-value
2000	0.27	0.26	0.21	0.35	0.03	0.99
2001	0.21	0.12	0.14	0.39	0.36	0.15
2002	0.23	0.02	0.15	0.24	0.52	0.00
2003	0.28	0.00	0.20	0.05	0.65	0.00
2004	0.30	0.00	0.23	0.02	0.56	0.00
2005	0.41	0.00	0.30	0.00	0.51	0.00
2006	0.24	0.01	0.17	0.13	0.50	0.00
2007	0.26	0.00	0.14	0.30	0.45	0.00
2008	0.24	0.02	0.17	0.19	0.42	0.00

are low but significant. This indicates presence of some inefficiency effect.[2]

As with our analysis for Chemicals, we now go beyond a summary statistic of the distribution of inefficiency to testing for stochastic dominance of the entire distribution. These results, which are analogous to those shown for the Chemicals industry in Table 6, are shown in Table 8.

The first and second columns of the table show test statistics and p-values of stochastic dominance tests of non-OFDI firms over OFDI firms. The third and fourth columns present test statistics and p-values of stochastic dominance tests of non-OFDI firms over low-OFDI firms. The fifth and sixth columns present test statistics and p-values of stochastic dominance tests of non-OFDI firms over high-OFDI firms. While comparing between non-OFDI firms over OFDI 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 non-OFDI firms versus high-OFDI firms.

Figures 3, 4 and 5 depict stochastic dominance of non-OFDI firms over OFDI 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 Conclusions

Trade and foreign investment in tradable services have not been as well analysed in the empirical and theoretical literature as trade in goods. This paper

[2]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 3 Stochastic dominance of technical efficiency: non-OFDI vs. OFDI firms in Software Services

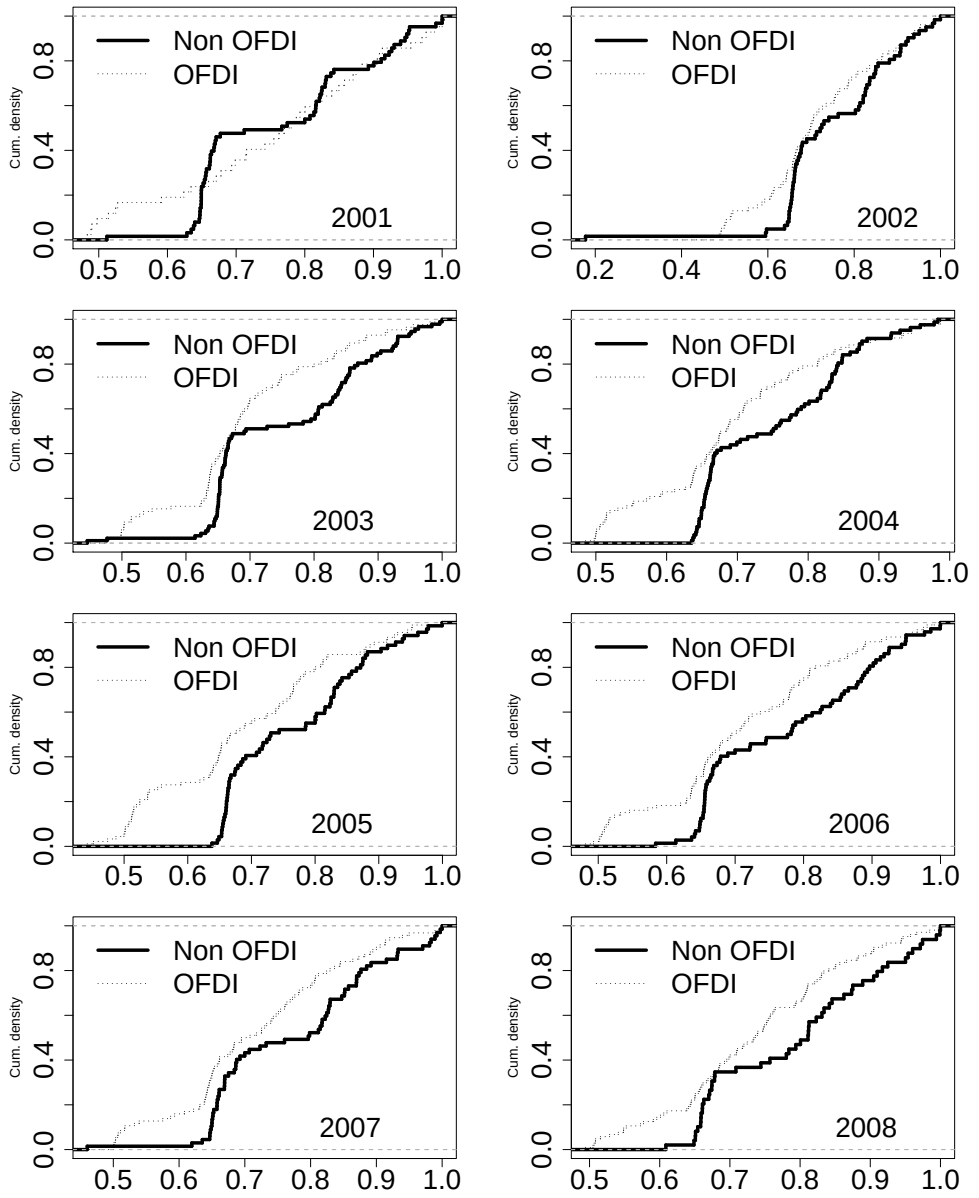


Figure 4 Stochastic dominance of technical efficiency: non-OFDI vs. low and high OFDI firms in Software Services

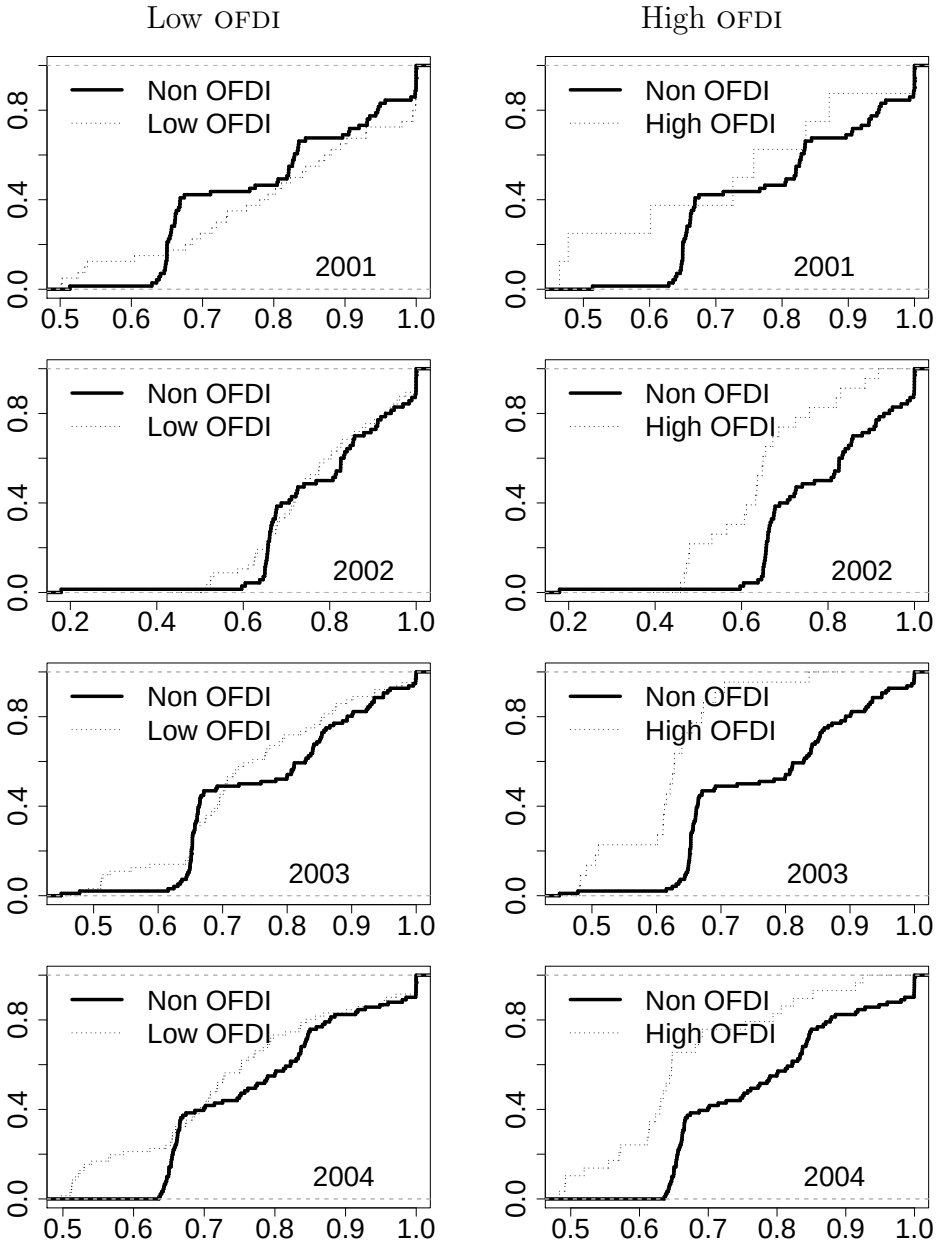
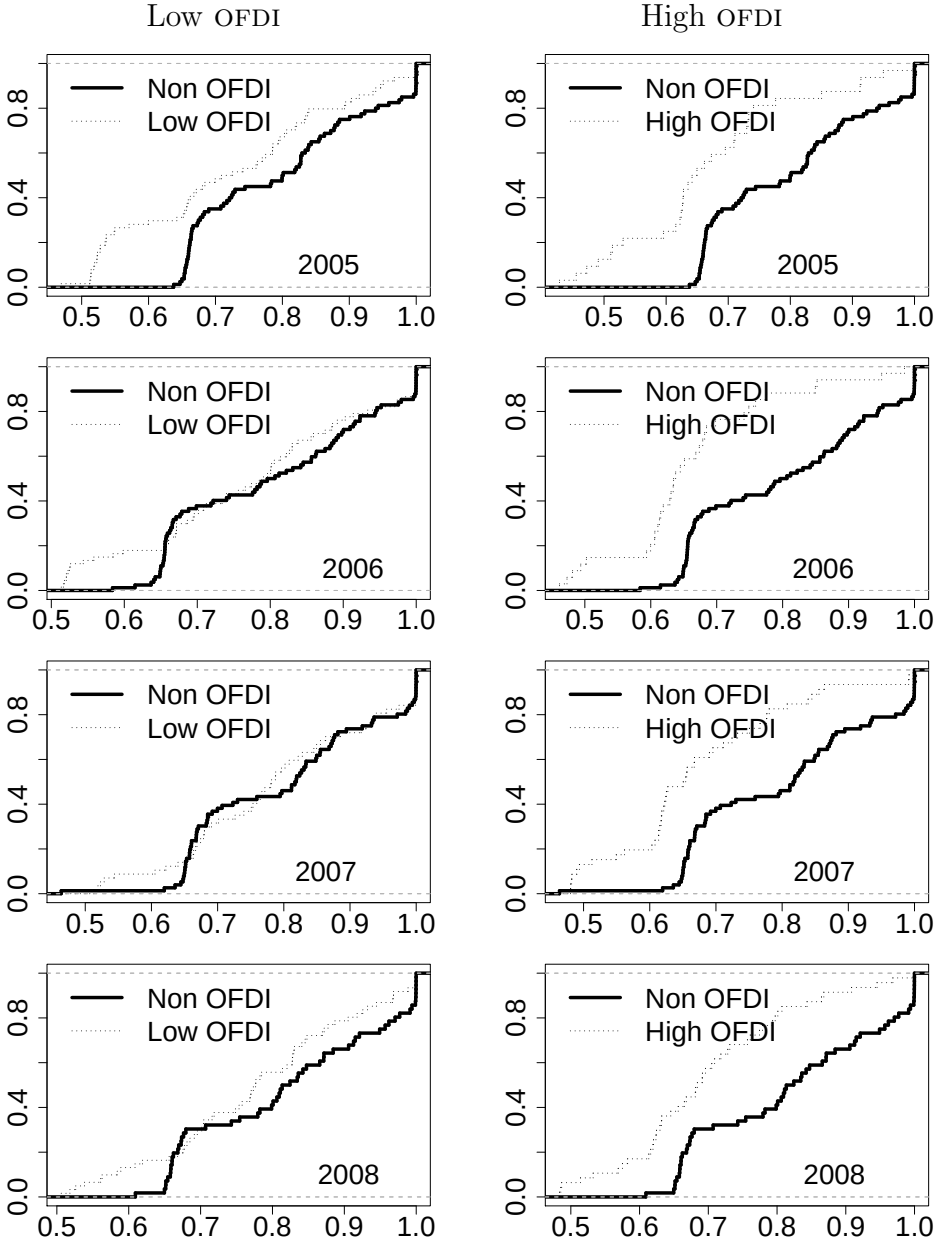


Figure 5 Stochastic dominance of technical efficiency: non-OFDI vs.low and high OFDI firms in Software Services



contributes towards this larger goal. We have extend the framework for exports of goods and outbound FDI by firms to the case of tradable services through the offshoring model. When buyers perceive that services which are produced far away involve greater risk, the model predicts that *less* productive firms would do OFDI. This prediction is supported by data from Indian software services industry.

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