R&D Activities and Export Performance of Indian Private Firms

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Abstract

This paper formulates a model of optimal export decision of private firms and then empirically studies the effect of firm size, R&D activities and competitiveness on export performance of Indian private firms during the period 1975-1986. The paper argues that the Cragg model is more appropriate to model firms' export behavior than the commonly used Tobit model. The evaluation of the export promotion and partial import liberalization policies of 1980 based on the Tobit model is found to be qualitatively quite different from the evaluation based on the Cragg model. The LR and LM specification tests reject the Tobit model against the Cragg model in all specifications.

Keywords: Exports, R&D, Price-Cost-Margin, Cragg Model.
JEL Classification Number(s): F12, O3, L11.

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1. Introduction

Since its first Industrial Policy Act in 1948 until the early 1980s, India's restrictive trade, technology and industrial policies severely affected its industrial development and led to poor export performance, foreign exchange crises and to eventual dismantling of these restrictions in 1991. India protected its industry from foreign competition by introducing high tariffs and quantitative restrictions on imports. India restricted its domestic competition by reserving a large number of goods for production by small scale firms and by limiting the capacity expansion of existing firms. To encourage indigenous technology production, India gave fiscal incentives for firms to do in-house R&D, and severely discouraged import of technology by setting very low limits on royalty payments to foreigners, and by imposing high tariff and other non-tariff barriers to import capital goods, and by virtually banning direct foreign investment. The technology and industrial policies also created strong entry and exit barriers. The world export market, however, consists of efficient firms drawn from all over the world. To succeed in the world export market, a firm must continuously modernize its technology either by importing technology or doing in-house R&D. Due to the above restrictive trade and technology policies, Indian firms gradually lost their comparative advantage; by 1980 India lost its market shares in the export markets for most manufacturing products.[1]

To correct these severe policy mistakes, the Indian government initiated limited import liberalization and export promotion policies in its 1980 Industrial Policy Statement. The main focus of these policies was to improve productivity growth and increase export earnings. Since

[1] India also benefited from its inward looking trade and technology policies. See Desai [1984] for an account of some of the positive and negative achievements that could be attributed to India's technology policies. See Srinivasan [1996] for a critical appraisal of India's trade and industrial policies.

the exporters had lost international competitiveness - being forced to use high-cost domestic inputs, they were granted the opportunity to import raw materials, machine components and capital goods on more liberal terms; limits on royalty payments of exporting firms were raised substantially upward, and sometimes they were also given cash benefits and duty exemptions on imports to make up for their use of high-cost domestic inputs. The exporting firms were allowed to import R&D related capital goods more easily and were given fiscal benefits to do in-house R&D.

The literature is sparse on the models of firm level export incorporating imperfect market structures. Most theoretical trade models of trade that incorporate imperfect competition assume that firms within an industry are homogeneous in terms of technology or cost function and the focus of the literature is to find conditions under which there is intra-industry trade and to study the welfare effects of trade policies, see Helpman and Krugman [1985]. The firm level empirical analyses of exports incorporating imperfect market structure are limited to developed country. For instance, Glejser, Jacquemin and Petit [1980] test the implications of imperfect market structure on export performance of Belgian firms, Wakelin [1998] studies the effect of firm R&D expenditures on export performance of British firms, and Sterlacchini [1999] studies the effect of non-R&D type of innovative activities on exports of small Italian manufacturing firms.

The empirical literature on the firm level export behavior of less developed countries is even sparser. Among a few others, Roberts and Tybout [1997] and Clerides, Lach and Tybout [1998] carried out studies on Colombia, Mexico and Morocco. The firm level studies on Indian export include Kumar and Siddharthan [1994], Patibandala [1995] and Hassan and Raturi [2002]. These studies mostly focus on the effect of firm size and R&D expenditures on export performance.

Most empirical studies with the exceptions of Wakelin [1998] and Hassan and Raturi [2002] formulate export behavior as a Probit or Tobit model, and none of these studies examine the role of competitiveness on export behavior.

In this paper I analyze how R&D activities influence export performance of private firms when they operate in an imperfect market structure induced by above type of policies. I estimate the effect of competitiveness on a firm's export decision. I first theoretically model the optimal export behavior of private firms operating in an imperfect market structure that resulted from Indian protective policies. I use this model to guide my econometric specifications. I argue that the Tobit model is not an appropriate model to analyze the effect of the export promotion and import liberalization policies. More specifically, the Tobit model assumes that any variable that increases the probability of positive export must also increase the average volume of export of the exporting firms. Given the nature of Indian policies, it is possible that a firm may like to attain the exporting status by exporting some positive amount so that it can take advantage of the benefits given to exporters. After the above type of export promotion policies are introduced, a firm is more likely to enter the export market but it's export volume is likely to be lower. Similarly the effect of R&D activities may differ for the probability of export and for the average volume of export of the exporting firms, given the type of incentives that were introduced for R&D activities of the exporting firms. The Cragg model is more flexible than the Tobit model and it allows these possibilities. In the paper, I carry out the likelihood ratio (LR) test and the Lagrange multiplier (LM) test of the Cragg model against the Tobit model, and show that the Tobit model is rejected in all specifications. I then point out some of the major differences in the policy evaluations that could be drawn from these two models.

The rest of the paper is organized as follows: In section 2, I describe the theoretical model of optimal export decisions of private firms. I examine the theoretical predictions of the model regarding the effects of firm size, productive efficiency, and domestic and foreign competition on exports decisions. In section 3, I describe the panel data on a sample of 415 firms during the period 1975-1986 that I use in this study. This 12 years period is also suitable for assessing the effect of the partial import liberalization and export promotion policies that India introduced in 1980. In section 4, I use the model of section 2 as guidance to formulate the empirical specification of the Cragg model, carry out two specification testing of the Tobit model against the Cragg model, and point out the type of wrong policy conclusions that may be drawn if one uses the Tobit model instead of the Cragg model. In section 5, I have my concluding remarks.

2. A model of optimal export decision

I present a model of optimal export decision of private firms operating in an imperfectly competitive market structure. I use the model to examine how the volume of export is related to the type of domestic competition conditioned by various industrial policies, foreign competition conditioned by import tariffs, quotas, and non tariff barriers, and to technological backwardness fueled by the restrictive technology import policies. These predictions are then used to formulate an econometric model of export for empirical analysis at the firm level.

2.1 Market Structure

Given the protective environment created by the trade, technology and industrial policies, the Indian firm acts as monopolists in the industry, each producing a product similar to others but differentiated by variety. Each firm takes the output levels and prices of other firms, the tariff rates and the volume of imports of similar goods as fixed and acts as a monopolist in the residual market. The firm assumes that its actions in its own market do not influence other firms' demand curves, and their actions. Or in other words, each firm is very small relative to the total size of the industry, but in its own market it acts as a monopolist. Thus, the firm takes the export price net of transport cost p_w as given and decides the volume of export, if it decides to export at all, and also decides the price p_D and the quantity q_D for the domestic market. All other firms in the industry act the same way, but they are heterogeneous with respect to their technology and firm size. More specifically, I assume a monopolistically competitive industrial structure.[2]

I assume that when the price is same, the consumers prefer a foreign variety over a domestic variety of a good. So the domestic producers act in the residual market. In this residual market, each producer may try to grab as much market share as possible by advertising and creating consumer confidence in their product. I assume that these activities are either absent or all firms behave identically in this respect.[3] That means, all firms have identical inverse demand functions and the intercept and the slope of the identical inverse demand curve of firms depend on the strength of domestic competition and foreign competition that prevail in the industry. The higher is the level of either type of competition, the lower are the intercept and the slope terms of the inverse demand curve. I parameterize the level of competition that a firm encounters by θ_d and denote its inverse demand function by $p(q;\ \theta_d)$. This inverse demand curve and the corresponding marginal revenue curve of a representative firm are shown in figure 1 as AR and MR respectively.

2.1 Production Technology

I represent the technology by cost function. I assume that the average cost to produce a given level of output consists of a fixed cost, which depends on the installed capacity, and a variable cost, which is assumed to be increasing for output levels produced above the installed capacity. This leads to a U-shaped average cost curve, shown in figure 1 as AC. The output level at which the average cost is minimized depends on the installed capacity of the firm: The higher the level of installed capacity, the higher is the output level q at which the average cost is

[2] An alternative formulation would be the oligopolistic market structure in the domestic market. There are, however, not enough empirical studies to ascertain which structure is relevant for Indian firms. It is more likely that the monopolistic competition framework is more appropriate to model the industrial structure of lighter industries, and oligopolistic competition for heavier industries.
[3] This is a simplifying assumption for our empirical analysis, since I do not have information on such activities in my data set.

minimized. Thus installed capacity can be characterized by the horizontal position of the tip of the average cost curve.

The Indian firms were restricted from importing foreign technology in every possible way: they were restricted in purchasing blueprints from abroad due to limits on royalty payments to foreigners, and from importing capital goods with embodied foreign technology due to high tariff rates and other non-tariff barriers to such imports. I assume that given their licensed capacities, the firms obtained their technologies from various sources at various times. I also assume that the firms varied in their managements. These led to differences in their cost curves. Given their licensed capacity, I represent the variations in cost curves across firms by a parameter θ_c and denote the cost functions by $C(q; \theta_c)$. The marginal cost curve and the average cost curve of a representative firm are shown in figure 1 as MC and AC respectively.

Under the assumption that production function is homothetic, and technological change is factor neutral, the cost function can be represented by $c(w, y; \theta_c) = \xi(w) \cdot \gamma(\theta_c) \cdot g(y)$, where w is a vector of factor prices and ξ, γ and g are functions. I assume that the variations of technologies across firms are such that all firms have a common input aggregator function $\xi(w)$, but differ in productivity level $\gamma(\theta_c)$. I also assume that factor prices are constant across firms and over time. It is then easy to see that $\gamma(\theta_c)$ represents the growth factor of total factor productivity with respect to a reference firm in the base period for which $\gamma(\theta_c)$ is normalized to 1. Thus for firms with a given level of capacity, the technological variations can be represented by $\gamma(\theta_c)$ which can be indexed by the vertical position of the tip of the average cost curve.

I further assume that the firms from the rest of the world that are active in the world export market are perfectly competitive and have achieved their long-run cost curve. Therefore, the world price p_w is the same as the tip of the long-run average cost curves of these exporting firms in the world market. Because of the limitations mentioned above, the unit cost of production is higher in India as compared to the cost of its peers in the world economy. In the following diagram this fact is reflected in having the tip of an Indian firm's average cost curve at a higher level than the world price level. I assume for now that all the distribution costs are included in the production cost, and that there is no extra cost associated with exporting. I will come back to exporting cost later in this section.

In sum, the three parameters that characterize the market structure of an industry in this set-up are 1) the slope and the intercept of the inverse demand curve, represented by the parameter θ_d, 2) the vertical position of the tip of the average cost curve, represented by the parameter θ_c and 3) the installed capacity or the firm size which determines the horizontal position of the tip of the average cost curve in figure 1.

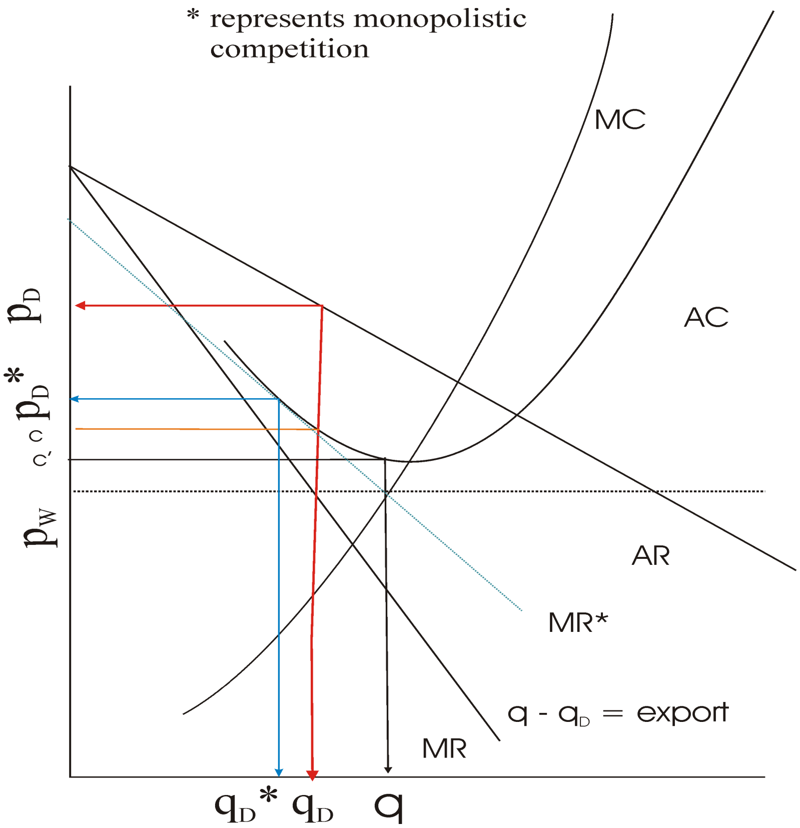

Figure 1: Determination of exports at the firm level

2.3 Optimal firm behavior

For profit maximization and assuming exporting of this product by any resident other than the monopolist is prohibitively costly or illegal, the optimal strategy of the monopolist is to quantity discriminate in the two markets – by controlling domestic supply q_D, it sets a domestic price p_D higher than the world price p_w and it acts as a price taker in the world market and exports the residual output, $q - q_D$. More formally, the profit maximization problem is given by

$$\pi(\theta_d, \theta_c) \equiv Max_{q,q_D}\ p(q_D;\theta_d)\cdot q_D + p_w \cdot (q - q_D) - C(q;\theta_c)$$

where $\pi(\theta_d, \theta_c)$ is the profit function of a firm parameterized by (θ_d, θ_c). The first order conditions of the problem are

With respect to *q*, $C'(q;\theta_c) = p_w$: MC = world price level.

With respect to q_D, $p'(q_D;\theta_d)q_D + p(q_D;\theta_d) = p_w$: MR = world price level

The above solution is obtained as follows: The firm produces output level *q* that equates marginal cost to the world price p_w, supplies output level q_D to the domestic market, which equates marginal revenue to the world price level p_w, and exports $q - q_D$.

It is clear from Figure 1 that export as a function of firm size will have the property that a firm will not export if its size is up to a critical level, q_D. Above this critical level q_D, the firm will have higher export, the higher is its size (measured in terms of capacity to produce). Thus, in this set-up, whether the firm size has any effect on export depends on whether capacity constraint of a firm implied by the Indian industrial licensing policy is below this critical firm size q_D or not.

It is clear from figure 1 that while for a given market condition θ_d and assuming that the licensed capacity is set at a significantly high limit, the critical level q_D that determines whether to export or not, does not depend on the productive efficiency level θ_c of the firm; the volume of exports $q - q_D$, however, depends positively on the productive efficiency level θ_c. Furthermore, notice that as the efficiency level θ_c becomes lower, i.e., the tip of the AC curve moves to a higher level, the export amount (q – q_D) becomes smaller. It is also clear that there exists a productive efficiency level below which the firms do not export, and above which the firms export positive amounts; furthermore, the volume of export is higher, the more productive a firm is.

The degree of competitiveness of a firm can be measured by the Learner index, also known as the price-cost-margin, $PCM = \left(p_D - MC \right) / p_D$. Notice that for a firm with demand elasticity e, $PCM = -1/e$. In the extreme case of perfectly competitive market, $1/e = 0$ and thus $p_D = MC$, and $PCM = 0$. Assuming cost curves are fixed, a higher competitiveness in the industry would then imply a lower PCM. Keeping the cost curves fixed, what will be the effect of a higher competitiveness on exporting activities? The effect is ambiguous because it is not clear how the inverse demand curve will shift because of higher competitiveness in the industry. Suppose a higher competitiveness shifts only the intercept term of the inverse demand curve to a lower level. Then, a higher competitiveness implies a higher likelihood of exports for firms which were not exporting before and a higher export volume for firms which were exporting before. If a higher competition leads to a flatter inverse demand curve, then the effects will be just the opposite. When we have both types of shifts, the effect of competitiveness on likelihood and volume of exports depend on their relative magnitude of these two effects and need be determined empirically.

What could be achieved in the long-run by introducing domestic competition with free entry and exit? In this limiting case of monopolistic competitive equilibrium, the firms will have the marginal revenue curve tangent to the average cost curve as shown by the flatter marginal revenue curve MR* in figure 1. As the economy moves towards this equilibrium due to free entry and exit, the PCM of the firms will fall and exports will rise. The PCM level corresponding to the monopolistic competition is the lowest level of PCM that can be attained only with domestic competition. To attain any further competitiveness in the industry (in the limit to achieve the perfectly competitive equilibrium outcome), the industry must allow foreign competition by lowering the tariff rates. So long as the tariff rate is positive, the model can explain intra industry trade.

I have so far assumed that there are no extra costs or benefits associated with exporting activities. Exporting may involve extra sunk costs. For instance, a firm may have to invest in R&D to meet the product quality standard of the export market. In that case firms with R&D capabilities will have higher likelihood of exporting, see Roberts and Tybout [1997] for a model of optimal firm level export along this line. One firm's R&D may create product and process innovations for the exporting markets and other firms in the same industry can benefit from such knowledge without investing in R&D. See Raut [1995] for evidence on R&D spillover in a different context. In this paper, I assumed R&D to be an exogenous variable and assumed that it does not create any externality. Exporting activity of one firm may reduce the information and networking cost associated with exporting of other firms in the same geographical area and in the same market and from this point of view, the presence of multi national enterprise (MNE) in an industry of a particular geographical area may influence the export decisions of local firms in the industry, see Aitken, Hanson and Harrison [1997] for a model along this line. While these effects are important, I have not pursed these aspects in this paper.

3. The Data Set

Data on variables such as net sales, fixed assets, and wages and salaries were taken from various issues of Bombay Stock Exchange Directory. Data on exports and imports of capital goods and raw materials came from annual reports of the individual companies that are registered with the Ministry of Company Affairs. The nominal variables were converted into real terms by using wholesale price index numbers, which came from Revised Numbers for Wholesale Price Indices, the Ministry of Industry, the Government of India. The firms in this study are taken to be those that were registered with the Bombay Stock Exchange Directory and the ministry of Company Affairs and had paid-up capital of at least 50 lakhs. There were about 2500 firms registered with the Ministry of Company Affairs, out of which only about 900 firms were registered with the Bombay Stock Exchange Directory. I had to further restrict the sample to firms having at least three consecutive years of data during the two periods to satisfy the data requirements for the econometric analysis, and I ended up with 415 firms in the sample. In this study, I define a firm to be exporting if it had some amount of exports during the period 1975-1986. According to each firm's primary output, I assigned a 3-digit Standard Industrial Classification code taken from the Annual Survey of Industries (ASI) volumes published by CSO (Central Statistical Organization). Although it would be ideal to carry out an analysis at the 2-digit industry level, due to paucity of data in certain industries, I regrouped the industries according to their technological complexities into two groups – light and heavy industries. The composition of each industry group and a few selected summary statistics of our variables are shown in table 1.

It appears from table 1 that there are 145 firms in the light industry and 270 firms in the heavy industry. About 32.48% firms in the light industry and 40.91% firms in the heavy industry are exporters. It is also apparent that in both industries, the exporting firms import proportionately more raw materials and capital goods and invest more in in-house R&D than the non-exporting firms.

Table 1: The industrial Classification of our Study

Characteristics \ Industry		Light Industry	Heavy industry	Overall
2-digit industries		food products (20-21); beverages and tobacco (22); cotton (23); wool, silk, and synthetic fiber (24); jute (25);and textile products (26)	Rubber, plastic, petroleum and coal products (30); chemical products (31); non-metallic mineral products (32); basic metal and alloys (33); metal products (34); machinery and machine tools: non-electric (35), and electrical (36)	
Number of firms		145	270	415
% of firms exporting		32.48	40.91	37.94
Export as percentage of net sales of the exporting firms		70.37	45.41	52.21
Import of capital goods as percentage of net sales	**Exporting**	4.40	58.83	44.00
	Non-exporting	0.95	2.84	2.11
Import of raw materials as percentage of net sales	**Exporting**	2.63	18.87	14.44
	Non-exporting	0.42	7.25	4.61
R&D expenditures as percentage of net sales	**Exporting**	0.26	1.63	1.26
	Non-exporting	0.03	0.14	0.10

4. Econometric formulation and empirical findings

From our model of optimal export decision it follows that the decisions to export and how much to export depend on the firm size, the cost factors represented by θ_c, the market demand conditions represented by θ_d and the export promotion policies. I take the logarithm of fixed capital as a measure of firm size. The cost parameter θ_c and the demand condition θ_d are not directly observed. In-house R&D investment and import of capital goods are assumed to be the main determinants of θ_c. It is often argued that barriers to import raw materials forced the Indian firms to use more expensive domestic raw materials, which increased the unit cost of production and hence adversely affected export. I also included this as another determinant of θ_c to see if this type of import barriers affected export decisions adversely. Notice that θ_d depends on the tariff structure of the industries, the government policies mentioned earlier regarding entry and exit and policies related to monopoly restrictive trade practices (MRTP). The detailed information about these variables is not available, so I take PCM as a summary measure of these factors. I follow the general convention of the empirical industrial organization literature to estimate PCM by, *PCM = (total sales – total wages and salaries – raw materials)/total sales.* I included a time dummy variable y_80s, defined as y_80s = 1 if year ≥ 1981, and y_80s = 0 otherwise. I included this dummy variable to see if after controlling for firm size, technology θ_c, and market condition θ_d, the firms showed favorable export performance after the export promotion policies were introduced in 1980.

4.1 Econometric Issues

Previous studies on Indian firm level exports used a Tobit model. As I mentioned in the introduction, given the type of export promotion policies that India introduced in 1980, some of the regressors in our model will have different impact on the likelihood of exporting and on the amount of exports. For instance, since a firm is allowed to import raw materials, capital goods and R&D related capital more easily if it is an exporting firm, the firm would respond to such export promotion policies by exporting some amount but the amount would not be higher than the average amount that the firms were exporting before such policies were introduced. That means, the dummy variable y_80s will have a positive effect on the probability of exporting but a negative or no effect on the average export amount of a representative exporting firm. Since the Tobit model restricts both these effects to be in the same direction, the Tobit model will give biased estimates of the parameters and may lead to wrong policy conclusions. I will use the Cragg model which is more flexible than Tobit model and which nests Tobit model as a special case. In the next subsection, I will show empirical evidence of how policy evaluations could be very different when we use the Tobit model instead of the Cragg model.

More specifically, let I_{it} be an indicator variable taking value 1 if firm *i* in period t has positive export, and taking value 0 otherwise. Let y_{it} denote the volume of export, and X_{it} denote a row vector of *k* explanatory variables for firm *i* in period *t*. The Cragg model assumes that the probability of a limit observation is driven by a Probit model $\Pr\{y_{it} = 0 \mid X_{it}\} = \Phi(-X_{it}\beta_1)$ with a column vector of parameters β_1 of dimension *k*, where Φ is the standard normal cumulative distribution function. The probability of a non-limit observation, i.e., the probability of exporting a positive amount y_{it} follows a truncated normal distribution with mean $X_{it}\beta_2$ and variance σ^2 and the density function of y_{it} is given by $\dfrac{\phi((y_{it} - X_{it}\beta_2)/\sigma)}{\Phi(X_{it}\beta_2/\sigma)}$, where ϕ is the standard normal probability density function. Notice that we have distinct parameter coefficients for the regressors in two models: β_1 for the limit observation, and β_2 for the non-limit observation. Our data consists of observations of the type $\{I_{it}, y_{it}, X_{it}\}$, where y_{it} is the export level of the firm *i* in period *t*. The likelihood of the sample is given by

$$\prod_{i,t}\left[\Phi(-\beta_1 X_{it})\right]^{(1-I_{it})} \cdot \left[\frac{\phi((y_{it} - \beta_2 X_{it})/\sigma)}{\Phi(\beta_2 X_{it}/\sigma)}\right]^{I_{it}}$$

Notice that the Cragg model nests the Tobit model under the null hypothesis $H_0 : \beta_1 = \beta_2/\sigma$.

Using the unrestricted and restricted maximized log-likelihoods of the sample I calculate the χ^2 statistic for the likelihood ratio (LR) test to statistically test the above null hypothesis. This χ^2 test statistic is distributed as chi-square with *k* degrees of freedom. The Tobit estimates and this χ^2 test statistics for each industry group are shown in table 2.

The log-likelihood function for Cragg model is not globally concave even when one re-parameterizes the Cragg model using Olsen transformation. Thus it may not always be possible to compute the maximized log-likelihood function for testing purpose. For instance, when I used both firm size and square of firm size in my specifications, the numerical maximization of the log-likelihood did not converge under all the available algorithms in SAS.[4] Lin and Schmidt [1984] proposed a LM (Lagrange Multiplier) test criterion which uses only the maximized log-likelihood of the Tobit model, but it is rather cumbersome to compute. Green[1997, pp.970] proposed an alternative χ^2 test statistic for the null hypothesis which requires only the maximized log-likelihood of the sample under Tobit, Probit and truncated normal distributions. In table 2, I also report the parameter estimates from the Probit models and the Green version of χ^2 statistics to test the null hypothesis of Tobit model against the Cragg model. In table 3, I present the parameter estimates from the Cragg model.

4.2 The empirical findings

Notice that both χ^2 tests reject the Tobit model against Cragg model for all our industry groups. Even though the Tobit model is rejected against the Cragg model, I present the parameter estimates from the Tobit model in table 2 so that we can compare the parameter estimates with a

[4] The Tobit and Probit models, however, did not have this problem. This is the reason why I did not include square of the firm size.

previous study by Kumar and Siddarthan [1994] who estimated a Tobit model of export, and to compare the differences in policy evaluations that may result from misspecification of the model.

Table 2: Parameter Estimates from the Probit and Tobit Model of Export

Variables	Light Industry		Heavy Industry		Overall Industry	
	Probit	**Tobit**	**Probit**	**Tobit**	**Probit**	**Tobit**
Intercept	-1.4496 (7.70)	-1.8098 (5.67)	-0.2781 (2.77)	-0.3428 (3.10)	-0.5690 (6.50)	-0.6441 (5.76)
Dummy variable, = 1 if 1980's	0.5767 (5.94)	0.6075 (3.88)	0.1570 (2.55)	-0.0358 (0.54)	0.3071 (6.04)	0.1340 (2.13)
Firm size	0.0788 (1.88)	0.0230 (0.35)	-0.0531 (2.38)	-0.0580 (2.39)	-0.0244 (1.25)	-0.0445 (1.84)
Import of capital goods	0.1191 (0.31)	0.3370 (0.60)	0.5333 (3.40)	0.0462 (13.80)	0.6767 (4.61)	0.0472 (12.36)
Imports of raw Materials	0.9244 (6.24)	0.7969 (4.93)	0.0010 (0.47)	0.0124 (7.36)	0.0015 (0.65)	0.0134 (6.93)
Price-Cost-Margin	-0.9352 (3.09)	-2.3695 (4.84)	0.0529 (0.31)	-0.0380 (0.21)	-0.1135 (0.85)	-0.4574 (2.79)
R & D expenditures	12.3835 (2.41)	13.9426 (2.63)	13.4343 (6.13)	1.0343 (3.11)	14.5197 (6.95)	1.2633 (3.35)
σ		1.6730 (20.16)		1.1526 (34.14)		1.3152 (39.57)
Green version of χ^2	197.00		671.00		868.00	
χ^2 for standard LR test	281.72		773.55		978.61	

Note: The absolute value of t-statistic is within parentheses. The critical value for χ^2_7 at 5% is 14.07 and 1% is 18.48.

The parameter estimates from table 2 show that the R&D investment increased a firm's likelihood to export and the propensity to export in all industries. Assuming capital good represents embodied technology, it appears that the import of technology is not an important determinant of exports in the technologically light industry, but it is an important determinant in the technologically heavy industry. These two facts together imply that in the light industry the indigenously produced technology in the in-house R&D help exports. In the heavy industry, however, it appears that for exporting activities import of technology and in-house R&D to adopt the technology to local condition help exports. This is broadly what was found by Kumar and Siddarthan.[1984] using firm level data from 1987-89 and using Tobit model. This pattern on sources of technology of these two industries are consistent with the pattern found in Raut [1988].

From the estimate of the coefficient of import of raw materials it appears that the tariffs and non-tariff import barriers that Indian government imposed in the past did adversely hurt exports. Furthermore, from the parameter estimate of the dummy variable y_80s it appears that the partial liberalization policies of 1980 had encouraged firms to have higher likelihood of engaging in exporting activities in all industries and also increased the propensity to export in the light industry. This effect is in addition to the effects through import of capital goods, raw materials and R&D activities that the partial liberalization policy of 1980 might have accomplished. Firm size is not an important detriment to export activities in the light industry but it affected adversely both the likelihood and propensity of exporting for the firms in the heavy industry.

Finally, it appears that competitiveness leads to higher likelihood of exports and higher propensity to export for firms only in the light industry. This result also holds for the Cragg model. This result is reasonable since in the light industry it is possible for firms to enter and it is reasonable since it is possible for light industry is capable to Let us now turn to the parameter estimates from the more flexible Cragg model in table 3 and point out how some of the policy conclusions differ when we use the more appropriate Cragg model of export.

Table 3: Estimates from the Cragg Model of Export

Variables	Light Industry		Heavy Industry		Overall Industry	
	Limit	**Non-limit**	**Limit**	**Non-limit**	**Limit**	**Non-limit**
Intercept	-1.4497 (7.70)	1.3176 (0.20)	-0.2781 (2.77)	-3.7002 (5.25)	-0.5690 (6.50)	-3.9228 (4.47)
Dummy variable, = 1 if 1980's	0.5770 (5.94)	-7.1679 (2.58)	0.1570 (2.55)	-9.2572 (25.70)	0.3071 (6.04)	-7.9391 (15.80)
Firm size	0.0786 (1.88)	-1.6535 (1.15)	-0.0531 (2.38)	-0.0447 (1.19)	-0.0244 (1.25)	-0.4073 (3.91)
Import of capital goods	0.1202 (0.31)	0.2140 (0.04)	0.5333 (3.40)	-0.0310 (4.44)	0.6767 (4.61)	-0.0388 (2.34)
Imports of raw Materials	0.9239 (6.23)	-0.5896 (0.30)	0.0010 (0.47)	0.0187 (5.97)	0.0015 (0.65)	-1.5337 (20.93)
Price-Cost-Margin	-0.9336 (3.09)	-22.9917 (3.08)	0.0529 (0.31)	0.1732 (0.52)	-0.1135 (0.85)	-10.8956 (7.60)
R & D expenditures	13.0360 (2.45)	1.2459 (0.02)	13.4344 (6.14)	-0.4163 (0.99)	14.5240 (6.95)	2.2557 (1.06)

The parameter estimates from the Cragg model in table 3 show that while the parameter estimates β_1 for the limit observations in the Cragg model are very similar to the estimates of the β_1 in the Probit model, but the parameter estimates for the non-limit observations of the Cragg model are very different from the estimates from Tobit model. For instance, notice that R&D expenditure cease to be a significant determinant of the propensity to export. Similarly, import of raw materials cease to be a significant determinant of export propensity in the light industry. Most striking difference between the Tobit and Cragg models are the coefficient estimates for import of capital goods and y_80s. The effect of import of capital goods on export propensity is now significantly negative in the heavy industry while it was significantly positive in the Tobit model. The effect of y_80s on export propensity is now significantly negative in both industries while it was significantly positive or insignificant in the Tobit model. The effect of PCM is the only effect that is conformable in both models.

From the fact that y_80s and import of capital goods have positive effect on the probability of exporting but negative effect on the propensity to export lead to an important policy judgment: the partial liberalization and export promotion policy of 1980 created a peculiar export incentives of the type that while the firms were more likely to export some positive amount to qualify as exporter so that they could import capital goods, raw materials, and technology more easily, the export propensity of these firms were lower on the average than the export propensity of the original exporters. Thus the export promotion and partial liberalization policies encouraged more firms to become exporters while dropping the average export propensity. This inference about the effect of liberalization and export promotion policies is qualitatively different from the inference based on estimates from the Tobit model. The other significant difference in inference is in the effect of R&D expenditure on export propensity.

5. Conclusions

In this paper I have examined how competitiveness and cost effectiveness influenced exporting activities of Indian private firms during 1975-1985. I considered a theoretical model of optimal export decision within an imperfectly competitive industrial structure and used it for guiding the econometric analysis. I considered three factors that influenced cost effectiveness of Indian firms: in-house R&D expenditures, import of technology embedded in capital goods, and import of raw materials. I carried this analysis separately for technologically light and technologically heavy industries. I also empirically evaluated if the partial liberalization and export promotion policies that were introduced in 1980 had significant positive effects on exporting activities of firms.

I have argued that commonly used Tobit model is not appropriate for modeling export activities and it may lead to incorrect policy evaluations: It is more appropriate to use Cragg model. I carried out specification testing of the Tobit model against the Cragg model, and found that the Tobit model was rejected for all specifications.

According to the Cragg model, the export promotion and partial liberalization policies that were introduced in 1980 encouraged firms to become exporter so that they could qualify to import capital goods, raw materials and technology more easily. These policies, however, lowered the average propensity to export. Furthermore, in-house R&D had positive effect on probability of exporting, but not on the propensity to export. The import of embedded technology increased the probability of exporting but had negative effect on propensity to export. The Tobit model in this study as well as the study by Kumar and Siddarthan [1994], on the other hand, gave a misleading inference by estimating positive effects of R&D and import technology on propensity to export. The only qualitatively robust inference across these two models is that higher competitiveness led to higher likelihood and propensity to export in the light industry. The findings of this paper also warn us to be cautious while using the Tobit estimates to judge the performance of export promotion and liberalization policies without carrying out a specification testing against another more flexible model.

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