Exporting/Importing and Firm Performance: Evidence from India

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November 14, 2019

Abstract

Contents

1 Introduction

There is vast literature which states that exporters tend to out-perform non-exporters in terms of wages, capital, productivity. Bernard and Jensen 1999 say that this can be due to these reasons:

- export increases productivity (Self-selection)
- productivity increases export (Learning by doing)

Self-selection (SS) hypothesis of more productive firms into export states that participation in the export market is accompanied by additional costs such as transport costs, establishing a distribution channel, cost of traversing beaurocratic channles etc. This means that there are substantial sunk costs to participating in the export market. Therefore, firms which are more productive plan to enter to the export market.

Learning-by-doing hypothesis (Haidar 2012) states that exporting firms deal with tougher competition in the international market as compared to the domestic market, and therefore must improve their performance to remain active in the export market. Moreover, participating in the international market leads knowledge flows from international buyers to help post entry performance of export starters. This means that exporting should cause productivity spillovers as well.

The same hypothesis (self-selection and learning-by-doing) can apply to import behavior of firms. Since importing also involves additional similar costs like additional taxes, transport costs etc. , firms that are more productive will enter the import market. Also, a firm participating in the import market can have access to better technology and higher quality goods. Topalova and Khandelwal 2011 and Halpern, Koren, Szeidl, et al. 2011 find that improved access to foreign technology can boost productivity.

Since, participating in the export/import market could involve costs that are complimentary. It would be interesting to see how participation in one activity affects the other. I plan to investigate is whether there are benefits of importing to exporting and vice-versa by estimating the complementary nature between the two.

So, my reasearch plan is to investigate:

- Self-selection hypothesis: Check whether more productive firms participate in the expprt/import market
- Learning-by-doing hypothesis: Check if there are productivity spillovers from participation in the export/import market
- Estimate the fixed and sunk costs of participation in the export/import market and the decrease in costs due to the complimentary nature between the two

- Run counter-factual experiment to see the effect of decrease in the costs to exporting/importing.

2 Data

I use annual firm level data from Centre for Monitoring Indian Economy (CMIE) which provides data from 1989 to 2017.

I fetch the following variables from CMIE:

Table 1 Data Variables

variable	indicator
sa_company_name	Prowess company name
sa_finance1_year	Year
sa_total_income	Total Income
sa_sales	Sales
sa_industrial_sales	Industrial sales
sa_sales_n_chg_in_stk	Sales and change in stocks
sa_total_expense	Total expenses
sa_rawmat_exp	Raw material expenses
sa_power_and_fuel_exp	Power & fuel
sa_salaries	Salaries & wages
sa_pat	Profit after tax
sa_pbdita	PBDITA
sa_current_liabilities	Current liabilities
sa_capital_employed	Capital employed
sa_borrowings	Borrowings
sa_commercial_papers	Commercial papers
sa_total_assets	Total assets
sa_gross_fixed_assets	Gross fixed assets
sa_current_assets	Current assets
sa_export_goods	Export of goods(fob)
sa_export_serv	Export of services
sa_import_rawmat	Import of raw materials (cif)
sa_import_stores_spares	Import of stores and spares (cif)
sa_import_fg	Import of finished goods (cif)
sa_import_cap_goods	Import of capital goods (cif)
nic.2digit	Broad industry classification code

Table 2 Compostion of firms by year

Year	Number of firms
1988	23
1989	60
1990	44
1991	56
1992	74
1993	148
1994	437
1995	562
1996	385
1997	388
1998	818
1999	1130
2000	3346
2001	3847
2002	3889
2003	4447
2004	4675
2005	5151
2006	5344
2007	5456
2008	5638
2009	5903
2010	5917
2011	5330
2012	4737
2013	4320
2014	4050
2015	3087
2016	2477
2017	3

Table 1 shows the variables and their meaning. I chose the variables which might be the most pertinent to my research question.

The variables stated above are nominal values. I fetch Wholseale Price Index (WPI), which provides the inflation rate of the wholesale prices and deflate the variables to give real values. Then, I clean the data to remove missing values and select firms with the broad industry classification code indicating that they are a manufacturing firms to get the following composition of firms:

India liberalised its economy in 1992 which resulted in import tariffs, deregulation of markets, reduction of taxes, and greater foreign investment. According to Topalova and Khandelwal 2011, The government's trade policy under the Eighth Five]Year

Plan (1992-97) ushered in radical changes to the trade regime by sharply reducing the role of the import and export control system. The share of products subject to quantitative restrictions decreased from 87 percent in 1987]88 to 45 percent in 1994-95, and the actual user condition on imports was discontinued. And since 1997, the decrease in output and input tariff has been very marginal. Therefore I restrict the time period of the study from 1997 to 2016. Since, firms are under no legal obligation to report their finances, which might mean that mean that small firms are less likely to report their finances. However, this dataset includes all publicly listed firms as their firm financials are public information. This might affect my results as it is biased towards bigger firms.

I create two additional variables *Export* , *Import*, *Domestic Sales* by adding the following variables from the Table 1.

1. Export: sa_export_goods + sa_export_serv
2. Import: sa_import_rawmat + sa_import_stores_spares + sa_import_fg +sa_import_cap_goods
3. Domestic Sales: Total Sales - Export Sales

Then, I create four dummy variables of trade market participation using the *Export* and *Import* variables:

- None: Firms that do not participate in the export/import market
- Export only: Firms that participate in the export market only
- Import only: Firms that participate in the import market only
- Both: Firms that participate in both export/import market

Table 3 displays the composition of firms according to their trade market participation status. It is seen that number of firms that do not participate in the trade market is low, around 20 to 35 %. Surprisingly, the number of firms that participate in the trade market is really high. Another interesting feature is that the number of firms that participate only in the import market is higher than the firms that participate only in the export market. This must mean that the demand for foreign intermediaries is really high. Almost 50 % of firms in each year participate in both export/import market. It is also seen that the participation rate in the trade is not increasing year on year.

Table 3 Composition of firms based on trade market participation

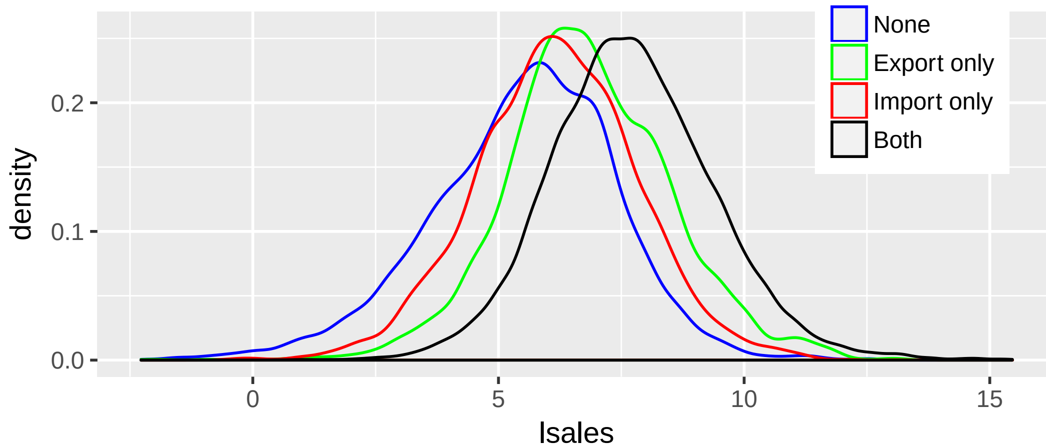
Year	None	Export only	Import only	Both	Total
1996	0.26	0.08	0.21	0.44	385
1997	0.29	0.08	0.23	0.40	388
1998	0.37	0.09	0.18	0.36	818
1999	0.40	0.10	0.18	0.32	1130
2000	0.28	0.08	0.19	0.45	3346
2001	0.28	0.08	0.18	0.46	3847
2002	0.29	0.08	0.18	0.46	3889
2003	0.30	0.08	0.18	0.44	4447
2004	0.32	0.09	0.16	0.43	4675
2005	0.35	0.08	0.16	0.41	5151
2006	0.34	0.08	0.16	0.42	5344
2007	0.35	0.08	0.16	0.42	5456
2008	0.34	0.08	0.16	0.42	5638
2009	0.35	0.08	0.15	0.42	5903
2010	0.36	0.08	0.16	0.40	5917
2011	0.37	0.08	0.15	0.41	5330
2012	0.35	0.07	0.14	0.44	4737
2013	0.33	0.08	0.14	0.45	4320
2014	0.31	0.08	0.14	0.47	4050
2015	0.24	0.08	0.14	0.54	3087
2016	0.20	0.07	0.14	0.58	2477

3 Descriptive Statistics

3.1 Self-Selection

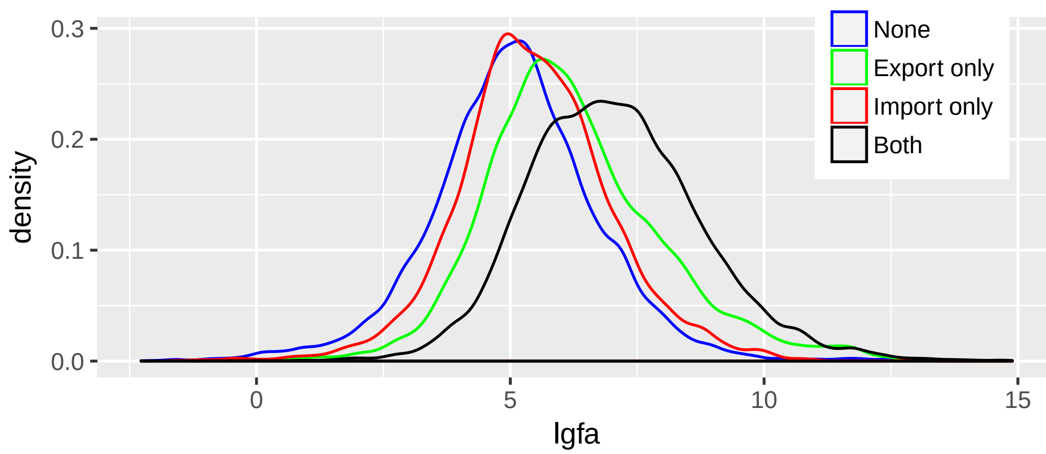
As a first step to see if more productive firms self-select into participating in the trade market, I calculated the mean and standard deviation and created the density plots for log of sales, gross fixed assets, salaries and expenditure on power and fuel. Tables 4-6 and 10-12 display the results for the variables mentioned above. It can be seen that firms that participate in the trade market have higher mean for all the variables mentioned above. It is also seen that firms that participate in the both export/import market have higher mean of sales,gross fixed assets, salaries, expenditure on power and fuel than firms that participate in only export and only import. On the other hand, the standard deviation in all the cases is very similar.

Table 4 Summary statistics of Sales (log)



Status	mean	sd
None	5.51	1.9
Import only	6.82	1.71
Export Only	6.17	1.66
Both	7.72	1.68

Table 5 Summary statistics of Gross Fixed Assets (log)



Status	mean	sd
None	5.09	1.66
Import only	6.23	1.77
Export Only	5.48	1.52
Both	7.04	1.72

Table 6 Summary statistics of Export (log)

Status	mean	sd
None	0	0
Import only	0	0
Export Only	3.51	2.29
Both	5.19	2.39

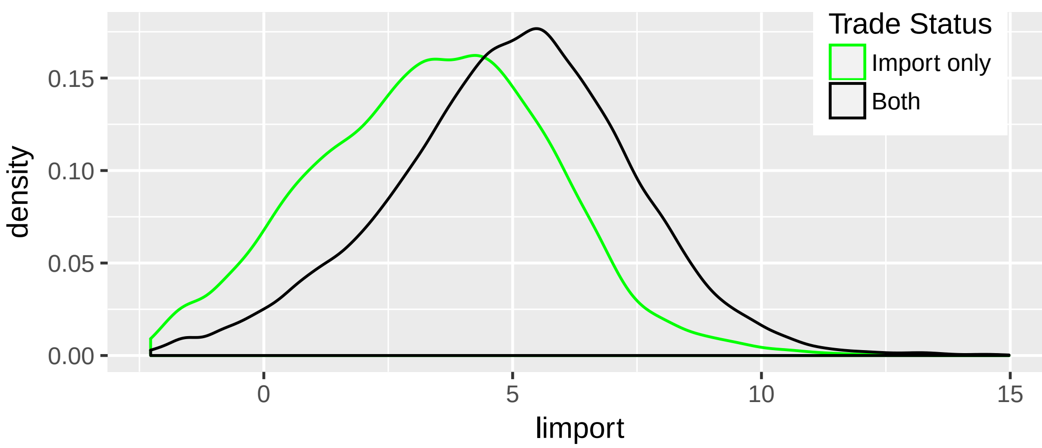
3.2 Complementarity between Exporting and Importing

Table 9 displays the export value for firms that participate only in the export market and for firms that participate in both export/import market. It is seen in Table 9 that firms that participate in both the export/import market have a higher exports than firms that only participate in the export market. This suggests that importing has a positive effect on exporting.

Table 10 displays the import value for firms that participate only in the import market and for firms that participate in both export/import market. It is seen in Table 10 that firms that participate in both the export/import market have a higher imports than firms that only participate in the import market. This suggests that exporting has a positive effect on importing.

Table 6 and Table 7 suggest that both these activities have a positive effect on the other and This might be because importing complements exporting and vice-versa. Therefore, there is correlation between these activities that needs further research.

Table 7 Summary statistics of Import (log)



Status	mean	sd
None	0	0
Import only	3.41	2.37
Export Only	0	0
Both	4.95	2.44

3.3 Productivity and Export/Import

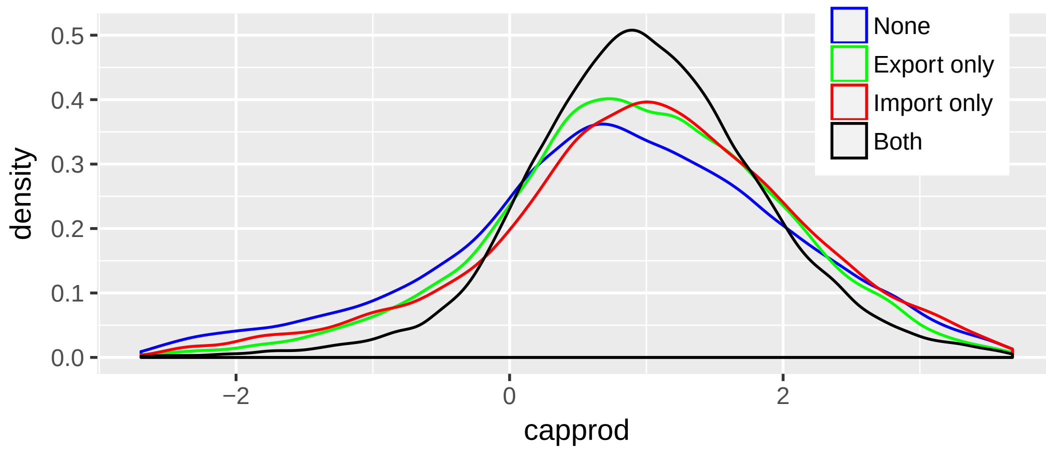
Gupta, Patnaik, and Shah 2018 define a rough measure of productivity known as *capital productivity*. It is defined as the log of value added per unit of capital used by a firm:

$$log(VA_{it} - log(K_{it}))$$

where VA_{it} is firm-level value added, computed as total industrial sales plus change in stock minus power and fuel expenditures, and raw material expenses. Table * displays the summary statistics for this variable based on the trade activity status. It can be seen that mean of capital productivity increases as activity status moves from *None* to *Export only/Import only* to *Both*, whereas the standard deviation also decreases.

Table 12 displays the summary statistics of Profit to Sales based on a firms trade market status. Profit to sales is calculated by dividing the profit after tax with sales. This measure can be interpreted as a profitability measure. It is seen in table 12 that participating in the trade market increases the profit to sales ratio. Firms that do not participate in the trade market have a very high standard deviation of

Table 8 Summary statistics of Capital Productivity (log)



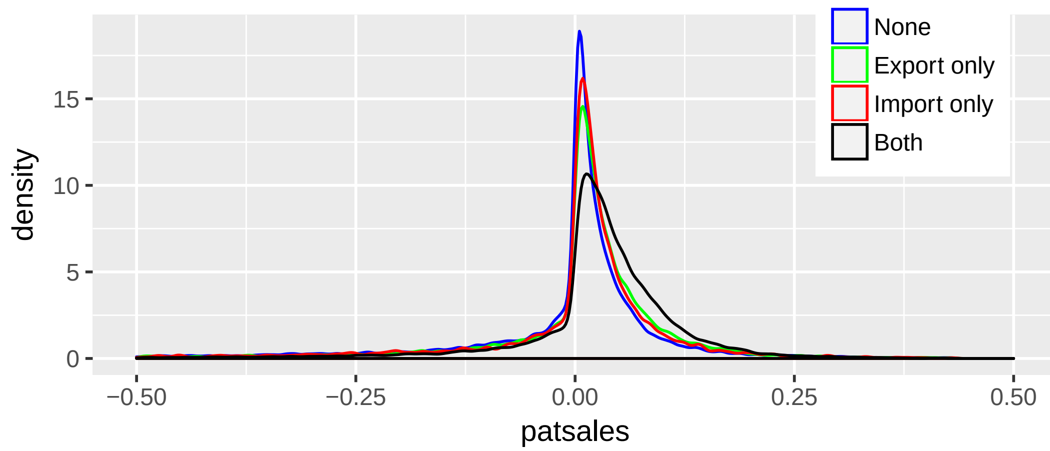
Status	mean	sd
None	0.8	1.2
Import only	0.92	1.03
Export Only	0.98	1.11
Both	0.98	0.86

profit to sales. It is also interesting to see that mean profit to sales ratio in every case is negative.

3.4 Transition Probability

Table 8 displays the transition probabilities observed in the data. It can be seen that there are very high levels of persistence from *None* in t-1 to *None* in t and from *Both* in t-1 to *Both* in t. This means that there must be high fixed costs to enter in the export/import market since only 12% of the firms that do not participate in the trade market in t-1 start participating in the trade market in t. The high levels of persistence in *Both* must mean that this mechanism benefits the firms in a lot of ways. The levels of persistence in *Import Only* and *Export Only* is not as high. A large portion of firms switch to participating in both the trade market activities.This can mean that participating in the export in time period in t-1 complements participating in the export market in period t and vice-versa. Also, the number of firms that flip-flop (i.e switch trade market status) is low, this can mean that there are fixed costs to participating in the stock market as well.

Table 9 Summary statistics of Profit to Sales



Status	mean	sd
None	-0.11	0.46
Import only	-0.04	0.31
Export Only	-0.07	0.38
Both	0	0.22

Table 10 Transition probability

T-1/ T	None	Import Only	Export Only	Both
None	0.874	0.07	0.034	0.023
Import Only	0.131	0.729	0.011	0.129
Export Only	0.136	0.024	0.661	0.179
Both	0.016	0.037	0.034	0.914

4 Preliminary Analysis

Before modelling this behavior, I try to check if the phenemenon mentioned above are seen in the data.

I divide this into three parts and check whether:

- Learning-by-doing: How does lagged choice of export/import impact productivity?
- Self-Selection: Selection of more productive firms into exporting/importing
- Complementarity between exporting and importing: Does engaging in one activity complements participation in the other?

4.1 Learning-by-doing

I use Levinsohn and Petrin 2003 to estimate productivity using a Cobb-Douglus production function:

$$y_{it} = \beta_o + \beta_l l_{it} + \beta_k K_{it} + \omega_{it}(m_{it}, k_{it}) + \eta_{it} \tag{1}$$

I use the variable gross fixed assets as a measure of capital, salary as a measure of labor and a expenditure on raw materials as a measure of intermediated input. The estimation procedure has been described below (see here 7.2.1). Since Levinsohn and Petrin 2003 assume a markovian nature of productivity evolution, where the productivity evolution is assumed to follow the procedure below:

$$\omega_{it} = \alpha_o + \alpha_1\omega_{it-1} + \alpha_2\omega_{it-1} + \alpha_3\omega^2_{it-1} + \alpha_4 d^X_{it-1} + \alpha_5 d^M_{it-1} + \alpha_6 d^X_{it-1} d^M_{it-1} + \nu_{it}$$

where d^X_{it-1} and d^M_{it-1} is the discrete decision to export and import respectively. I use the method highlighted in De Loecker 2013 to accommodate endogenous productivity evolution which allows past export experience to impact the evolution of capital. The estimates of the productivity evolution are shown in Table 11 (7.2.1). The Cobb-Douglus coefficients are shown in Table 13.

Table 11 Cobb-Douglus coefficients

	Value	Bootstrap Standard Errors
$ \beta_{l}$	0.296	0.006
$ \beta_{k}$	0.458	0.018

Table 18 and 19 (7.2.1) display the Cobb-Douglus coefficients when the productivity is dependent on the continuous value of export and import and they show

Table 12 Productivity Evolution

	Dependent variable:
	ω_{it}
$alpha_1$	0.707^{***}
	(0.005)
$alpha_2$	0.081^{***}
	(0.002)
$alpha_3$	-0.008^{***}
	(0.0002)
$alpha_4$	0.0004
	(0.007)
$alpha_5$	0.037^{***}
	(0.005)
$alpha_6$	-0.003
	(0.008)
$alpha_0$	0.320^{***}
	(0.007)
Observations	67,593
Note:	*p<0.1; **p<0.05; ***p<0.01

results similar to the ones shown in tables 12 and 13. It is seen that productivity evolutions depends non linearly on past productivity. The interesting result is that lagged exporting does not a have a significant effect on productivity. However, it is seen that importing does have a significant effect on productivity i.e the decision to import causes the productivity to increase by 3 per cent. The interaction term between exporting and importing also does not have a significant effect on productivity. Based on these results, I conclude that manufacturing firms experience learning-by-importing and do not experience learning-by-exporting.

In the next section, I check whether more productive self-select into exporting/importing

4.2 Self-Selection

I use the following equations to verify that more productive firms self-select into participating in the export/import market:

$$log(T\hat{F}P)_{t-j} = \gamma_1 log(export)_{it} + \gamma_2 log(import)_{it} + \beta c_{i,t-j} \tag{2}$$

$$log(T\hat{F}P)_{t-j} = \gamma_1 d_{it}^X + \gamma_2 d_{it}^M + \gamma_3 d_{it}^X d_{it}^M + \beta c_{i,t-j} \tag{3}$$

where $c_{i,t-j}$ contains log of capital and labour. I estimate the equation mentioned above for three time periods $j = 1, 2\&3$ and for the discrete decision as well as the value of exports/imports. The coefficients are estimated using fixed-effects regression. Table 11 and Table 12 display γ estimates for equation 2 and 3 respectively

In the discrete case, productivity of firms which export in year t is 12.5 %, 7% and 4.2 % higher than non-exporting firms in in year t-1,t-2 and t-3 respectively. And the productivity of firms which import in year t is 13.8 %, 8% and 4.9 % higher than non-nonimporting firms in in year t-1,t-2 and t-3 respectively. The interaction variables are not significant in all the three cases. This suggests that for firms to participate in both the markets, their lagged productivity needs to be higher than firm who participate in either the export or the export market. Another interesting feature is that firms that only import in year t have higher lagged productivity than firms that only export in year t.

Tables 11 and 12 provide evidence that lagged productivity at for all the three time periods before is higher when the firm participates in the export market in year t. This gives evidence of self-selection of firms into exporting and importing as the lagged productivity for three consecutive time periods before exporting/importing has a significantly positive value.

Table 13 Effect of Discrete Decision on Lagged Productivity

	Dependent variable:		
	t-1	t-2	t-3
	(1)	(2)	(3)
d_{it}^X	0.125***	0.070***	0.042***
	(0.011)	(0.012)	(0.013)
d_{it}^M	0.138***	0.080***	0.049***
	(0.009)	(0.010)	(0.011)
$d_{it}^X * d_{it}^M$	−0.020	0.015	0.026*
	(0.013)	(0.014)	(0.015)
Observations	59,634	46,246	36,293
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 14 Effect of Traded Value on Lagged Productivity

	Dependent variable:		
	t-1	t-2	t-3
	(1)	(2)	(3)
$log(Export)_{it}$	0.048***	0.035***	0.026***
	(0.002)	(0.002)	(0.003)
$log(import)_{it}$	0.081***	0.056***	0.038***
	(0.002)	(0.002)	(0.003)
Observations	27,544	22,547	18,523
Note:	*p<0.1; **p<0.05; ***p<0.01		

4.3 Complimentarity between exporting and importing

In this section, I try to check if the probability of participating in one activity in year t increases the odds of participating in the other. This will provide evidence that participating in one activity complements participating in the other activity.

This can be done by estimating the following dynamic discrete choice models:

$$d_{it}^X = \gamma_1^X d_{it-1}^X + \gamma_2^X d_{it-1}^M + \gamma_3^X \hat{\omega}_{it-1} + \beta_1^X K_{it-1} + IndustrialDummy_i^X + TimeDummy_t^X + \epsilon_{it}^X \tag{4}$$

$$d_{it}^M = \gamma_1^M d_{it-1}^M + \gamma_2^M d_{it-1}^X + \gamma_3^M \hat{\omega}_{it-1} + \beta_1^M K_{it-1} + IndustrialDummy_i^M + TimeDummy_t^M + \epsilon_{it}^M \tag{5}$$

Here γ_1 identifies the sunk costs, γ_2 accounts for the fact that participating in one activity in time t-1 improves the odds of participating in the other at time t,γ_3 accounts for the self-selection mechanism, β_1 accounts for capital at time t-1 and $IndustrialDummy_i^M$ $TimeDummy_t^M$ are industrial and time dummies respectively. The above equations can be estimated by dynamic probit model. But we need to account for initial conditions. This can be dealt in a number of ways. Since I want to check the contemporaneous relationship between exporting and importing at time t, there needs to be a provision to allow for the correlation of the errors and therefore I need estimate a Bivariate dynamic probit model.

5 Model

I use a model inspired from Aw, Mark J. Roberts, and Xu 2011, De Loecker 2011 and Kasahara and Lapham 2013.

5.1 Static Decision

A firm i has a standard Cobb-Douglas Production Function

$$Q_{it} = k_{it}^{\alpha_k} L_{it}^{\alpha_l} M_{it}^{\alpha_m} exp(\omega_{it} + u_{it}) \tag{6}$$

where

- K_{it} is the unit of output
- L_{it} is the unit labour
- M_{it} is the domestic and imported unit of materials
- ω_{it} is the productivity shock

- u_{it} is the measurement error

A firm faces a constant elasticity of demand (CES) function assumed to be of the Dixit-Stiglitz form :

$$Q_{it}^D = Q_{dt}(\frac{P_{it}}{P_{dt}})^{\eta_d} \tag{7}$$

where Q_{idt}^d is the industry aggregate output, P_{dt}^d is the price index and P_{it}^d is the firm i's price.

The demand function in the export market has a similar structure except that it also depends on an industry-specific demand shifter:

$$Q_{it}^X = Q_{Xt}(\frac{P_{it}^X}{P_{dt}^X})^{\eta_X} exp(z_{it}) \tag{8}$$

where z_{it} is the unobserved firm specific demand shock.

Equation 2 can be used to obtain an expression for P_{it} and a firms domestic revenue is $R_{it} = P_{it}Q_{it}$, and inserting price into the revenue function and taking a log to get the revenue function in the domestic market:

$$\tilde{r_{it}} = \beta_l l_{it} + \beta_m M_{it} + \beta_K K_{it} + \beta_d Q_{dt} + \omega_{it}^* + u_{it} \tag{9}$$

The revenue function for the export market can be similarly derived to get:

$$\tilde{r_{it}} = \beta_l l_{it} + \beta_m M_{it} + \beta_K K_{it} + \beta_X Q_{Xt} + \omega_{it}^* + u_{it} + z_{it}^* \tag{10}$$

where $\beta_h = \frac{\eta_d+1}{\eta_d}\alpha_h$, $\beta_{s.m} = \frac{1}{\eta_d}$, $\omega_{it}^* = \omega_{it}^* \frac{\eta_d+1}{\eta_d}$ and $z_{it}^* = z_{it}eta_d^{-1}$

Das, Mark J Roberts, and Tybout 2007 display a relation between profits and revenue. I use this estimate the constant demand of elasticity in both the domestic and export market. In the domestic market, the profits are:

$$\pi_{it}^d = \frac{1}{\eta_d} r_{it}^d (K_{it}, \omega_{it}) \tag{11}$$

In the export market, the profits are:

$$\pi_{it}^X = \frac{1}{\eta_X} r_{it}^X (K_{it}, \omega_{it}) \tag{12}$$

5.2 Transition of Productivity

The firm-level productivity is allowed to the be endogenously affected by the firms decision to export and import. Therefore, the law of motion of productivity is:

$$\omega_{it} = g(\omega_{it-1}, d^X_{it-1}, d^M_{it-1}) + \nu_{it} \tag{13}$$

$$\omega_{it} = \alpha_o + \alpha_1\omega_{it-1} + \alpha_2\omega_{it-1} + \alpha_3\omega^2_{it-1} + \alpha_4 d^X_{it-1} + \alpha_5 d^M_{it-1} + \alpha_6 d^X_{it-1} d^M_{it-1}\nu_{it} \tag{14}$$

where d^X_{it-1} is an indicator function of the firms lagged export participation, d^M_{it-1} is an indicator function of the firms lagged import participation and ν_{it} is an iid shock to the productivity. The lagged export and import indicator variables allow for learning-by-exporting and productivity benefits from importing.

The model assumes that productivity is only affected by the intensity of export/importing but is only dependent on the decision.

The firm-specific demand shock is modelled as an AR(1) process.

5.3 Dynamic Model

Firm must pay a fixed/sunk costs of trading. Let $d^X_{i,t}$ be the indicator function of participation in the export market and $d^M_{i,t}$ be the indicator function of participation in the import market. Then the total costs paid by firm i in period t is given by:

$F(d_{it}, d_{it-1}) =$

1. $f^x + c^X(1 - d^X_{it-1})$ for $(d^X_{it}, d^M_{it}) = (1, 0)$
2. $f^x + c^M(1 - d^M_{it-1})$ for $(d^X_{it}, d^M_{it}) = (0, 1)$
3. $\lambda[f^x + f^M + c^X(1 - d^X_{it-1}) + c^M(1 - d^M_{it-1})]$ for $(d^X_{it}, d^M_{it}) = (1, 1)$
4. 0 for $(d^X_{it}, d^M_{it}) = (0, 0)$

Here f^X is the fixed cost of exporting,C^X is the sunk cost of exporting, f^M is the fixed cost of importing, f^M is the fixed cost of importing and λ captures the degrees of complementarity between exporting and importing.

$$S_{it} = (\omega_{it}, K_{it}, d^X_{it-1}, d^M_{it-1})$$

$$V_{it}(S_{it}) = max_d(\pi^d_{it} + d_{it}\pi^X_{it} + F(d_{it}, d_{it-1}) + \beta E(V_{it}(s_{it+1}|s_{it}))) \tag{15}$$

6 Estimation

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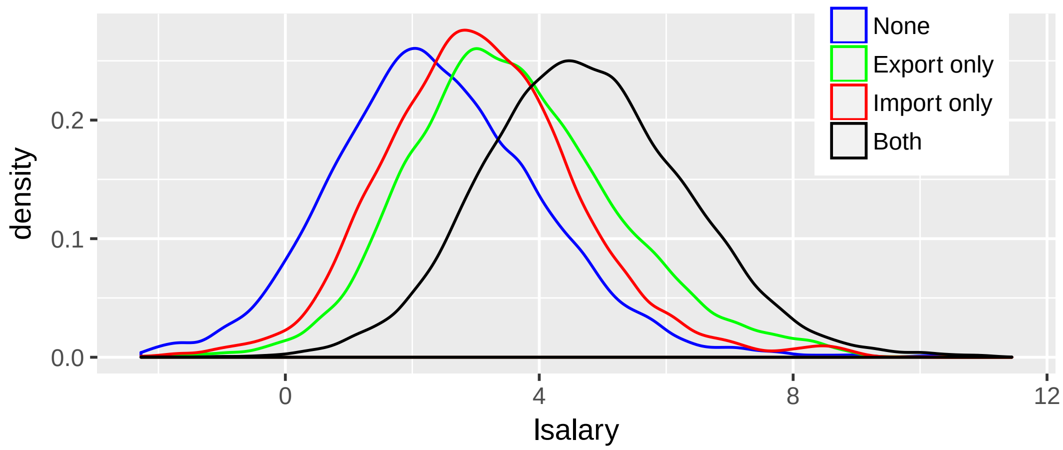
Table 15 Summary statistics of Salary (log)



Status	mean	sd
None	2.4	1.66
Import only	3.6	1.65
Export Only	3.1	1.56
Both	4.73	1.63

7 Appendix

7.1 Descriptive Statistics

7.2 Productivity Estimation

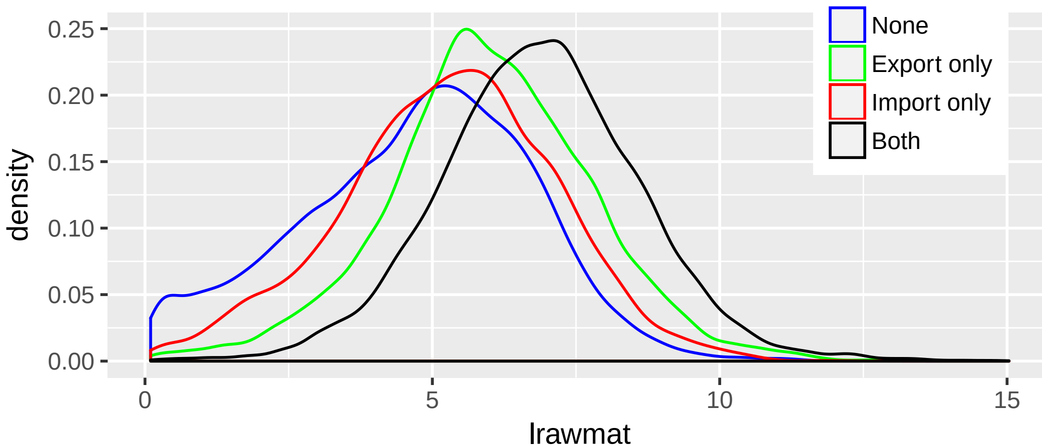
7.2.1 Levinsohn-Petrin Productivity Estimation

Levinsohn and Petrin 2003 suggest a strategy to estimate productivity and it goes as follows:

Let the production function be:

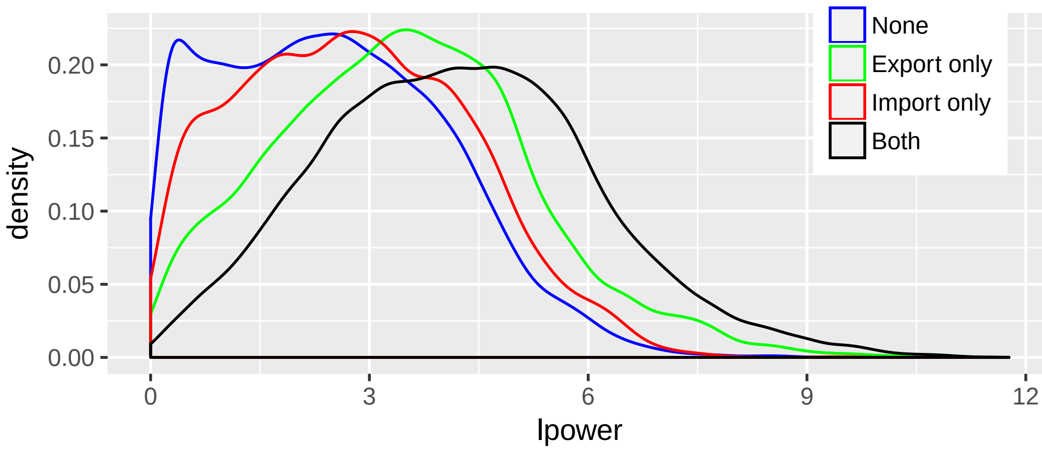
$$y_{it} = \beta_o + \beta_l l_{it} + \beta_k K_{it} + \omega_{it} + \eta_{it} \tag{16}$$

Table 16 Summary statistics of Expenditure on raw material (log)



Status	mean	sd
None	4.72	2.02
Import only	5.99	1.81
Export Only	5.28	1.87
Both	6.86	1.76

Table 17 Summary statistics of expenditure on power and fuel (log)



Status	mean	sd
None	2.51	1.56
Import only	3.48	1.75
Export Only	2.8	1.56
Both	4.23	1.88

where l_{it} is labour, K_{it} is capital, m_{it} is the demand for materials, ω_{it} is firm-level-productivity observable to the firm and η_{it} is an iid shock.

Here, the intermediated material demand function is given by:

$$m_{it} = m_{it}(\omega_{it}, k_{it})$$

This function is assumed to be montonically increasing and therefore productivity can be found by inverting the function above. Therefore, we can write the equation above as:

$$y_{it} = \beta_l l_{it} + \phi_{it}(m_{it}, K_{it})$$

where $\phi_{it}(m_{it}, K_{it}) = \beta_o + \beta_k K_{it} + \omega_{it}(m_{it}, K_{it})$

They suggest to use a third degree polynomial approximation of ϕ_{it} and substitute it into the equation above to give the following result:

$$y_{it} = \beta_o + \beta_l l_{it} + \sum_{i=0}^{3}\sum_{j=0}^{3-i} \delta_{ij} k_{it}^i m_{it}^j$$

The coefficient is β_l is estimtated by OLS using the equation above and $\hat{\phi_{it}}$ is estimtated by subtracting labor from the fitted value of the above equation:

$$\hat{\phi_{it}} = \hat{y_{it}} - \hat{\beta_l} l_{it} = \hat{\beta_o} + \sum_{i=0}^{3}\sum_{j=0}^{3-i} \hat{\delta_{ij}} k_{it}^i m_{it}^j$$

Therefore,

So, for any value of β_k^*:

$$\hat{\omega_{it}} = \hat{\phi_{it}} - \beta_k^* k_{it}$$

$$y_{it}^* = y_{it} - \beta_l l_{it} = \beta_o + \beta_k K_{it} + \omega_{it}(m_{it}, K_{it})$$

It is also assumed that ω_{it} follows a first order markov process :

$$\omega_{it} = E[\omega_{it}|\omega_{it-1}] + \epsilon_{it}$$

They assume a polynomial expansion of the expectation above to give:

$$\omega_{it} = \gamma_o + \gamma_1 \omega_{it-1} + \gamma_2 \omega_{it-1}^2 + \gamma_3 \omega_{it-1}^3 + \epsilon_{it}$$

Therefore, the value of β_l, for which the expression below is minimized is chosen to be the coefficient.

$$\max_{\beta_k^*} \sum (y_{it} - \beta_l \hat{l}_{it} - \beta_k^* K_{it} - E[\omega_{it} \hat{|} \omega_{it-1}])^2 \tag{17}$$

Table 18 Cobb-Douglus coefficients

	Value	Bootstrap Standard Errors
$ \beta_{l}$	0.300	0.005
$ \beta_{k}$	0.435	0.022

Table 19 Productivity Evolution

	Dependent variable:
	ω_{it}
$alpha_1$	0.688***
	(0.005)
$alpha_2$	0.085***
	(0.002)
$alpha_3$	−0.008***
	(0.0002)
$alpha_4$	0.001
	(0.007)
$alpha_5$	0.038***
	(0.005)
$alpha_6$	−0.003
	(0.008)
$alpha_0$	0.352***
	(0.007)
Observations	67,593
Note:	*p<0.1; **p<0.05; ***p<0.01

7.2.2 Ackerberg Productivity Estimation

7.3 Dynamic Random Effects Probit Model

Let i be the unit and t be the time. A dynamic random effects probit is written as:

$$y_{it}^* = \gamma y_{i,t-1} + x_{it}'\beta + \alpha_i + \epsilon_{it}; y_{it} = 1[y_{it}^* > 0]$$

where γ is the state dependence parameter.

There are three ways to estimate the above equation:

1. Treat y_{i1} as exogenously given and do not explain it
2. Heckman Method
3. Wooldridge Method