Essays on Firm Dynamics and International Trade

Ali Saadatnia

Ph.D. Thesis in Economics

Supervisor: **Omar Licandro**

International Doctorate in Economic Analysis
Departament d'Economia i d'Historia Economica
Universitat Autonoma de Barcelona

Barcelona, September 2015

Acknowledgements

When I moved from my small hometown to Esfahan (a big and pretty city in Iran) at the age of 15, I did not have any idea about the world. In our Literature classes, we had an autobiography of *Mohammad Bastani Parizi* whom has passed away last summer. He had an especial trip by plain from Iran to Greece, Italy, and finally France. Reading his autobiography, I dreamed to visit Europe as an especial adventure in future. Now, I am here at GREQAM, Marseille and there are a lot of people who helped me in my precious adventure. I may not mention all of them here but I share my feeling with them deeply in my heart.

First and the most, I would like to thank Omar Licandro, my supervisor, for constant and huge supports and patience. I could not have come up here without his way of looking in economic issues and considering all aspects and dimensions of a theme, I deeply thank him. I definitely thank help and support of Alessandra Bonfiglioli as my Master thesis supervisor. I may not be able to appreciate enough Daniel Miles, but I had great time visiting Vigo and receiving his precious comments and elucidations.

I deeply acknowledge financial support from the "Ministerio de Economa y Competitividad" FPI fellowship with reference:BES-2010-036646. I also appreciate the warm environment of the Finance and Macroeconomic Research Group at Banco Sabadell, in particular Josep M Vilarrubia. He always gives helpful advices and support, especially in presenting methodology. Pere Arque Castells help me going through data and facing econometrics problem, I appreciate his time and precious helps. I also appreciate great helps of Hannes Mueller for his help and valuable comments. I acknowledge Foundation SEPI for providing the dataset, especially Isabel Sanchez- Seco for her eternal helps with the data.

I also appreciate help of all my professors at IDEA, especially Jordi Caballe, Francesc Obiols-Holmes, Julien Prat, Nezih Guner, Ana Rute Cardoso, Hugo Rodriguez Mendizabal, Susanna Esteban and Caterina Calsamiglia. Angels Lopez Garcia and Merce Vicente always have been so helpful and supporting. I also thank huge support and help of GREQAM faculties and students at Aix- Marseille, especially Philipe Pier and Raouf Bousekine.

To my mother and father, especially Maedeh and the rest of my family, I thank all of them for all of supports and encouragements receiving from them when I really need it. I could not afford to go through all these steps without their warm pushes.

My friends at IDEA and Barcelona community always were helpful to me. I would like to thank my friends at UAB Arnau Valladares Esteban, Dimitrios Bermperoglou, Ezgi Kaya, Jan Grobovsel and Joan Demone. I especially thank Iranian community at Barcelona and Marseille: especially Omid Eskandari, Hamed Rabiei, Parastoo Nasr, Amin Ashtiani, Mohammad Hosein Rezazade Mehrizi, Zahra Nourian, Fakhra Aldin Zaveh and Hedyeh Faridi, Seyed Mohammad Reza Farahi, Majid Shabani, Omid Mordabadi, Mehdi Bagherzade, Mohammad Ghaderi, Mohammad Ali Saadeghi, and all other friends that have been helpful and encouraging all the time.

Contents

1 Technical Efficiency and Product Value in Measuring Firm Level Productivity **4**

1.1 **Introduction** 4

1.2 A Simple Model 6

1.3 Data and Estimations 8

1.3.1 Data 8

1.3.2 Technical Efficiency 10

1.3.3 Product Value 11

1.4 Firm Dynamics 12

1.4.1 Persistence 14

1.4.2 Firms' Exit and Entry 15

1.4.3 Growth, Technical Efficiency and Product Value 18

1.5 Conclusion 20

1.6 Appendix A 21

2 Technical Efficiency, Product Value, Innovation and Trade **23**

2.1 Introduction 23

2.2 Data 25

2.3 Empirical steps 27

2.3.1 Total Factor Productivity (TFP) 27

2.3.2 Product values 29

2.3.3 Exporters and Foreign-Owned Firms 31

2.3.4 The impact of trade on productivity 32

2.3.5 R&D, Innovation and Productivity 34

2.4 Conclusion 37

2.5 Appendix A 38

3 Foreign-owned firms, Technological choice, and Trade Openness: Evidence from Spain **40**

3.1 **Introduction** 40

3.2 Theoretical Framework . . . 42
3.2.1 Demand . . . 43
3.2.2 Production . . . 44
3.2.3 Equilibrium . . . 44
3.2.4 Effect of opening to trade on a firm's decision . . . 48
3.3 Data Description . . . 49
3.3.1 Trade reduction costs . . . 49
3.3.2 Industry data . . . 50
3.4 Empirical Work . . . 51
3.5 Conclusion . . . 58
3.6 Appendix A Theoretical Calculations . . . 59
3.7 Appendix B Figures and Tables . . . 63
Bibliography **65**

List of Tables

1.1 Summary Statistics 9
1.2 Revenue, Output, Price and Productivity 11
1.3 Estimated Price Elasticities 13
1.4 Persistence 14
1.5 Productivity of Exiting and Entering Firms 16
1.6 Productivity Changes of Exiting and Entering Firms 16
1.7 Productivity by Age Groups 17
1.8 Productivity and Product Value on Firm's Exit 17
1.9 Effects of Productivity on Sales and Output 19
1.10 Lagged Effects of Productivity Shocks on Prices and Output 20
1.11 Estimated Price Elasticities by Industry 22

2.1 Summary Statistics 26
2.2 Quota reduction in EU textile market 27
2.3 Revenue, Output, Price and Productivity 29
2.4 Estimated Price Elasticities 30
2.5 Productivity/Product Value of Exporters and Foreign-Owned Firm 31
2.6 Export Probit Estimations on TFP and Product Value 32
2.7 Foreign-owned Probit Estimations on TFP and Product Value 33
2.8 The effect of quota reduction on TFP and product value 34
2.9 R&D and Productivity 35
2.10 Technical efficiency and Product value and Innovation activities 36
2.11 Productivity, R&D and Innovation 37
2.12 Innovation Estimations on TFP and Product Value 37
2.13 R&D Activities Summary Statistic 39

3.1 Total number of firms, Export and FDI shares 51
3.2 Change in FDI status to tariffs reduction (1995–2002) 55

3.3 Change in FDI status (high and low technology) and Tariffs reduction 1995–2002 55
3.4 Domestic non-exporters and Tariff changes 1995–2002 56
3.5 Change of FDI status and tariffs changes 1995-2002 57
3.6 Domestic non-exporters and Tariffs changes 1995-2002 57
3.7 Change os Domestic non-exporters status and Tariffs reduction, 1995-2002 64

List of Figures

3.1 A firm's decision to serve foreign markets with technology choices 45
3.2 Spanish weighted manufacturing tariffs 1990–2009 49
3.3 TFP density before and after reduction in the trade cost 52
3.4 Pareto distribution of estimated total factor productivity (1994) 53
3.5 Pareto distribution of estimated total factor productivity (2002) 53
3.6 Weighted average of Spain manufacturing Tariffs 63

Introduction

This thesis focuses on firm dynamics and international trade, and the link between them. During the last decade, extensive researches have been done on firm dynamics, especially on productivity, firms' growth and innovation. Here, it is deeply focused on productivity, innovation and trade. There are huge number of papers that have already reported productivity gains from international trade or role of productivity in firm's selection and growth.[1] They all try to answer the following well-known questions: "Does productivity determine firms' selection and growth?"; "Are there productivity gains from opening to trade?" Here, we may add some other questions: What is the effect of trade on high-tech and low-tech firms? Does investing in innovation activities have any effect on productivity? The point is that in the most of previous works, the effect of trade on productivity and demand has been mixed (due to lack of data on firm level prices). If using previous results misdirects firm dynamics or trade effect on firms' productivity, there may be few things that can be directed by a better measure of productivity and accessing to a rich data set (here Spanish manufacturing panel data, ESEE). Shortly, in this thesis, three main topics have been studied: a. Using firm level price information to measure product value (demand shocks) and physical productivity, and linking them to firms' performance and innovation behavior, b. Investigating the effect of trade on both physical productivity and product value, c. Verifying the effect of trade on foreign-owned firms, and the role of R&D expenses and undertaking a higher level of technology on the status of firms in the international market.

The first Chapter, *"Technical Efficiency and Product Value in Measuring Firm Level Productivity"*, addresses estimation of firm level productivity and the link between productivity and product value with firms performance by using information on firm level prices. In the firm dynamics literature, an average price index of industry is employed to deflate output and compute output quantity. Using this price index causes the mix of demand and productivity shocks, shown in Foster et al. (2008) and De Loecker (2011) among others. For solving this problem and disentangling demand and productivity shocks, it is necessary to access rich datasets in which output quantity can be achieved. Foster et al. (2008) use data

[1] See e.g. Tybout et al. (1996), Bernard et al. (1999, 2007a) and Helpman et al. (2005) among others.

on homogeneous products, for which prices can be meaningfully derived from the value of sales and physical production. They utilize output and quantity to determine each product prices and calculate physical TFP (Total Factor Productivity) by using the quantity (not revenue) as the regressor in production function. They use the physical productivity as instrumental variable to calculate demand disturbance in homogenous industries. They show that failing to disentangle demand and TFP shocks leads to an underestimation of new entrants' contribution to productivity growth.

In the first chapter, following Foster et al. (2008), a unique data set is employed to disentangle the role of productivity on manufacturing firms performance. Indeed, the dataset includes firm specific input and output price information, allowing to measure firm's output and inputs on well-defined real units. Consequently, the productivity of the firm is decomposed to technical component and product value component. We find that product value component is significantly as important as TFP shocks in firm performance and turnover, however the degree of response to output and prices is longer and larger for TFP shocks.

In the second chapter,*"Technical Efficiency, Product Value and Trade"*, Olley and Pakes (1996) method, for estimating the parameters of the production function, is extended to include other endogenous variables that impact on productivity like firms' R&D expenses. Estimation of the process for productivity evolution is important for investigating the firm's dynamic and the status of a firm in the market as domestic, exporter or foreign-owned firm. Firm level productivity is an important source of firm heterogeneity that is relevant in both domestic and export markets. In the last two decades, productivity has been used to identify the impact of trade on firm's growth within industries. There is a significant literature showing that liberalizing trade by either tariff or quota reductions increases TFP. These studies also show that international firms (exporters and foreign-owned firms) have higher productivity.[2] Our results show that both exporters and MNEs (multinational enterprises) have higher productivity and product values. The role of product value is, however, more important for accessing to foreign markets. Using Physical and Revenue TFPs to evaluate trade openness on firms' performance shows that previous literature exaggerates the role of trade in firms' productivity, and distorts its effect on demand side.

This chapter also investigates the effect of R&D expenditures on firm level productivity, and the link be- tween firm innovation activities and productivity are . To do so, this section tries to answer the following questions: Does investing in R&D activities lead to an increase in firm specific productivity? Do firms with higher technical efficiency and product value perform process and product innovations more frequently? Results show that those firms that invest in R&D activities have higher productivity comparing to other firms and firms

[2]Bernard et al. (1995, 1999 and 2007a using U.S. data), Clerides et al. (1998, for Colombia, Mexico, and Morocco).

with low technical efficiency or high product value are more likely to undertake product innovation, but firms that have high technical efficiency or high product value are more likely to perform process innovation. Interestingly, product innovation is mostly related to high firm specific product value, but low technical efficiency. However, process innovation is related to both firms product value and technical efficiency. This may reflect that firms that undertake product activities are not as productive as firms with no innovation activities. One reason can be that, they are producing new product and they can not be as productive as before while these new products have higher product value. In another side, process innovation reduces cost of production and increase product value in the market.

In the last chapter of thesis, *"Foreign-owned firms, Technological choice and Trade Openness"*, a two-country general equilibrium model is studied that jointly addresses the decision of heterogeneous firms to serve foreign market either through export or foreign direct investment (FDI) and their technological choices. In equilibrium, only the more productive firms (Exporters and FDIs) choose to serve in foreign markets and the most productive firms will further choose to upgrade their technology. In addition, as trade liberalization takes place, the cut off productivity of exporters increases and the cut off productivity of foreign-owned firms decreases. Finally, foreign-owned firms with low level technology leave the market more than those adopting high technology. Spanish manufacturing data set (ESEE) is employed to verify the effect of openness on firm level productivity. Results show that tariffs reduction, in average, decreases low-tech FDIs by 4% to 6% but there is not any significant effect on high-tech foreign-owned firms from 1990 to 2009. This may point out that firms that invest on R&D activities survive more than those with no R&D activities after trade openness.

Chapter 1

Technical Efficiency and Product Value in Measuring Firm Level Productivity

1.1 Introduction

In the firm dynamics literature, firms are heterogeneous in productivity. Firms that are less productive exit from the market and high-enough productive firms (have zero or positive profits) enter to the market. Moreover, firms' growth (in sales, productions or revenues) are also linked to their level of productivity. Productivity in empirical works is usually defined as the ratio of output to input in physical units. However, physical output and input are not reported in firm data sets. In the firm dynamics literature, industry price-indexes are employed to deflate output and to compute output physical units. Using industry price-index causes mix of productivity and product values (demand shocks) shown in Foster et al. (2008) and De Loecker (2011) among others. For solving this problem and disentangling productivity and product value, it is necessary to access rich datasets in which output quantity (and input) can be achieved by observing firm level prices.

Foster et al. (2008) employ data on homogeneous products, for which quantities can be meaningfully defined, to derive a price index from the value of sales and physical production. They use output and quantity of products to determine product prices and calculate physical TFP (Total Factor Productivity) by utilizing quantity as the regressor in production function and not revenue. For calculating demand disturbance in homogenous industries, they use the physical TFP as instrumental variable. They show that failing to disentangle demand and TFP shocks leads to an underestimation of new entrants' contribution to productivity growth.

De Loecker (2011) exploits theoretical restrictions to isolate physical productivity from confounding demand factors in estimating the effects of trade barriers on productivity for Belgian textile firms. We develop this literature by using a unique dataset, which contains input and output price indices for each firm in twenty different industries.

Our study is one of recent contributions that takes the advantage of opportunities to observe firm level price informations (De Loecker, Goldberg, Khandelwal and Pavcnik (2012); Fan, Roberts, Xu and Zhang (2012)). De Loecker et al. (2012) use Indian firms prices and physical quantity informations to separate mark ups from productivity and examine trade openness on these performance indexes. They find that after trade openness marginal costs decrease more than prices. Fan et al. (2012) use manufacturing Chinese data and conclude that firms product value, prices and cost components are very useful to explain extensive and intensive margin of trade like number of destination and the time and volume for export to a destination. In our dataset, as firm level price information is available, this approach allows us to consider industries characterized by firms differentiation. First, information on firms prices is used to define each firm output quantity from revenue in all twenty industries which are not necessarily homogeneous. Firm level physical productivity (technical efficiency) is computed by accessing to output (and input) quantities. For comparability reasons, and following Foster et al. (2008), we also create a revenue-based measure of TFP. For every year and every industry, we create an average industry price index and use it to deflate firm specific nominal revenues. Revenues (real) are used to estimate production function, and then revenue productivity was measured. Second, calculated physical productivity is used as instrumental variable to estimate demand residuals (product values). Interestingly, correlation of firm level prices and physical productivity is negative as described by theoretical models while its correlation with revenue productivity is positive. Furthermore, autoregressive estimation of our main variables of interest (productivity, product value and prices) show that revenue productivity and prices have substantial persistent in the data. Technical efficiency and product value show higher persistent which it may emphasize the role of product value and technical efficiency in firm's performance.

Estimated technical efficiency and product value are used to investigate their effects on firm's growth and survivals, and their link to firms innovation activities. Estimations reveal significant effect of both product value and technical efficiency on firms' performance, growth and turnover. As a result, exiting firms have negative growth in their price, productivity and product value (before exiting from the market) comparing to incumbents while entering firms have positive growth in all variables of interest (productivity, price and product value). Firms with lower prices, productivity and product value are more likely to exit from the market. While product value is important and significant factor for survival, the dominant factor is firm level physical productivity when both used simultaneously in the estimation. Subsequently, the effect of both product value and technical efficiency on firms' growth is investigated. Both of them have huge and significant effect on prices, production and revenue while the effect of product value on firms growth (change of sales, prices and production) is more important and higher than the effect of technical efficiency.

The rest of this chapter proceeds as follows. Section 2 presents a standard model of monopolistic competitive equilibrium characterized by supply and demand residuals. Data set, the estimation approach and details of firm specific productivity and product value are introduced in Section 3. Section 4 discusses about the effects of product value and technical efficiency on firms' growth and turnover.Finally, there is a conclusion section.

1.2 A Simple Model

The model in this section illustrates the type of problems faced when measuring productivity at the firm level. It will help to define the main concepts used in this dissertation, which are needed to measure and analyze firm's productivity using the ESEE.

Let us assume there is a continuum of final firms producing an industry good j by the mean of a CES technology[1]

$$Q_j = \left(\int_0^1 (e^{\tilde{\eta}_{ij}}\, Q_{ij})^{\rho_j} di \right)^{\frac{1}{\rho_j}}, \tag{1.1}$$

where the Q_{ij}'s are physical units of the intermediary inputs i, for $i \in (0,1)$, used to produce Q_j physical units of the industry good j. Parameter $\tilde{\eta}_{ij}$ measures the quality of input i or, equivalently, the efficiency of final firms j in using it. The elasticity of substitution between an arbitrary pair of intermediary inputs is given by $\sigma_j \equiv \frac{1}{1-\rho_j}$, under the restriction that $\rho_j \in (0,1)$. For simplicity, let us assume that intermediary inputs are industry specific and that firms produce only one input.

Final firms maximize profits taking input and output prices as given. Let us denote by p_j and p_{ij} to the (log of the) price of industry j and input i, respectively. Consequently, the demand for input i (in logs) is given by

$$q_{ij} - q_j = -\sigma_j\,(p_{ij} - p_j) + \eta_{ij}, \tag{1.2}$$

where $\eta_{ij} = (\sigma_j - 1)/\sigma_j\,\tilde{\eta}_{ij}$. From the point of view of the intermediary firm i, η_{ij} will be referred as *product value*. Lowercase variables in (1.2) are the log of the corresponding capital letter variables above.

[1] A similar argument applies when interpreting it as Dixit-Stiglitz preferences.

Intermediary firms in industry j are assumed to produce in a monopolistically competitive environment. They use the following production technology

$$q_{ij} = \omega_{ij} + x_{ij}, \tag{1.3}$$

where x_{ij} is (the log of) a specific production factor used in the production of q_{ij}, measured in its own physical units, and ω_{ij} is the productivity (in logs) of this production factor measured in physical unit of good j per unit of the intermediary good i. From the point of view of the intermediary firm, ω_{ij} will be referred as *technical efficiency*. The optimal pricing rule of the monopolistic competitive firms is

$$p_{ij} = w_{ij} - \rho_j - \omega_{ij},$$

where w_{ij} is the (log of the) unit cost of the production factor ij. Notice that physical productivity ω_{ij} is negatively relate to the price p_{ij} set by the intermediary firm. More productive firms sell at lower prices.

What can we learn from this simple model about the fundamental issue of TFP measurement? When firm specific prices are observed, standard measures of total factor productivity will deliver technical efficiency. Let us refer to this measure, following Foster et al. (2008), as

$$tfpq_{ij} \equiv (p_{ij} + q_{ij}) - p_{ij} - x_{ij} = \omega_{ij}.$$

An estimation of the demand function (1.2), as in Foster et al. (2008) for example, will deliver an estimation of the product value η_{ij}. Notice that if quality adjusted prices were used, instead of unit values, real output would become $q_{ij} + \eta_{ij}$ and the corresponding TFP measure will be equal to $\phi_{ij} = \eta_{ij} + \omega_{ij}$. This is the way NIPA measures output; aggregate TFP is then someway close to an aggregate measure of the ϕ_{ij}'s. In fact, by substituting intermediary technologies (1.3) into the sector j production function (1.1), we see that intermediary specific inputs transform into output with productivity $\phi_{ij} = \eta_{ij} + \omega_{ij}$. In this simple framework, product value and technical efficiency add up in a single productivity measure.

However, firm specific prices are not observed in general and, as an alternative, industry prices are used to deflate firm's revenue. Let us use sectorial prices p_j to deflate firm's revenue and then, following Foster et al. (2008), define TFP revenue (TFPR) as

$$tfpr_{ij} = (p_{ij} + q_{ij}) - p_j - x_{ij} = \frac{q_j - x_{ij}}{\sigma_j} + \underbrace{\frac{\sigma_j - 1}{\sigma_j}\,\omega_{ij} + \frac{\eta_{ij}}{\sigma_j}}_{\equiv \mu_{ij}}.$$

The last equality results from substituting p_j using the demand function (1.2) and q_{ij} using technology (1.3). It can be seen that TFPR is correlated with the productivity measure μ_{ij}, which combines technical efficiency and product value.

Firm specific price indices are indeed available in the ESEE. Each of these price indices cumulates the annual average percentage change in firm specific unit prices.[2] Consequently, these firm specific prices do not correct for quality, which allows us to follow the previous strategy for measuring a firm specific productivity couple $\{\phi, \eta\}$. However, since they are indices, they don't have a price level. Of course, the ESEE does not allow us to identify physical units, which in any case will be unfeasible, since most firms in the ESEE are multi-product, and uninteresting, since rarely two different firms in the sample produce similar goods. By construction, price indices are normalized to one at some year, say the *base year*. In this sense, the firm specific couples $\{\phi, \eta\}$ are all measured in euro of the base year. This has the advantage of rendering comparable estimation of technical efficiencies – technical efficiency measured in physical units is only comparable for firms producing the same good. However, this comparison hides the fundamental problem that low productive firms charging a high price at the base year will look as being more productive when real units are measured at base year prices.

1.3 Data and Estimations

1.3.1 Data

The dataset in this paper comes from the longitudinal survey of Spanish manufacturing firms named *Encuesta sobre Estrategias Empresariales* (ESEE).[3] It has been compiled by Fundación SEPI and it is designed to be representative of the Spanish manufacturing sector. In the ESEE, firms with 10 to 200 workers are sampled randomly by industry and size groups (retaining 5%), while all firms with more than 200 workers are requested to participate –the collaboration rate is around 64%.

The sample is an unbalanced panel of 5,040 firms with a total number of 40,678 observations from 1990 to 2011. Firms belong to 20 different industries (see Table 1.1 for summary statistics of the data by industry).

The ESEE contains standard information on firms' inputs and output. More interesting, firms report price changes for their main products and inputs. Using this information, the ESEE creates an annual estimation of firm specific output and input price changes. We have chained these price changes to build firm specific input and output price indices,normalizing them to one at 1989 –which we will refer as our base year.[4] For firms that were not surveyed in 1990, we normalize their prices to the average of the corresponding industry at the year

[2]Firms in the ESEE are asked about price changes for the largest products representing at least 50% of total sales. Based on the answer to this question, the ESEE creates an annual firm specific price change.

[3]For more information, see http://www.fundacionsepi.es/esee/sp/spresentacion.asp

[4]Notice that this normalization strongly reduces the variance of firm specific prices, in particular in the first years of the sample.

Table 1.1: Summary Statistics

Industry	Observations	Size	Output
1. Meat products	1181	228	38
2. Food and tobacco	4039	240	50
3. Beverage	844	337	68
4. Textiles and clothing	3766	138	10
5. Leather, fur and footwear	1189	41	3
6. Timber	1231	88	10
7. Paper	1271	229	38
8. Printing	2004	150	17
9. Chemicals and pharmaceuticals	2763	320	90
10. Plastic and rubber products	2085	223	34
11. Nonmetal mineral products	2921	206	30
12. Basic metal products	1243	562	154
13. Fabricated metal products	4360	117	14
14. Machinery and equipment	2427	170	21
15. Computer, electronics and optical	1145	450	105
16. Electric materials and accessories	2205	301	48
17. Vehicles and accessories	1958	986	294
18. Other transport equipment	986	684	79
19. Furniture	2021	87	7
20. Other manufacturing	1039	116	12
Average	2043	253	50

Notes: Size is firms' average employment and output are firms average output in million euro at 1989.

before they enter the sample. Firms' missing values in price changes have been replaced by their industry average. The age of the firm has been calculated according to the number of years it has been active in the marketplace. Firms may exit the sample because of different forms of attrition. Indeed, the ESEE defines the following situations as an *exit*: A definitive closure, the case of firms that are in a liquidation process or have changed to a non-manufacturing activity, or have been took over by other firm in the sample or a less important firm merged with another firm(s) in the sample. At the same time, new firms have been incorporated into the panel in order to avoid reductions in sample size and, indeed, to assure representativeness across industries and size-segments. Moreover, the ESEE records the year in which the firm was created, which allows us to identify newly created firms among those joining the sample, at the time we record the age of the firm.

1.3.2 Technical Efficiency

Firm specific total factor productivity (TFP) has been estimated under the assumption that (the log of) production at the firm level can be represented by the mean of the following Cobb-Douglas technology:

$$q_{it} = \alpha k_{it} + \beta \ell_{it} + \gamma m_{it} + \omega_{it}, \tag{1.4}$$

where ω_{it} is total factor productivity of firm i at period t, k_{it}, ℓ_{it} and m_{it} are the log of physical capital (equipment and machinery), employment and materials, respectively.[5] Parameters in (1.4) are estimated following Olley and Pakes (1996). According to equation (1.4), TFP is then measured as

$$\hat{\omega}_{it} = q_{it} - \hat{\alpha} k_{it} - \hat{\beta} l_{it} - \hat{\gamma} m_{it}. \tag{1.5}$$

In order to estimate technical efficiency in (1.5), firms' output has been deflated using the firm specific price index mentioned in the previous section. In following, we will refer to it as *output*, the empirical counterpart of q_{ij} in the previous section. Productivity in (1.5) is then measured in real terms, being close to the so-called TFPQ measurement in Foster et al. (2008). Differently to them, TFPQ in this paper is not measured in physical units (tons of carbon black, for example) but in base year prices, and can be compared not only through time for the same firm but also across firms.[6] In this sense, the variability of TFPQ across firms reflects dispersion in real efficiency measured in 1989 euro.

For comparability reasons, and following Foster et al. (2008), we have also created a revenue-based (real) measure of TFP. For every year and industry, we have created an average industry price index, the average price index of all firms in the industry, and used it to deflate firm specific nominal revenues, that we refer as firms' *revenue*. Revenues were used in equation (1.4) to estimate production functions and, then, TFPR was measured using (1.5).

Remarkably, all these measures show a very similar pattern than those used by Foster et al. (2008), as can be observed by comparing Table 1.2 with Table 1 in Foster et al.

[5] As usual, firm's capital has been measured by the Permanent Inventory Method. Firm's investments in equipment and machinery were deflated using industry specific price indices produced by the Spanish Instituto Nacional de Estadística (INE). Depreciation rates also come from the INE. The book value of capital for year 1990 has been used to set the initial capital for firms that were in the sample at that time; for firms entering the sample after, it has been set as the book value of capital at the first observed year. Materials has been deflated using firm specific intermediate consumption prices. Finally, labor is measured in yearly hours.

[6] Of course, at the base year, this measurement strategy faces the problem mentioned above that more productive firms likely sell at lower prices. However, using physical units, as in Foster et al. (2008), reduces comparability to firms producing the same highly homogenous good. The distribution of physical productivity across firms producing different goods, measured then in different physical units, is meaningless. Real quantities measured in base year prices render comparability meaningful.

(2008). In Table 1.2, firm's revenue and output show a very high correlation, 0.996. This is because of the high dispersion in firm size, as evidenced by the standard deviations of both measures.

Table 1.2: Revenue, Output, Price and Productivity

	Revenue	Output	Price	TFPR	TFPQ
Revenue	1				
Output	0.996	1			
Price	-0.05	-0.12	1		
TFPR	0.19	0.17	0.28	1	
TFPQ	0.24	0.29	-0.47	0.70	1
S.D.	2.05	2.06	0.24	0.28	0.30

Notes: All variables are in logs.

TPF measures are also highly correlated and exhibit solid dispersion.[7] More interesting, measured TFPQ is negatively correlated with prices, 0.47 in absolute value.[8] The negative correlation between TFPQ and prices reflects the fact that more efficient firms face lower marginal costs and, in turn, charge lower prices, a common implication of models of imperfect competition as the simple model in Section 1.2. Moreover, as expected, measured TFPR is positively correlated with prices.

1.3.3 Product Value

To measure firm specific product values, a demand system has been estimated separately for each industry:

$$\tilde{q}_{it} = \beta_0 + \beta_1 \tilde{p}_{it} + \sum_t \beta_t year_t + \sum_{prov.} \beta_p loc_{it} + \sum \beta_m mark_{it} + \alpha_i + \eta_{it}, \qquad (1.6)$$

where $\tilde{q}_{it} = q_{it} - q_j$ subtracts to the (log of) real output of firm i the (log of) average real output of the industry j to which the firm belongs; $\tilde{p}_{it} = p_{it} - p_{jt}$ is an equivalent measure for prices; α_i is a firm fixed effect; finally, η_{it} is the firm-year specific product value. For simplicity, the notation omits that any firm i belongs to a particular industry j. However, parameter β_1 corresponds to $-\sigma$ in Section 1.2, and it is industry specific. The

[7] The standard deviations of revenue and output in Table 1.2 double those in Foster et al. (2008), likely due to the fact that the ESEE surveys 64% of firms larger than 200 workers but only 5% of smaller firms.

[8] It is important to notice that all price indices are normalized to unity at 1989. Consequently, they show small variability at the beginning of the sample period. Contemporaneous correlations between prices and TFPQ show that the correlation is -0.17 in 1990, then increasing to reach -0.55 in 1996 to remain turning around this number until 2011 (in facts, it fluctuates between -0.52 and -0.60).

dummy $year_t$ takes value equal to one if the observation corresponds to year t and zero otherwise. The dummy loc_{it} takes value equal to one if a firm is located in a particular Spanish province at year t and zero otherwise. Finally, the *market destination* dummies define the degree of geographical influence of the firm, since firms may mainly operate at the local, provincial, regional, national or international level.

Since producers may optimally respond to shocks in the product value η_{it} by changing prices, firm specific prices $\tilde{p}_{it}$ may be correlated with it. To avoid this problem in the estimation of equation (1.6), firm specific output prices were instrumented by firm specific input prices and firm technical efficiencies as measured by TFPQ.

Estimations were performed industry by industry; Table 1.3 shows the results of the estimations for the different industries. As it can be seen, all estimated price elasticities are negative, strongly significant, and exceed one in absolute value except for "Textiles and clothing." For the other industry, they range between 9.48 for "Other transport equipment" and 1.15 for "Electric materials and accessories".

Finally, firm specific product values has been calculated as the demand residuals

$$\hat{\eta}_{it} = \tilde{q}_{it} - \hat{\beta}_0 - \hat{\beta}_1 \tilde{p}_{it}. \tag{1.7}$$

It does include the time dummy as well as any specific effect associated to the location of the firm and the markets in which it operates.[9] As can be seen in the bottom of Table 1.3, the estimated product values are uncorrelated with TFPQ, which then appear quite suitable as instrument for firm final prices.

1.4 Firm Dynamics

This section uses our empirical estimations to study the role of technical efficiency and product value in firm dynamics. First, it examines the persistence of firm specific technical efficiencies, prices, and product values. Second, it explores the contribution of technical efficiency and product value to plant survival and productivity growth, as well as to entry and exit dynamics. Third, it studies the effect of technical efficiency and product value on firms' growth. Finally, the correlation of these productivity measures with firm's innovation behavior is investigated.

[9] For compatibility reason, we also use Tybout et al. (2007) to calculate product values using firms' total costs. Results are reported in Appendix A

Table 1.3: Estimated Price Elasticities

Industry	Coef.	Std. Err.
1. Meat products	-1.51	0.17
2. Food and tobacco	-2.08	0.10
3. Beverage	-6.46	0.90
4. Textiles and clothing	-.96	0.22
5. Leather, fur and footwear	-2.97	0.53
6. Timber	-4.44	0.72
7. Paper	-1.81	0.15
8. Printing	-1.71	0.17
9. Chemicals and pharmaceuticals	-2.53	0.12
10. Plastic and rubber products	-1.75	0.14
11. Nonmetal mineral products	-2.31	0.15
12. Basic metal products	-1.54	0.11
13. Fabricated metal products	-1.81	0.13
14. Machinery and equipment	-2.24	0.26
15. Computer, electronics and optical	-2.66	0.29
16. Electric materials and accessories	-1.15	0.17
17. Vehicles and accessories	-2.60	0.25
18. Other transport equipment	-9.48	1.55
19. Furniture	-2.34	0.32
20. Other manufacturing	-3.23	0.46

Product Value Correlation with TFPQ and TFPR

	TFPQ	TFPR	Rev. Output
η	0.07	0.19	0.8905

Notes: Estimated industry-by-industry by 2SLS IV using TFPQs as instruments for firm specific output prices. All regressions include year, province and market destination fixed effects.

1.4.1 Persistence

Foster et al. (2008), among others,[10] observe that conditional on survival, there is substantial persistence in firm specific productivity and prices. Spanish data confirm their results. For this purpose, we have estimated the following (one year) autoregressive regression

$$x_{it} = \beta\, x_{it-1} + \epsilon_{it},$$

where x_{it} corresponds to one of the following variables of interest: technical efficiency (TFPQ), price change, product value and TFPR. Industry and year fixed effects were also included in the estimation. Results are reported in Table 1.4. It is important to notice that prices in our dataset have an autocorrelation coefficient equal to one by construction. Remind that price indices chain firm specific price changes. For this reason, Table 1.4 gives information about the persistence of price changes instead of the persistence of prices.

Table 1.4: Persistence

Variable	One-year persistence rates
TFPQ	0.83
	(0.004)
Product Value	0.99
	(0.001)
Δ Price	0.16
	(0.00)
TFPR	0.76
	(0.003)

Notes: This table reports the results of regressing each variable on its own (one-year) past. Reported coefficients are those on the lagged variable. Standard errors are in parenthesis.

As it can be seen in Table 1.4, TFPQ, TFPR and product values are highly persistent, with one-year auto-correlation coefficients ranging between 0.76 for TFPR and 0.99 for product values. The fact that TFPQ is more persistent than TFPR, 0.83 compare to 0.76, comes at no surprise, since revenue productivity can be interpreted as the sum of physical productivity and prices, and these two are negatively correlated. Product values are more persistent compared to TFP measures, with an estimated autocorrelation coefficient of 0.99. Foster el al. (2008) also find that product values are more persistent than technical efficiencies, conjecturing that they have to be more important for market selection.

[10]See Roberts and Supina (1996), Baily, Hulten, and Campbell (1992); Roberts and Supina (1996); and Foster, Haltiwanger and C. J. Krizan (2006).

1.4.2 Firms' Exit and Entry

There is substantial entry and exit of firms in the ESEE. The pooled sample has an entry rate of 10.8% and an exit rate of 9.8%.[11] The exit rate ranges between 4.1% in the "Meat Products" industry and 16.1% in "Textiles and Clothing." For entry firms, the minimum rate is in the "Beverage" industry and the maximum rate is in the "Textiles and Clothing" industry, 4.0% and 13.4%, respectively.

This section studies the effect of technical efficiency and product value on firm turnover. For this purpose, entry and exit dummies have been created. An entry dummy takes value one at period t if a firm was created between $t-4$ and t, both included, zero otherwise. An exit dummy takes value one at period t if a firm exits between $t+1$ and $t+5$, both included.

Let us first run the following regression

$$x_{ijt} = \beta_0 + \beta_1\, exit_{ijt} + \beta_2\, entry_{ijt} + \sum_{t=1990}^{2011} \beta_t\, year_t + \sum_{prov.} \beta_p\, loc_{it} + \sum_{j=1}^{20} \beta_j\, ind_{jt} + \epsilon_{ijt},$$

where x represent one of the main variables of interest: technology efficiency, prices and product values. The dummies $year_t$ and location loc_{it} were defined above in Section 1.3.3. The dummies ind_{jt} take value one if the observation corresponds to industry j at time t, zero otherwise. The coefficients associated to the exit and entry dummies measure the average distance for the variable of interest between entering and exiting firms, on one side, and incumbent firms, on the other side.

The results of these estimations are shown in Table 1.5. Exiting firms have lower technical efficiency and product value than incumbent firms, but they do not show any significant difference in prices. As expected, exit firms are less productive than incumbents; likely, this is the reason why they are exiting. Estimated coefficients are of a similar order of magnitude as those estimated by Foster et al. (2008).

Surprisingly, however, entering firms perform even worse than exiting firms. Differently from the US, learning effects or startup costs seem to dominate any vintage effect on Spanish entering manufacturing firms. Table 1.6 confirms this statement. Notice that while exit firms were loosing productivity before exiting (in both dimensions, technical efficiency and product value) and reducing prices, entering firms improve in all these dimensions after entry.

Following Foster et al. (2008), let us categorize firms in our sample according to their age. Let us assign *old firms* to those that are aged more than 20 years, which represents half of

[11] The exit rate in year t has been measured as the fraction of number of firms in year $t-5$ that exit between $t-4$ and t over the total number of firms in t. Analogously, the entry rate in year t is the fraction of number of firms that enter between $t-4$ and t over the total number of firms in t.

Table 1.5: Productivity of Exiting and Entering Firms

Variable	Exit	Entry
TFPQ	-0.014	-0.034
	(0.005)	(0.006)
Product Value	-0.20	-0.66
	(0.033)	(0.036)
Price	-0.002	0.005
	(0.003)	(0.003)
TFPR	-0.018	-0.029
	(0.005)	(0.006)

Notes: This table reports the results of regressing each variable on exit and enter dummies. All specifications include location, industry and year fixed effects. Standard errors are in parenthesis.

Table 1.6: Productivity Changes of Exiting and Entering Firms

Variable	Exit	Entry
Δ TFPQ	-0.006	0.014
	(0.003)	(0.004)
Δ Product Value	-0.080	0.061
	(0.007)	(0.008)
Δ Price	-0.290	0.048
	(0.109)	(0.113)
Δ TFPR	-0.011	0.013
	(0.003)	(0.004)

Notes: This table reports the results of regressing each variable on exit and enter dummies. All specifications include location, industry and year fixed effects. Standard errors are in parenthesis.

the sample. In top of entering firms (aged less than 5 years), let us designate as *young firms* those that are aged between 5 and 12 years, and *medium aged firms* those aged between 13 and 20. Using these criteria, 13.5% of all firms are medium age and 17.1% are young. Then, we have run the following regressions, which adds young and medium aged dummies to the previous one,

$$x_{it} = \beta_0 + \beta_1 \, exit_{it} + \beta_2 \, entry_{it} + \beta_3 \, young_{it} + \beta_4 \, medium_{it} + \sum_{t=1990}^{2011} \beta_t \, year_t + \sum_{j=1}^{20} \beta_j \, ind_{jt} + \epsilon_{it}.$$

The estimations are reported in Table 1.7. Results for exiting firms are very similar to those in Table 1.5. Interestingly, the table shows how the observed differences between entrants and old incumbents are progressively reduced, which we can take as additional evidence on a long-lasting learning process.

Table 1.7: Productivity by Age Groups

Variable	Exit	Entry	Young	Medium
TFPQ	-0.014	-0.048	-0.038	-0.023
	(0.006)	(0.007)	(0.004)	(0.005)
Product Value	-0.19	-1.01	-0.92	-0.67
	(0.032)	(0.037)	(0.025)	(0.027)
Price	-0.004	0.009	0.011	0.005
	(0.003)	(0.004)	(0.002)	(0.003)
TFPR	-0.019	-0.040	-0.028	-0.019
	(0.005)	(0.005)	(0.004)	(0.004)

Notes: This table reports the results of regressing each variable on exit, enter, young and medium age dummies; all specifications include region and industry-year fixed effects. Standard errors are in parenthesis.

After clarifying the connections of entry and exit dynamics with our different measures of productivity and prices, let us now study the impact of these productivity measures and prices on firms' exit decisions. To this purpose, we run Probit regressions on the exit dummies defined above, using explanatory variables as the variables of interest, one at a time, and a full set of location, year and industry dummies as controls. Table 1.8 reports the results of the Probit exit regressions. Each column presents the effect on exit of the

Table 1.8: Productivity and Product Value on Firm's Exit

Variable	(1)	(2)	(3)	(4)	(5)
TFPQ	-0.100				-0.089
	(0.035)				(0.034)
Product Value		-.048			-0.047
		(0.006)			(0.006)
Price			-0.091		
			(.056)		
TFPR				-0.161	
				(0.038)	

Notes: This table reports the results of the Probit exit regressions. The regression includes location, industry and year controls. The regression was run on a pooled sample of 30,307 firm-year observations. Standard errors, clustered by firm, are in parentheses.

corresponding variable of interest. We find that firms with higher technical efficiency and product value are more likely to stay in the market. A one-standard-deviation reduction in technical efficiency and product value corresponds respectively to an increase of 1.4 and 0.8 percentage points, respectively, in the probability of exit.

The previous results confirm the findings in Foster et al. (2008) that firm's market value is as important as firms' technical efficiency to understand firms' turnover. Indeed, TFPR is a good predictor of TFPQ and product value, even if it slightly overestimates the join effect of both technical efficiency and product value.

1.4.3 Growth, Technical Efficiency and Product Value

By defining productivity as a vector of both technical efficiency and product value, we are able to quantify the contribution of productivity to firms' performance better. This section shows that the level and change of both technical efficiency and product value have a positive and significant effect on output level and growth, respectively; and that the level and change effects on prices are positive for product value but negative for technical efficiency. Product value is at least as important as productivity shock for firm's output and prices.

In order to do so, we regress firm sales, nominal and real output and prices on technical efficiency (ω) and product value (η), under the assumption that both are exogenous:

$$y_{it} = \alpha\, \eta_{it} + \beta\, \omega_{it} + \epsilon_{it},$$

where y is the dependent variable: sales, nominal and real output or prices. All specifications use the pooled sample and again include a full set of location, industry and year dummies as controls. As reported in Panel A of Table 1.9, both technical efficiency and product value have large, positive effects on sales, nominal and real output. Moreover, as expected, technical efficiency has a negative effect on prices, while product value has a positive effect.

The effect of product value on quantities (sales, revenue and output) is slightly smaller than the effect of technical efficiency. Finally, consistently with the observed correlations in Table 2, technical efficiency has a smaller effect on output that it has on sales and revenues, mainly due to the negative correlation between TFPQ and prices.

We explore this empirical pattern a bit further by estimating the effect of technical efficiency and product value changes on the growth rate of sales, revenue, output and prices. We regress firms growth and prices adjustments on the growth of technical efficiency and product value according to the relation

$$\Delta y_{it} = \alpha\, \Delta\eta_{it} + \beta\, \Delta\omega_{it} + \epsilon_{it},$$

Table 1.9: Effects of Productivity on Sales and Output

Panel A

Variable	Nominal Sales	Nominal Output	Real Output	Price
TFPQ	0.93	0.96	0.79	-.32
	(0.011)	(0.011)	(0.013)	(0.003)
Product Value	0.45	0.47	0.95	0.02
	(0.001)	(0.002)	(0.002)	(0.001)
Observations	34147	34147	34147	34147
R-Squared	0.91	0.91	0.88	0.53

Panel B

Variable	ΔNominal Sales	ΔRevenue	ΔOutput	ΔPrice
ΔTFPQ	0.14	0.24	0.30	-0.06
	(0.006)	(0.006)	(0.00)	(0.001)
Δ Product Value	0.58	0.61	0.57	0.05
	(0.003)	(0.003)	(0.00)	(0.001)
Observations	29835	29835	29835	29835
R-Squared	0.53	0.62	0.40	0.31

Notes: All variables are in logs. All specifications include location, industry and year fixed effects. Standard errors are in parenthesis.

where Δ represents the change in the corresponding variable. Results are shown in Panel B of Table 1.9. All specifications use the pooled sample and again include a full set of location, industry and year dummies as controls. In the price regression, the estimated coefficients have similar value but different sign (negative for TFPQ, as expected).

To explore our results even further, we also study the effect of lagged productivity shocks on firms growth by estimating

$$\Delta y_{it} = \alpha_0 \Delta\omega_{it} + \alpha_1 \Delta\omega_{it-1} + \alpha_2 \Delta\omega_{it-2} + \beta_0 \Delta\eta_{it} + \beta_1 \Delta\eta_{it-1} + \beta_2 \Delta\eta_{it-2} + \epsilon_{it}.$$

Results are reported in Table 1.10. Past technical efficiency shocks have sizable and significative effects on the growth rate of both prices (Columns 1 and 3) and output (Columns 4 and 6), with the expected sign. This may be interpreted that more time is required to update prices and output capacity to technical efficiency shocks. The dynamics of both prices and output to shocks in product

Table 1.10: Lagged Effects of Productivity Shocks on Prices and Output

Variable	(1) ΔPrice	(2) ΔPrice	(3) ΔPrice	(4) ΔOutput	(5) ΔOutput	(6) ΔOutput
ΔTFPQ	-0.05		-0.08	0.62		0.36
	(0.002)		(0.002)	(0.009)		(0.007)
ΔTFPQ_{t-1}	-0.03		-0.03	0.08		0.07
	(0.002)		(0.002)	(0.010)		(0.008)
ΔTFPQ_{t-2}	-0.01		-0.00	0.01		0.02
	(0.002)		(0.002)	(0.009)		(0.007)
$\Delta\eta$		0.04	0.05		0.56	0.50
		(0.001)	(0.001)		(0.003)	(0.003)
$\Delta\eta_{t-1}$		0.01	0.01		0.01	0.01
		(0.001)	(0.001)		(0.004)	(0.004)
$\Delta\eta_{t-2}$		0.00	0.00		0.00	0.01
		(0.001)	(0.001)		(0.004)	(0.004)
Observations	22308	23694	22308	22308	23694	22308
R-Squared	0.08	0.27	0.34	0.26	0.47	0.54

Notes: All dependent variables and the demand and TFP shocks are in delta logs. TFP is calculated using Olley and Pakes (1996). η is the product value. All specifications include region and industry-year fixed effects. Standard errors are in parenthesis.

values follow a rather different pattern. Lagged product values have a small effect on output at lag 1 and no effect at lag 2.

1.5 Conclusion

In this chapter, a unique dataset is employed to disentangle technical efficiency and product value in firms' performance. We use Spanish manufacturing firms dataset, ESEE, which contains firm level data from 1990 to 2011. The uniqueness of the dataset comes from the existence of input and output price informations, which allows observing physical output at firm level. By observing firm level price information, physical productivity and firm specific product value can be estimated separately. Revenue productivity is also computed along with physical productivity to compare our results with the results in the literature. Physical productivity is employed as instrumental variable to estimate product values. Outcomes show small correlations between product values and instrumental variable, as in Foster et al. (2007).

In our exercise, correlation of firm level prices and physical productivity are negative, as described by theoretical model, while its correlation with revenue productivity is positive. Revenue productivity and prices show substantial persistent in the data. Interestingly, technical efficiency and product value show higher persistent which it may emphasize the role of product value and technical efficiency in firm's performance. By computing technical efficiency and product value, we investigate their role in firm's growth and survivals, and their link to firms' innovation activities.

Estimations report significant effect of both product value and technical efficiency on firms' performance, growth and turnover. As a result, exiting firms have negative growth in their price, productivity and product value (before exiting from the market) comparing to incumbents while entering firms have positive growth in all variables of interest (productivity, price and product value). Firms with lower prices, productivity and product value are more likely to exit from the market. While product value is important and significant factor for survival, the dominant factor is firm level physical productivity when both are used simultaneously in the estimation.

Turning to firms' growth (real and nominal sales and production), the effect of both product value and technical efficiency on firms' growth is investigated. Both technical efficiency and product value have huge and significant effect on prices, production and revenue while the effect of product value on firms growth (change of sales, prices and production) is larger than the effect of technical efficiency. As an outcome of this work, verifying the contribution of product value in firms dynamics can be very interesting for further research.

1.6 Appendix A

Calculation of Demand Elasticity

Following Das, Roberts, and Tybout (2007), we use firm's data on total variable costs to estimate demand elasticities to see their deferences with the results in our first method. To do so, a demand system has been estimated using total variable costs of each firm. Das, Roberts, and Tybout (2007) assume that

$$R_i(1 + \frac{1}{\sigma_i}) = TC_i, \tag{1.8}$$

where R_i is total revenue of firm i, TC_i is its total cost and $|\sigma_i| > 1$ is product value elasticity. As each firm's marginal cost is constant to the output, using the first-order condition for profit maximization, marginal cost is equal to marginal revenue and thus TC (total cost) is an elasticity-weighted combination of total revenue.

$$TC_{it} = Q_{it}C_{it} = R_{it}\big(1 + \frac{1}{\sigma_j}\big) + \epsilon_{it}, \tag{1.9}$$

where ϵ is the error term which defines measurement error in total cost. Industry elasticity of demands can be calculated using this method. Estimated elasticities are shown in Table 1.11.

In this table, first column shows total elasticity in each industries. All the elasticities are significantly larger than 1 in magnitude except for industries 2 and 18.

Table 1.11: Estimated Price Elasticities by Industry

	σ	St. errors
1. Meat products	-8.31	0.59
2. Food and tobacco	-2.26	1.14
3. Beverage	-5.03	0.37
4. Textiles and clothing	-9.77	1.35
5. Leather, fur and footwear	-9.11	2.93
6. Timber	-7.14	0.45
7. Paper	-5.91	0.32
8. Printing	-5.49	0.22
9. Chemicals and pharmaceuticals	-9.39	0.97
10. Plastic and rubber products	-7.21	0.14
11. Nonmetal mineral products	-4.38	0.27
12. Basic metal products	-6.38	0.56
13. Fabricated metal products	-5.81	0.83
14. Machinery and equipment	-6.07	0.41
15. Computer, electronics and optical	-7.97	0.27
16. Electric materials and accessories	-8.13	0.76
17. Vehicles and accessories	-10.36	1.71
18. Other transport equipment	24.57	5.40
19. Furniture	-7.36	0.81
20. Other industries	-7.62	0.39

Notes: Elasticities are estimated according to Das, Roberts, and Tybout (2007). First column, shows price elasticity of demand in each industries. All regressions include year, province and market destination fixed effects.

Chapter 2

Technical Efficiency, Product Value, Innovation and Trade

2.1 Introduction

There are extensive researches in trade literature that try to reveal the impact of openness to trade (by either tariffs or quotas reduction) on firm level productivity within industry.[1] These studies are based on a great interest in examining policy changes to see the impact of trade liberalization on firms' decision to serve foreign markets. They imply that international firms (exporters and foreign-owned firms) have higher productivity[2] while there is not a certain conclusion about the effect of trade on firms' productivity. Empirical evidences on this point are less uniform, with some studies find higher productivity gains for firms after openness to trade and others find no effect.[3]

Productivity measure that has been used to claim the previous results is called revenue productivity here and it contains both demand (price) and productivity components. An industry price index is used to compute physical output and then revenue productivity. In other word, average industry prices are used for deflating production and eliminating price effect. By using this measure, the results incorporate both supply and demand sides and not supply side alone. Using this price index causes mix of demand and productivity shocks as shown in Foster et al. (2008) and De Loecker (2011) among others. For solving this problem and disentangling demand and productivity shocks, it is necessary to access rich datasets in which output quantity can be achieved.

Foster et al. (2008) use data on homogeneous products for which physical quantities can be defined. They use output value and product quantity to determine each product prices. They are able to calculate physical TFP (Total Factor Productivity) by using quantity as the regressor in production function and not revenue. To compute demand disturbance in their product groups, they use the

[1] See e.g. Tybout et al. (1996), Bernard et al. (1999, 2007a) and Helpman et al. (2005) among others.

[2] See e.g. Pavcnik (2002) and Melitz (2003).

[3] See Bernard et al. (1999, 2007a), Helpman et al. (2005) and Tybout and Westbrook (1994) among others.

physical TFP as instrumental variable. They show that failing to disentangle demand and TFP shocks leads to an underestimation of new entrants' contribution to firms' growth.

De Loecker (2011) exploits theoretical restrictions to isolate physical productivity from demand factors in estimating the effects of trade cost reduction on productivity for Belgian textile firms. We further develop this literature by using a unique dataset, which contains firm level input and output price information in different sectors, to separate price effects in TFP estimation. The literature has focused mostly on controlling for the simultaneity bias when estimating production functions by relying on proxy methods (Olley and Pakes (1996), Levinsohn and Petrin (2003)). A series of papers used this approach to verify the productivity gains from changes in the operating environment of firms, such as trade liberalization. In almost all of the empirical applications, the omitted price variable bias is ignored or assumed away. This implies that trade impact on both prices and firms' efficiency are identified and not its impact on physical productivity.

Our study is one of recent contributions that takes the advantage to observe firm level prices (De Loecker, Goldberg, Khandelwal and Pavcnik (2012), Fan, Roberts, Xu and Zhang (2012)). De Loecker et al. (2012) use Indian firms' prices and physical quantity informations to separate mark ups from productivity and examine trade openness on these performance indexes. They find that after trade openness marginal costs decrease more than prices. Fan et al. (2012) use manufacturing Chinese data and conclude that firms product value, prices and cost components are very useful to explain extensive and intensive margin of trade like number of destination and the time and volume for export to a destination. In our method, firm level price information is used to define each firm output quantity from revenue in all sectors. In this work, as in the previous chapter, Spanish manufacturing dataset is employed to estimate firm productivity. Following Doraszelski and Jaumandreu (2006) Olley and Pakes' method can be extended to include other endogenous variables (here R&D expenses) that impact productivity. It is assumed that unobserved productivity has a first order Markov process transition that can be rewritten as a function of previous year productivity and R&D expenses. Finally, technical efficiency is computed by considering the mentioned assumptions.

Technical efficiency and product value are employed to investigate their connection to status of a firm in international markets. Productivity is an important source of firm heterogeneity that is relevant in both domestic and export markets. Results reveal that both exporters and foreign-owned firms, in average, have higher technical efficiency and product value comparing to domestic non-exporter firms. We put one step further and study the effect of productivity on decision of firms to serve foreign market. As a result, both firm level technical efficiency and product value have significant effect on decision of firm to export or do FDI, while product value has a dominant effect. By including both of variables of interest in the estimation, it shows that technical efficiency does not have any significant effect on decision of a firm to export while firm level product value has significant effect on firms' decision to export.

As an application, physical productivity and product value are used to study the true effect of trade liberalization on productivity gains. We estimate our productivity measure responses to a specific trade liberalization process that took place in the European textile market from 1993 to 2003. During this period, quotas protection decreased as much as 58% in this market. As a result, the estimated productivity gains from relaxing protection are less when relying on physical productivity while it has statistically strong and significant effect on revenue productivity and product value. This reveals that in previous literature [4], the role of trade on firms' productivity gains is exaggerated and its connection with firms product value is widely neglected due to use a bias measure of productivity.

Finally, productivity is linked to firms' R&D expenses and innovation activities. This section tries to investigate if investment in knowledge-based activities like process and product innovation increases the firm specific productivity and demand. Results show that R&D activities increase firm level productivity comparing to other firms (by 4%). Firms with lower physical productivity or higher product value are more likely to undertake product innovation but firms that have higher productivity and product value are more likely to perform process innovation. It is a very interesting phenomena that product innovation is mostly related to product value (product value) and not to productivity but process innovation is related to both of them.

The rest of this chapter is as follows. Section 2 presents a standard model of monopolistic competitive equilibrium characterized by productivity and demand residuals. Data is described in Section 3. Next section contains empirical part which reveals the role of productivity and product value in status of firm in international markets and the effect of trade openness on firms' productivity. The link between R&D activities and productivity is also illustrated here. Finally, there is a conclusion section.

2.2 Data

Two categories of data set are employed in the empirical section. One is related to firm level production and demand, which is Spanish manufacturing panel data (ESEE), and the other one is applied-quota statistics in European Textile Market. Since ESEE is the same dataset that is utilized in the first chapter, we neglect data description and only emphasize on applied statistics in this chapter. We restrict our data, to firms with at least two years observations (lag of variables are used in estimations then at least two years variable information is needed). Since this chapter tries to illustrate the link between productivity and status of a firm as exporter or foreign-owned, here we report export and FDI (Foreign Direct Investment) statistics in our sample. Summary statistics of exporters and foreign owned firms along with their size in each industry are reported in Table 2.1.[5]

The descriptive statistics in the table has been computed for each industry from 1990 to 2011. Exporters are firms that sell a strictly positive magnitude of their production in foreign markets; foreign-owned firms or FDIs based on OECD Benchmark Definition are those with at least 10% of their capital hold by foreign investors.[6] Domestic non-exporter firms are firms that do not export neither are foreign-owned. Interestingly, big share of total number of firms are exporters, ranging

[4]See Bernard et al. (1999, 2007a), Helpman et al. (2005) and Tybout and Westbrook (1994) among others.

[5]This data set has also been used in other papers e.g. Gonzalez, Jaumandreu and Pazo (2005) and Delgado, Farinas and Ruano (2002).

[6]We are using the same index as Bernard et al. (2007), Epifani (2003) and Mayer & Ottaviano (2008). OECD Benchmark Definition of Foreign Direct Investment, 2008: Direct investment enterprises are corporations, which may either be subsidiaries, in which over 50% of the voting power is held, or associates, in which between 10% and 50% of the voting power is held.

Table 2.1: Summary Statistics

Industry	Obs.	Size	Output	Export %	FDI %
1. Meat products	1181	228	38	56	10
2. Food and tobacco	4039	240	50	51	11
3. Beverage	844	337	68	60	14
4. Textiles and clothing	3766	138	10	53	15
5. Leather, fur and footwear	1189	41	3	59	13
6. Timber	1231	88	10	44	11
7. Paper	1271	229	38	68	13
8. Printing	2004	150	17	39	16
9. Chemicals and pharma.	2763	320	90	81	13
10. Plastic and rubber products	2085	223	34	68	14
11. Nonmetal mineral products	2921	206	30	48	11
12. Basic metal products	1243	562	154	82	12
13. Fabricated metal products	4360	117	14	50	10
14. Machinery and equipment	2427	170	21	74	11
15. Computer, electronics	1145	450	105	78	18
16. Electric materials and acce.	2205	301	48	64	13
17. Vehicles and accessories	1958	986	294	84	13
18. Other transport equipment	986	684	79	71	13
19. Furniture	2021	87	7	52	11
20. Other manufacturing	1039	116	12	73	12
Ave.	2040	253	50	61	13

Notes: Size is average employment of firms and output is average output (1989 million euro), from 1990 to 2011. Export share is the fraction of firms that have positive amount of export to total firms number and FDI is the ratio of foreign owned firms to total firms in each industry.

from 39% to 84% in different sectors. There is a significant ratio of foreign-owned firm in each industry which is ranged from 10% to 18% of firms. In average, 61% and 13% of firms are exporters or foreign-owned respectively. Table 2.1 indicates positive relationship between the size of the firms and their participation in the export market, like in literature. Vehicle, Basic metal and Chemical industries have bigger size and higher export ratio.

To study the effect of trade openness on firm's productivity and product value, textile industry data from EUROSTAT has been employed. European textile industry experienced a huge reduction in quota protection between 1994 and 2003.[7] There are significant decreases in textile quota protection in European textile industry from 1994. This huge reduction in quota of textile industry had a significant effect on firms' investment, demand and production of this sector. The number of protection, quotas and the average quota levels (in million) are presented in Table 2.2. In our data

[7] This data comes from EUROSTAT which has been employed in De Loecker (2011).

Table 2.2: Quota reduction in EU textile market

	N. of Quota Protections	Kg N. of Quotas	N. Pieces N. of Quotas
1994	1,050	469	581
1995	940	452	484
1996	824	411	413
1997	857	413	444
1998	636	329	307
1999	642	338	304
2000	636	333	303
2001	574	298	276
2002	486	259	227
2003	433	224	211
Change 94-03	−58%	−48%	−64%

Notes: This table shows the summary statistic of trade openness in European textile market. Second column reports total number of quota lines which is sum of quotas in volume (column 3) and pieces (column 5).

set, there are 685 firms in Textile industry which count as 5995 observations. 10% of these firms are foreign-owned and 50 % of them are exporters.

The number of quota restrictions has decreased in both size and volume from 1994 to 2003. During this period, the number of quotas has decreased by 58 percent over a 10-year period and the average level of protected items increased both in levels and number of pieces by 76% and 48% respectively. Theses huge reduction in number of quotas or increase in the level of protected items are claimed as a period of trade openness in European textile market as it has been described in details by DE Loecker (2011).

2.3 Empirical steps

2.3.1 Total Factor Productivity (TFP)

As in the previous chapter, the production function of firm i can be presented by the mean of the following Cobb-Douglas technology

$$q_{it} = \alpha k_{it} + \beta \ell_{it} + \gamma m_{it} + \omega_{it}, \tag{2.1}$$

where k_{it}, ℓ_{it} and m_{it} are physical capital, employment and materials, respectively, used in the production of output q_{it} (all in log). Let us assume that technical efficiency ω_{it} can be decomposed into two terms,

$$\omega_{it} = \varphi_{it} + u_{it},$$

a shock u_{it}, unobserved by both firm and econometrician, and a shock φ_{it} observed by firm i but not by the econometrician. A firm knows its productivity when it decides to operate the technology. Capital is accumulated according to $k_{it+1} = (1 + \delta)k_{it} + \iota_{it}$, where ι_{it} is investment at time t, and δ is depreciation rate. According to the capital law of motion, firm's investment in capital will be productive in following year.

It is usually assumed that TFP follows an exogenous Markov process $P(\varphi_{it}|\varphi_{it-1})$ (see Olley Pakes (1996) and Levinson Petrin (2003)) and then it is not related to R&D activities. However, started by Griliches 1979, it is assumed that R&D expenditures have effect on productivity (also see Griliches (1995) for an extensive survey on effect of knowledge-based expenditures on productivity). Following Doraszelski and Jaumandreu (2006), R&D expenditures are also included in first order Markov process of TFP, $P(\varphi_{it}|\varphi_{it-1}, r_{it-1})$ where r_{it-1} is previous year firm's R&D expenditure. First-order Markov process of productivity can be defined as

$$\varphi_{it} = E[\varphi_{it}|\varphi_{it-1}, r_{it-1}] + \upsilon_{it} = h(\varphi_{it-1}, r_{it-1}) + \upsilon_{it}, \tag{2.2}$$

in which, φ_{it} is decomposed to an expected part ($h(\varphi_{it-1}, r_{it-1})$), and a random shock ($\upsilon_{it}$) which is independent from R&D expenditures. $h(\varphi_{it-1}, r_{it-1})$ is defined to be a polynomial function of lag of TFP and lag of R&D expenditure.[8] Olley and Pakes (1996) use information on firm's investment behavior to control simultaneity while they use a selection equation to correct the selection bias. They assume that investment function can be invertible under certain assumption. Therefore, observed part of technical efficiency can be written as a function of capital, age (a_{it}) and investment

$$\varphi_{it} = g(\iota_{it}, k_{it}, a_{it}), \tag{2.3}$$

where $g(.)$ is a polynomial function. By plugging (2.3) and (2.2) into (2.1) correlation of inputs and residuals can be controlled

$$q_{it} = \alpha k_{it} + \beta \ell_{it} + \gamma m_{it} + h(g(\iota_{it-1}, k_{it-1}, a_{it-1}), r_{it-1}) + \upsilon_{it} + u_{it}, \tag{2.4}$$

where q_{it} is firms' production deflated by firm prices, $h(g(.))$ is a polynomial function and here, it is assumed to be a trinomial function. This equation is estimated following Olley and Pakes (1996).[9] Finally, technical efficiency (TFPQ) can be computed by the mean of

$$\hat{\omega}_{it} = q_{it} - \hat{\alpha} k_{it} - \hat{\beta} l_{it} - \hat{\gamma} m_{it}. \tag{2.5}$$

For comparability reasons, we have also created a revenue-based measure of productivity (TFPR) by replacing q_{it} with its revenue measure. Industry prices p_j are used to deflate firms revenue and construct revenue measure of output.

[8] As in Olley and Pakes (1996), it is assumed that $h(.)$ is a trinomial function in our empirical estimations.

[9] Using above equation, β and γ can be estimated but because there is selection effect on capital, α is biased. We also follow OP to correct selection bias. As in the previous chapter, firm's capital has been measured by the Permanent Inventory method. Firm's investments in equipment and machinery were deflated using an industry level price index and then accumulated on a capital stock measurement. We set capital stock for the year 1999 as K_0. Depreciation rates and price indices of capital goods come from Spain Instituto Nacional de Estadística. We obtained capital stock, K, by depreciating real net capital and adding the yearly investment in equipment goods; materials, M, by deflating intermediate consumptions by intermediate prices; labor, L, that is hourly used employment by a firm, by multiplication of firm employment to its yearly active hours. For further details see the previous chapter.

Including R&D expenditures in measuring productivity show a very similar pattern than those used in previous chapter and by Foster et al. (2008), as can be observed by comparing Table 2.3 with Table 1.2. In Table 2.3, firm's revenue and output show a very high correlation, 0.996. This is because of the high dispersion in firm size, as evidenced by the standard deviations of both measures.

TPF measures are also highly correlated and exhibit solid dispersion.[10] More interesting, measured TFPQ is negatively correlated with prices, 0.49 in absolute value.[11] The negative correlation between TFPQ and prices reflects the fact that more efficient firms face lower marginal costs and, in turn, charge lower prices, a common implication of models of imperfect competition as the simple model in Section 1.2. Moreover, as expected, measured TFPR is positively correlated with prices.

Table 2.3: Revenue, Output, Price and Productivity

	Revenue	Output	Price	TFPR	TFPQ
Revenue	1				
Output	0.996	1			
Price	-0.05	-0.12	1		
TFPR	0.17	0.15	0.31	1	
TFPQ	0.21	0.26	-0.49	0.68	1
S.D.	2.05	2.06	0.24	0.30	0.29

Notes: All variables are in logs.

2.3.2 Product values

Product values are also estimated using the same method in the previous chapter. Estimations were performed industry by industry; Table 2.4 shows the results of the estimations for the different industries. As it can be seen, all estimated price elasticities are negative, strongly significant, and exceed one in absolute value except for "Paper Industry." For the other industry, they range between 13.21 for "Beverage" and 1.13 for "Timber". The results are very similar with the ones in the first chapter.

After estimation of technical efficiency and product values, their effects on status of firms in domestic and foreign market, and their relation to innovation and R&D expenditures are illustrated in the next sections.

[10] The standard deviations of revenue and output in Table 2.3 double those in Foster et al. (2008), likely due to the fact that the ESEE surveys 64% of firms larger than 200 workers but only 5% of smaller firms.

[11] It is important to notice that all price indices are normalized to unity at 1989. Consequently, they show small variability at the beginning of the sample period. Contemporaneous correlations between prices and TFPQ show that the correlation is -0.18 in 1990, then increasing to reach -0.56 in 1996 to remain turning around this number until 2011 (in facts, it fluctuates between -0.52 and -0.59).

Table 2.4: Estimated Price Elasticities

Industry	Coef.	Std. Err.
1. Meat products	-4.71	0.79
2. Food and tobacco	-3.31	0.50
3. Beverage	-9.41	7.90
4. Textiles and clothing	-2.04	0.43
5. Leather, fur and footwear	-2.57	0.13
6. Timber	-3.55	1.13
7. Paper	-0.91	0.32
8. Printing	-1.32	0.51
9. Chemicals and pharmaceuticals	-1.54	0.12
10. Plastic and rubber products	-2.4	0.23
11. Nonmetal mineral products	-2.02	0.43
12. Basic metal products	-2.92	0.22
13. Fabricated metal products	-2.54	0.43
14. Machinery and equipment	-5.4	1.02
15. Computer, electronics and optical	-3.9	0.60
16. Electric materials and accessories	-3.1	0.63
17. Vehicles and accessories	-6.86	0.94
18. Other transport equipment	-13.21	11.34
19. Furniture	-4.21	1.2

Product Value Correlation with TFPQ and TFPR

	TFPQ	TFPR	Rev. Output
η	0.03	0.23	0.87

Notes: Estimated industry-by-industry by 2SLS IV using TFPQs as instruments for firm specific output prices. All regressions include year, province and market destination fixed effects.

2.3.3 Exporters and Foreign-Owned Firms

Productivity measures have been widely used during the last two decades to identify the effects of international trade on firms' productivity. Previous studies show that exporters and foreign-owned firms have higher productivity (on average) than domestic and nationally-owned firms.[12] Here, we use already computed technical efficiency and product value to define the effect of them on the firms' decision to serve foreign markets.

At every year t, an exporter is a firm selling a strictly positive magnitude to foreign markets and foreign-owned firms are those with at least 10% of its capital hold by a foreign investor(s). The variables of interest, technical efficiency, product value and TFPR, are regressed on export, foreign-owned and export-foreign-owned dummies as status of a firm in foreign market. According to Table 2.5, exporters and foreign-owned firms have higher technical efficiency and product value than non-exporters and nationally-owned firms, respectively.

Table 2.5: Productivity/Product Value of Exporters and Foreign-Owned Firm

Variable	Exporter	Foreign-owned	Export-Foreign-owned
TFPQ	0.021	0.042	0.054
	(0.003)	(0.003)	(0.006)
Product Value	0.54	0.71	0.76
	(0.073)	(0.044)	(0.026)
TFPR	0.007	0.041	0.030
	(0.003)	(0.022)	(0.005)

Notes: This table reports the results of regressing each variable on export and foreign-owned dummies. All specifications include location, industry and year fixed effects. Standard errors are in parenthesis.

This is particularly true for foreign-owned exporters that are exporters with at least 10% of their capital hold by a foreign investor(s). Moreover, coefficients for these two variables are larger than the corresponding coefficients for TFPR which implies that by employing TFPR, the role of productivity on decision of firms to export in Spanish manufacturing industries is underestimated.

After clarifying the connection of exporters and foreign-owned firms to our different measures of productivity and product value, let us now study the impact of productivity measures and product value on firms decision to serve foreign market (as exporter or FDI). To this purpose, we run Probit regressions on the export and FDI dummies defined above, using as explanatory variables the variables of interest, and a full set of location, year and industry dummies as controls. Table 2.6 reports the results of the Probit export regressions and each column presents the effect of the corresponding variable of interest on export.

We find that firms with higher technical efficiency and product value are more likely to be exporters. A one-standard-deviation increase in technical efficiency and product value corresponds respectively to an increase of 5 and 13 percentage points in the probability of export. It clearly shows that while both of productive parts are important in determination of the firms' export behavior, the effect of

[12]See for example Bernard et al. (1995, 1999, 2007a).

product value is significantly higher. In regression (4), both physical productivity and product value are included in the estimation. A one-standard-deviation increase in product value corresponds to an 8% increase in the probability of export and no significant effect of physical productivity. The effect of technical efficiency disappeared and the effect of product value is decreased to similar magnitude as the effect of revenue productivity; this bolds the role of product value on firm decision to export. One possible reason can be that Spanish exporters give priority to quality than low cost products (when compared with Spanish firms producing for the domestic market only).

Table 2.6: Export Probit Estimations on TFP and Product Value

Variable	(1)	(2)	(3)	(4)
TFPQ	0.05			-0.01
	(0.013)			(0.02)
Product Value		0.13		0.08
		(0.005)		(0.002)
TFPR			0.08	
			(0.017)	

Notes: This table reports the marginal effects of Probit estimations of the probability of a firm being exporter as a function of TFPQ, product value or TFPR. All specifications include location, industry and year fixed effects. The regression was run on a pooled sample of 33,467 firm-year observations. Standard errors are in parenthesis.

To shed a light on the effect of productivity on foreign-owned firms, the same regression is applied for FDIs and results are presented in Table 2.7. A set of location, industry and year dummies are included in the regression. A one-standard-deviation increase in technical efficiency and product value corresponds to an increase of 8% and 6% in the probability of FDI, respectively. Considering both variables of interest in the regression, it implies that the effect of product value is larger than the effect of technical efficiency.

As a results, in both export and FDI status, product value is more important in determination of status of a firm in international markets. Comparing the effect of revenue productivity and other variables of interest, it implies that TFPR shows higher effect of productivity on possibility of a firm to be exporter/FDI and similar (or smaller) effect comparing to product value. One of the outcomes of this work emphasizes on the role of firms product value on status of firms in foreign market which is neglected in previous studies.

2.3.4 The impact of trade on productivity

TFP measures have been used widely to identify the impact of openness to trade on firm's productivity within industries. Trade literature shows that liberalizing trade by either tariff or quota

Table 2.7: Foreign-owned Probit Estimations on TFP and Product Value

Variable	(1)	(2)	(3)	(4)
TFPQ	0.08			0.04
	(0.009)			(0.005)
Product Value		0.06		0.07
		(0.001)		(0.001)
TFPR			0.09	
			(0.007)	

Notes: This table reports the marginal effects of Probit estimations of the probability of a firm being foreign-owned as a function of TFPQ, product value or TFPR. All specifications include location, industry and year fixed effects. The regression was run on a pooled sample of 31,657 firm-year observations. Standard errors are in parenthesis.

reductions increases TFP.[13] As it is mentioned, the productivity measure that is used to get these results is called revenue productivity and it contains both prices and supply side factors. In other word, average industry prices are used for deflating production and eliminating price effect. By using this measure, the results incorporate both supply and demand sides and not just supply side.

Previous studies have focused mostly on controlling the simultaneity bias in estimating production functions by relying on proxy methods (Olley and Pakes (1996), Levinsohn and Petrin (2003)). They did not focus on price effects as firms data sets have not include it. A series of papers used Olley Pakes approach to verify the productivity gains from changes trade liberalization. The price variable bias has not been mentioned in these studies and they assume the trade openness (here, quotas protection reduction) affect on prices. This assumption is not considered in the previous studies, see Pavcnik (2002) and Helpman et al. (2005) among others. It implies that previous works studied the link between trade reduction cost and both prices and firms' efficiency and not only its impact on firms' efficiency.

Here as an application, technical efficiency and product value are employed to study the true effect of trade liberalization on productivity gains. We estimate our productivity measures' response to the specific trade openness process (quota reduction) that took place in the European textile market which is explained in data section.[14]

We run an OLS regression of change in quotas relative to year 1994 on variables of interest (TFPQ, TFPR and product value)

$$\Delta x_{it} = \beta_q \, \Delta\tau_{jt} + \epsilon_{it},$$

where $\Delta\tau_{it}$ is the percentage of quota change (in kg) for industries j (textiles, clothing, leather,

[13] see Pavcnik (2002) and Helpman et al. (2005)

[14] In our data set, there are 685 firms in Textile industry which count as 5995 observations. 10% of theres firms are foreign-owned and 50 % of them are exporters. We run previous regressions and construct all the previous tables for Textile industries, Results are similar.

fur and footwear) at time t relative to year1994. Δx_{it} is shift in revenue productivity, physical productivity, or product value to the previous year. In this regression, the interest lies in estimating β_q. A full set of location, year and industry dummies are included as controls. The effect of quotas reduction on variables of interest are reported in Table 2.8. The last estimation is the same as the one in traditional literature on trade. We analyze the effect of quota shift on revenue productivity which is simply not the true productivity but the combination of productivity and prices together. In first two rows, we separate the effect of quota shifts on physical productivity and product value.

Table 2.8: The effect of quota reduction on TFP and product value

Variable of interest	$\Delta\eta$	Δ TFPQ	ΔTFPR
β_q	-0.071	-0.031	0.064
	(0.021)	(0.011)	(0.030)

Notes: All dependent variables, change in product value, TFPQ and TFPR, are in logs differences. TFP is calculated using Olley and Pakes (1996). All specifications include region and industry-year fixed effects. Standard errors are in parenthesis.

Quota reduction in European textile market increases average sectorial revenue productivity by 6.4%. However, this is not the true effect of this trade openness on productivity as it also contains price effects. Results in the first and third rows of this table implies that true trade openness effects on physical productivity are strongly smaller than the ones on revenue productivity. These results indicate that eliminating quotas, on average, only raises productivity by 3.1%, half of its effect on revenue productivity. The effect of reduction in trade protection on product value is higher: 1% reduction in quotas protection increases average firms' product value by 7.1%. Our results show that the effect of opening to trade on product values is more important than on technical efficiency to define the status of a firm in international market. For further research, revenue productivity can be disentangled in trade literature widely to investigate true effect of productivity and to emphasize on the role of product value.

2.3.5 R&D, Innovation and Productivity

This section investigates the effect of R&D expenditures on firm level productivity, and the link between firm innovation activities and productivity. To do so, this section tries to answer the following questions: Does investing in R&D activities lead to an increase in firm specific productivity? Do firms with higher technical efficiency and product value perform process and product innovations more frequently? In the following, we try to answer the mentioned questions by illustrating the link between technical efficiency and product value with R&D expenditure, and firms' process and product innovation.[15] In order to assess the role of R&D investments in determining the differences in productivity and productivity growth across firms and over time, we investigate the link between R&D intensity and both technical efficiency and product value. The effect of R&D intensity on

[15]For R&D comparative statistics among firms in different industries see Appendix A

productivity can be estimated by the mean of the following equation

$$x_{it} = \beta\, r_{it-1} + \epsilon_{it},$$

where x_{it} is our productivity measure (technical efficiency or product value), and r_{it-1} is the logarithm of lagged R&D expenditures. A full set of year-industry fixed effects are included in the estimation. The estimation shows that a 1% increase in R&D expenditure raises technical efficiency by 0.04% percentile points and product value by 0.08% percentile points in the following year (see Table 2.9).[16]

Table 2.9: R&D and Productivity

Variable	r_{t-1}	r_{t-1}
TFPQ	0.04	
	(0.004)	
Product Value	0.08	
	(0.001)	
ΔTFPQ		0.008
		(0.003)
Δ Product Value		0.006
		(0.001)

Notes: Standard errors are in parenthesis. r_{t-1} are the R&D expenditures in the previous year.

The ESEE also provides information on firms' innovation activities. In particular, firms report if they have undertaken process and/or product innovation. The link between process and product innovation with technical efficiency and product value is studied in the following.[17] We start by estimating the differences in productivity between firms that perform product or process innovation and those that do not. These differences are estimated by regressing technical efficiency and product value on dummy variables for both product and process innovation. The estimated model is

$$\Delta\omega_{it} = \alpha_0\, I(pdi)_{it} + \alpha_1\, I(pci)_{it} + \alpha_2\, I(pdpci)_{it} + \epsilon_{it},$$

$$\Delta\eta_{it} = \beta_0\, I(pdi)_{it} + \beta_1\, I(pci)_{it} + \beta_2\, I(pdpci)_{it} + \varepsilon_{it},$$

where $I(pdi)_{it}$ is a *dummy variable* which takes value 1 if a firm only undertakes product innovation and 0 otherwise, and, $I(pci)$ is another *dummy variable* which takes value 1 if a firm undertakes only process innovation and 0 otherwise. $I(pdpci)$ is another *dummy variable* which takes value 1 if a firm undertakes process and product innovation and 0 otherwise. The outcome of this exercise is reported in Table 2.10. Firms that undertake product innovation have lower technical efficiency and higher product value (in average) compared to firms that have not engaged in any innovation activities. This may reflect that product innovation is addressed to capture a larger product value at the cost

[16] This estimation has been done considering r_{t-1} as the ratio of R&D expenditures to total sales. Results are similar to the ones reported here.

[17] R&D expenditure in the sample is positively correlated with both product and process innovation.

of reducing technical efficiency (likely, producing new high quality products is more costly). On the other side, firms that undertake process innovation show higher technical efficiency and product value. Even if firms producing new high quality products are expected to have lower technical efficiency, those among them that additionally undertake process innovation have high technical efficiency and product value. It explains the facts that if firms perceive innovative activities, they are improving the value of their products what ever innovations they undertake.

Table 2.10: Technical efficiency and Product value and Innovation activities

Variable	ΔTFPQ	ΔProduct Value
pdi_t	-0.0004	0.015
	(0.002)	(0.007)
pci_t	0.003	0.037
	(0.001)	(0.005)
$pdpci_t$	-0.002	0.043
	(0.001)	(0.006)
pdi_{t-1}	-0.0007	0.022
	(0.003)	(0.007)
pci_{t-1}	0.008	0.027
	(0.002)	(0.006)
$pdpci_{t-1}$	0.004	0.029
	(0.001)	(0.006)

Notes: The regression was run on a pooled sample of 31,562 firm-year observations. A full set of year-industry dummies are included. Standard errors are in parenthesis.

To so if R&D expenditures affect the type of innovation, we run following regression

$$\omega_{it} = \alpha\, r_{it-1} + \alpha_0\, I(pdi)_{it} * r_{it-1} + \alpha_1\, I(pci)_{it} * r_{it-1} + \alpha_2\, I(pdpci)_{it} * r_{it-1} + \epsilon_{it},$$
$$\eta_{it} = \beta\, r_{it-1} + \beta_0\, I(pdi)_{it} * r_{it-1} + \beta_1\, I(pci)_{it} * r_{it-1} + \beta_2\, I(pdpci)_{it} * r_{it-1} + \varepsilon_{it},$$

This helps to verify the intensity of process or product innovation. Table 2.11 reports the results. The results are the same as the ones reported in the previous tables. R&D expenditures have positive effects on both product value and TFP while there is a negative effect of undertaking product innovation on TFP.

We now turn to the main scope of this section which is exploring the role of technical efficiency and product value on firms' innovation activities (process and product). Table 2.12 reports the marginal effects resulting from a Probit estimation of technical efficiency (TFPQ) and product value on the probability of introducing product and process innovation –columns 1, 2, and 3, 4, respectively. A full set of industry-year dummy variables is included in all estimations as controls.

The results illustrate that firms with low technical efficiency or high product value are more likely to undertake product innovation, but firms that have high technical efficiency or high product value

Table 2.11: Productivity, R&D and Innovation

Variable	r_{t-1}	$r_{t-1} * pdi$	$r_{t-1} * pci$	$r_{t-1} * pdpci$
TFPQ	0.05	-0.004	0.002	-0.002
	(0.004)	(0.000)	(0.004)	(0.001)
Product Value	0.084	0.002	0.01	0.012
	(0.001)	(0.002)	(0.002)	(0.001)

Notes: The regression was run on a pooled sample of 32,345 firm-year observations. A full set of year-industry dummies are included. Standard errors are in parenthesis.

Table 2.12: Innovation Estimations on TFP and Product Value

Variable	(1)	(2)	(3)	(4)
TFPQ	-0.06		0.04	
	(0.007)		(0.008)	
Product Value		0.05		0.06
		(0.001)		(0.001)

Notes: This table reports the marginal effects of Probit estimations of the probability of a firm undertaking product or process innovation as a function of TFPQ or product value. Columns (1) and (2) correspond to product innovation and columns (3) and (4) to process innovation. All specifications include industry and year fixed effects. The regression was run on a pooled sample of 31,657 firm-year observations. Standard errors are in parenthesis.

are more likely to perform process innovation. Interestingly product innovation is mostly related to high firm specific product value, but low technical efficiency. However, process innovation is related to both firm's product value and technical efficiency. This may reflect that firms that undertake product activities are not as productive as firms with no innovation activities. One reason can be that, they are producing new product and they can not be as productive as before while these new products have higher product value. In another side, process innovation reduces cost of production and increase product value in the market. These results deserve future analysis.

2.4 Conclusion

In this chapter, we employ Spanish manufacturing data set (ESEE) to estimate firm level productivity (technical efficiency and product value), an important source of firm heterogeneity that is relevant in both domestic and export markets. Olley and Pakes method is extended to estimate the parameters of the productivity process and include other endogenous variables (here R&D expenses) that impact productivity.

Estimation of the productivity evolution is important for estimating the firm's decision to serve in foreign market. The results point out that both productivity and product values are important for firms' decision to serve foreign markets. Foreign-owned firms and exporters, in average, have more technical efficiency and product value comparing to domestic non-exporter firms. The effect of variables of interest on decision of firms to serve foreign markets is investigated. Results show that firms with higher product value and technical efficiency more likely decide to serve foreign market via export or FDI. While including both of them simultaneously in the estimation, it reveals that technical efficiency does not have significant effect on decision of firms to export and it has smaller effect on firms' decision to do FDI. Interestingly, firm product value has dominant effect which has been neglected in previous studies.

As an application, we use the physical productivity to study the true effect of trade liberalization on productivity gains. European textile industry experienced a huge reduction in quota protection between 1993 and 2003 which is documented by De Loecker (2011). There are significant decreases in textile quota protection in European textile program from 1993. During this period, quotas protection decreased 58% in European textile market. Our productivity measures' responses to this specific trade liberalization process are estimated. We find that the estimated productivity gains from relaxing protection are less when relying on physical productivity while it has statistical strong and significant effect on product value. The results show that effects of trade reduction cost on product value are more important than its effect on supply side. This reveals that the previous literature exaggerates the role of trade in firms' productivity gains and is assumed away its effect on firm product value.

Finally, in order to assess the role of R&D investments in determining the differences in productivity across firms and change of productivity over time, we examine the link between R&D and productivity (technical efficiency and product value). We find differences between productivity of firms that have R&D expenditure in the previous period and other firms. Estimations show that R&D expenditure in previous year has 4% significant increase in productivity. We also verify the link between process innovation or product innovation with productivity and product values. The results illustrate that firms with low technical efficiency or high product value are more likely to undertake product innovation, but firms that have high technical efficiency or high product value are more likely to perform process innovation. Interestingly product innovation is mostly related to high firm specific product value, but low technical efficiency. However, process innovation is related to both firm's product value and technical efficiency. This may reflect that firms that undertake product activities are not as productive as firms with no innovation activities. One reason can be that, they are producing new product and they can not be as productive as before while these new products have higher product value. In another side, process innovation reduces cost of production and increase product value in the market. These results deserve future analysis.

2.5 Appendix A

R&D Intensity

To clarify that how common is R&D activities in firms, R&D intensity in each industry is reported as following. For each firm, R&D intensity is defined as the ratio of R&D expenses to total sales. This ratio is not very high in Spanish manufacturing industries when compared to other European countries, even if it raised after Spain joined to the European market. Most R&D activities are undertaken by multinational firms or firms connected to multinationals. Those small and medium size firms involved in R&D activities receive subsidies or are included in tax deductible programs (see Gonzalez, Jaumandreu and Pazo(2005)).

In our dataset, average R&D intensity in manufacturing is 0.8%, even if 71% of firms declare to have performed some R&D activities at least once in the sample period, as reported in Table 2.13. Only 1017 out of 3847 firms have not performed any R&D activities during the sample period. However, only 22% of firms performed R&D continuously (column 5) and 49% of firms performed R&D in few years (column 6). R&D intensity varies from 0.2% to 1.9% across industries, as reported in the last column. Industries definitely differ in their R&D expenses: Chemical products (row 9), Machinery and equipment (14), Vehicles and accessories (17), and Electric materials (16) show high R&D intensity, while it is low for Meat and Food products (1 and 2), Timber and Paper industries (6 and 7).

Table 2.13: R&D Activities Summary Statistic

Industry	Obs	Firms	R&D Obs	Stable	Oca.	R&D(%)
1. Meat products	1181	154	308	18	70	0.2
2. Food and tobacco	4039	504	1300	65	184	0.2
3. Beverage	844	113	358	18	64	0.3
4. Textiles and clothing	844	510	1219	65	198	0.5
5. Leather, fur and footwear	1189	184	352	13	56	0.4
6. Timber	1189	191	241	12	73	0.2
7. Paper	1271	160	406	25	80	0.3
8. Printing	2004	287	327	13	76	0.3
9. Chemicals and pharm.	2763	324	1957	120	167	1.9
10. Plastic and rubber prod.	2085	296	853	44	231	0.5
11. Nonmetal mineral prod.	2921	381	948	56	174	0.3
12. Basic metal products	1243	152	692	37	72	0.4
13. Fabricated metal prod.	4360	681	1298	117	178	0.4
14. Machinery and equipment	2427	370	1229	101	128	1.3
15. Computer, electronics	1145	183	882	114	255	0.4
16. Electric materials	2205	326	1233	124	482	1.0
17. Vehicles and acc.	1958	276	1229	131	125	1.2
18. Furniture	2021	328	119	28	25	0.3

Notes: Sample period: 1991 to 2011. The total number of observations and firms are reported in columns 2 and 3, respectively. The total number of observations with positive R&D expenditure, the total number of firms that undertakes R&D in all years of the sample, and the total number of firms that occasionally do R&D are reported in columns 4, 5 and 6, respectively. Finally, R&D intensity is reported in the last column.

Chapter 3

Foreign-owned firms, Technological choice, and Trade Openness: Evidence from Spain

3.1 Introduction

Multinational entrepreneurs (MNEs) engaging in foreign direct investment (FDI) have grown tremendously in the last decades.[1] Growth of multinational firms especially has produced a remarkable expansion of trade in manufacturing, and trade literature has introduced foreign market access into the "new" trade theory.[2] Firms can supply a foreign market through a variety of channels: export their products, direct investment, or license or contract with foreign firms to produce and sell their products.

There are several studies that claim exporters have higher productivity and higher technology level comparing to domestic non-exporters.[3] Melitz (2003) shows that increases in the exposure to trade through either a transition from autarky to trade or a reduction of trade costs will force the least productive firms to exit and reallocate market share from less productive to more productive firms. He further shows that increased exposure to trade will always deliver welfare gains.

Helpman et al (2003) show that foreign-owned firms (multinational firms with FDI) are more productive than exporters for the US firms. They show that more productive firms serve foreign

[1] UNCTAD estimated that global FDI inflows rose by 18 per cent to 1.54 trillion US$ in 2007. FDI to Latin America (e.g. Brazil, Chile and Mexico) and Russia have been particularly strong (50% and 70%, respectively). The ratio of FDI to GDP increased from 5.2% in 1984 to 25.3% in 2006 (WTO 2009).

[2] Helpman et al (2003) among the others.

[3] See Bernard and Jensen (1999) for the U.S.; Clerides, Lach, and Tybout (1998) for Mexico, Colombia, and Morocco, also Bustos (2012), Pavcnik (2002), Melitz (2003), Bernard et al. (2003), and Tybout (2003).

markets and low productive firms only serve the domestic market. They added horizontal FDI[4] to the previous trade theoretical models and let firms also decide to supply foreign markets by engaging in FDI. They show that the most productive firms are those which supply the foreign markets via FDI with less productive firms deciding to export compared to MNEs. Their model emphasizes variations across firms within industries in their heterogeneity but not on the technology that firms were using.

The current study tries to investigate the effect of technology choice on MNEs' decision to supply a foreign market. It illustrates the effect of trade liberalization on low and high technological MNEs. Firms face the well-known trade off, whereby multinational firms save in trade costs but have to bear a high sunk investment cost. As mentioned above, exporters gain from trade reduction costs and may upgrade their technology using this gain. However, by exposure to trade FDIs revenue and faction of MNEs decrease.

In this chapter, a two-country equilibrium model is studied that jointly addresses the decision of heterogeneous firms to supply foreign markets through either export or FDI, and their technological choices. We introduce technology upgrading into a model of trade with heterogeneous firms. In the model, only the more productive firms choose to supply the foreign market via export or FDI. Only the most productive firms can afford the sunk fixed cost to adopt high technology and these are the ones that supply the foreign market. One of the main differences of this study from earlier studies is the inclusion of a firm's technology level in determination of the effect of trade openness on firm productivity. In particular, exporters and MNEs are compared in their level of productivity and technology. In this model, a reduction in tariffs increases export revenues more than it decreases domestic or MNEs revenues, which induces more firms to adopt the new technology. The number of exporters adopting high technology increases and the number of low-tech FDIs decreases while there is no significant effect on MNEs undertaking innovation activities.

The model developed in this study is also built on the theoretical literature analyzing the effects of trade on firms technological level. This is an extension of earlier research studying the effect of trade on technological choices. Grossman and Helpman (1991) provide an exceptional analysis of the effects of integration on firms' technology and growth. Eaton and Kortum (2001) show the effect of small trade barriers on choice of innovation. Yeaple (2005) describes an alternative explanation of the economic implications of international trade in the presence of differences among firms. In his model, firms are the same when they decide to engage in a market. Differences arise when they choose to employ different technologies and systematically hire different types of workers. In a two-sector economy, firms in one sector produce a differentiated product. In this sector, firms can choose to employ medium or high technology, where the fixed investment costs for the high technology are greater than for the medium technology. In the second sector, according to Yeaple, firms produce the same product, employing a standard low technology. However, there are different types of workers. Highly skilled workers have a comparative advantage in using the high technology whereas medium skilled workers will have a comparative advantage using the medium technology. Therefore, firms that choose to use the high technology employ highly skilled workers in equilibrium. Firms that do not find it profitable to choose the high technology might still find it profitable to use the medium technology and to hire the medium skilled workers. Finally, he claims that trade

[4] "Horizontal" refers to the same stage of producing goods, while "vertical" refers to different stages of processing, for example the production of intermediate inputs for further use in the production of final products.

openness increases the share of exporters that upgrade technology.

In Bustos (2011), trade liberalization directs firms to invest and upgrade their technology to assess a better productivity level, a concept first developed by Yeaple (2005), as mentioned above. Employing a panel of around 1,400 Argentinian firms in a period of trade liberalization between Argentina and Brazil from 1991 to 1997, she finds that firms in sectors with higher reduction in tariffs were more likely to export and enhance their technology expenditures than firms in other sectors where trade opening was very small. As both new and existing exporters try to increase their productivity, she claims that when trade costs decrease, it leads to have higher profits from exporting. This lets firms to invest in better technology rather than transfer new techniques and innovations from abroad. In our work, we follow Bustos but multinational firms which engage in FDI are included in Melitz model of trade along with domestic non-exporters and exporters with technological choices, and employ ESEE to study the outcomes of the model.

The rest of this chapter is as follows: Section 3.2 describes the theoretical model and its predictions on productivity level of domestic non-exporter, exporters and FDI firms. We then explain the dataset used for verification of outcomes of the model, Section 3.3. In Section 3.4 the effect of trade liberalization on entry to the foreign market and technology upgrading is studied. Finally, we present our conclusions in Section 3.5.

3.2 Theoretical Framework

In this section, a model of monopolistic competition is presented in which firms decide to enter the market (domestic non-exporter, export, or FDI) and upgrade their level of technology. There are symmetric countries which use labor to produce outputs. Each country consists of a single monopolistically competitive industry where firms produce differentiated products under increasing returns to scale (IRS), using labor. Firms are heterogeneous in productivity and there are fixed costs of entry and fixed costs for production in domestic or foreign markets (export or FDI). Firms also can choose to pay an extra fixed cost to adopt new technology and/or upgrade their technology level, as in Yeaple (2005). Our model is borrowed from Bustos (2011) and the choice of supplying a foreign market via FDI and the subsequent foreign-owned firm's technological choice is incorporated into the model. When the firms pay the fixed cost of entry, they draw their productivity from a distribution. After observing their productivity, firms decide whether to stay in the market or exit. They then decide to export or engage in FDI, and finally, they can choose to upgrade their technology level.

Each country uses L labor units to produce differentiated products in a single industry. It is assumed both countries are symmetric. Since wages, which are the numeraire, and all other aggregate variables are the same for both countries, the model is represented for home country only.

Firms are characterized by monopolistic competition and each product i is produced by one firm, so number of firms and total number of products are the same. Marginal labor costs vary across firms using the same technology. Firms are heterogeneous in their productivity levels ω, which also indexes firms and varieties. To enter into an industry in a given country, firms pay a fixed entry cost consisting of f_e units of labor. Entrants then draw their productivity from a Pareto cumulative distribution function $F(\omega)$. Upon observing their productivity, firms may decide to exit from the market or stay and produce. If a firm decides to stay and produce, it pays fixed production costs f_d. This firm will not pay any other fixed cost to produce goods in domestic market but it pays $1/\omega$ variable costs as the marginal cost of producing with low technology. Firms can choose to upgrade their technology by paying an additional fixed cost to reduce their marginal cost of production to $1/\gamma\omega$, in which $\gamma > 1$. This can be represented as a choice between two different technologies, l and h, where h features a higher fixed cost, $(f_h > f_d)$, and a lower marginal cost $1/(\gamma\omega)$.

If a firm chooses to export, it bears an additional fixed cost f_x. In addition, goods that are exported to a country are subjected to per-unit iceberg trade costs, $(\tau > 1)$. This models that τ units need to be shipped to sell 1 unit in the foreign market. f_x is the cost of marketing and sales at the foreign country, similar to the same costs for the home market which included in f_d.

A firm can also choose to supply foreign markets by engaging in FDI, after entry. FDI firms invest f_m in the other country and sell its production there. This type of firm does not pay the iceberg trade costs τ but the amount of investment is larger than f_d and also f_x.[5] On the other hand, if it chooses to supply a foreign market via FDI, it bears additional fixed costs, f_m, in the foreign market. We assume production in another country has higher fixed costs than in home country (distribution costs are higher when the supplier is located in a foreign country as culture and language are different, and it requires additional access to knowledge about the foreign laws, etc.). Comparing cost of exporting and establishing a plant abroad, fixed costs of production abroad (f_m) should be larger as the firm should pay for building a new establishment in the foreign market. Only firms with adequately low marginal costs will be able to sell enough to cover fixed costs. Firms with the lowest marginal costs will find it profitable to pay the entry cost for both the domestic and the foreign market, while firms with intermediate productivity levels will find it profitable to pay only the entry cost for the domestic market.

3.2.1 Demand

Preferences across varieties have the standard constant elasticity of substitution (CES) form, with an elasticity of substitution $\sigma = 1/(1-\rho) > 1$, over a continuum of products (ω)

$$U = \left(\int_0^\Omega q(\omega)^\rho d\omega \right)^{1/\rho}, \tag{3.1}$$

where $q(\omega)$ is the demand function of a firm with productivity ω, and Ω represents the mass of existing varieties. Aggregate demand in real terms is measured as $Q \equiv U$, with an aggregate price

$$P = \left(\int_0^\Omega p(\omega)^{1-\sigma} d\omega \right)^{1/(1-\sigma)}. \tag{3.2}$$

[5] Similar to Helpman et al (2003). They assume that constructing foreign plants (including costs for establishing a plant, duplication of production costs, etc.) is more expensive than exporting (which includes only construction of a distribution section and market servicing).

Using (3.1) and (3.2), the demand of variety ω can be obtained as

$$q(\omega) = RP^{\sigma-1}p(\omega)^{-\sigma}, \tag{3.3}$$

where $p(\omega)$ is the price of a firm with productivity ω, R is the aggregate level of spending (revenue) in an industry which is equal to PQ.

3.2.2 Production

Preferences CES, so a monopolistic firm with productivity ω using technology l sets the price $p_l^d(\omega) = 1/\rho\omega$ in the domestic market, where $1/\omega$ represents the markup factor. This firm charges a price in the export market $p_l^x(\omega) = \tau/\rho\omega$, that imported products are more expensive. If a firm adopts new technology, h, it charges lower prices in both markets: $p_h^d(\omega) = 1/\gamma\rho\omega$, and $p_h^x(\omega) = \tau/\gamma\rho\omega$. For firms doing FDI, prices are similar to the firms that only serve the domestic market. As discussed above, it is assumed that supply a foreign market by FDI has the highest fixed cost, $(f_m > \tau^{\sigma-1}f_x > f_d)$, and the fixed cost of production using higher technology is larger than with low technology $(f_h > f_d)$.

Profits from production in the domestic market employing technology l or h can be represented respectively as

$$\pi_l^d(\omega) = B\omega^{\sigma-1} - f_d$$

$$\pi_h^d(\omega) = B(\gamma\omega)^{\sigma-1} - f_h,$$

where $B = \sigma^{-1}R(P\rho)^{(\sigma-1)}$. Additional profits from exporting are

$$\pi_l^x(\omega) = B\tau^{1-\sigma}\omega^{\sigma-1} - f_x$$

$$\pi_h^x(\omega) = B\tau^{1-\sigma}(\gamma\omega)^{\sigma-1} - f_x$$

and profits from FDI are

$$\pi_l^m(\omega) = B\omega^{\sigma-1} - f_m$$

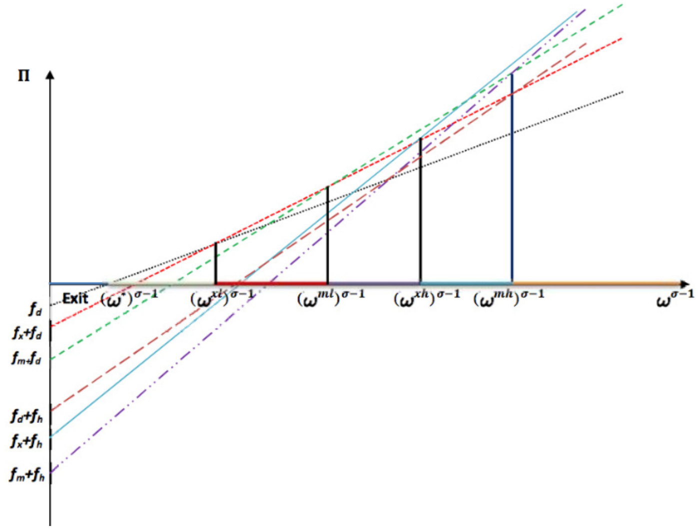
$$\pi_h^m(\omega) = B(\gamma\omega)^{\sigma-1} - f_m.$$

3.2.3 Equilibrium

A firm's decision to enter to the market and its choice of serving foreign markets (either by export or FDI) with the choice of adopting a high level of technology is presented in Figure 3.1. The six possible total profits discussed above are graphed as a function of the firm's productivity, $(\omega^{\sigma-1})$. Since $\sigma > 1$, this increases monotonically with productivity, and can be used as a productivity index. Firms' profits (six profit functions) increase as linear functions of the productivity index. More productive firms are therefore more profitable in the firm's three activities supporting domestic and foreign markets.

The figured equilibrium in Figure 3.1 is defined when $(\omega^{xl} < \omega^{ml} < \omega^{xh} < \omega^{mh})$, where ω^{xl} is the level of productivity at which a low technology firm has positive profits by exporting;

Figure 3.1: A firm's decision to serve foreign markets with technology choices



$[\Pi_l^d(\omega^{xl}) = \Pi_l^x(\omega^{xl})]$, equivalent to $\Pi_l^x(\omega) = 0$. ω^{ml} is the level of productivity above which a firm finds production with low technology profitable investing in abroad; $[\pi_l^x(\omega^{ml}) = \pi_l^m(\omega^{ml})]$. ω^{xh} is determined as the level of productivity at which an exporter finds pursuing technology h profitable; $[\Pi_l^x(\omega^{xh}) = \Pi_h^x(\omega^{xh})]$, and ω^{mh} is the level of productivity above which a FDI finds adoption of productivity h profitable; $[\Pi_l^m(\omega^{mh}) = \Pi_h^m(\omega^{mh})]$, see Appendix A for details.

In the equilibrium, firms are classified into six different groups

- Exit: The least productive firms ($\omega < \omega^*$) exit. There is free entry to the market, so the exit cutoff ω^* is defined by

$$\Pi_l^d(\omega^*) = 0 \ or \ \ B(\omega^*)^{\sigma-1} - f_d = 0, \tag{3.4}$$

  then the lowest cut off productivity may be rewritten as

$$\omega^* = \left(\frac{f_d}{B}\right)^{\frac{1}{\sigma-1}}. \tag{3.5}$$

  This equation implies that firms with productivity below ω^* exit from the market.

- Domestic non-exporter firms: The low productive firms ($\omega^* < \omega < \omega^{xl}$) only serve the domestic market and use technology l.

- Export with low technology: Low technology exporters have higher productivity than domestic non-exporter firms. To find their cut off productivity (ω^{xl}), it is necessary that $\Pi_l^d(\omega^{xl}) = \Pi_l^x(\omega^{xl})$, then

$$B\tau^{1-\sigma}(\omega^{xl})^{\sigma-1} = f_x \tag{3.6}$$

  To compare this to the domestic cut off productivity, it is divided by (3.5),

$$\frac{\omega^{xl}}{\omega^*} = \tau \left(\frac{f_x}{f_d}\right)^{\frac{1}{\sigma-1}}. \quad (3.7)$$

Since $\tau^{\sigma-1} f_x > f_d$, then $\omega^{xl} > \omega^*$, which shows that only more productive firms export.

- Low-tech FDI: The medium productive firms ($\omega^{ml} < \omega < \omega^{xh}$) use technology l undertaking FDI. ω^{ml} can be expressed in terms of ω^* using the difference condition between export and FDI, $\pi_l^m(\omega^{ml}) = \pi_l^x(\omega^{ml})$,

$$B(\omega^{ml})^{\sigma-1} - f_m = B\tau^{1-\sigma}(\omega^{ml})^{\sigma-1} - f_x. \quad (3.8)$$

To compare cases, (3.8) is divided into (3.5) and (3.6),

$$\frac{\omega^{ml}}{\omega^*} = \frac{1}{(1-\tau^{1-\sigma})^{\frac{1}{\sigma-1}}} \left(\frac{f_m - f_x}{f_d}\right)^{\frac{1}{\sigma-1}} \quad (3.9)$$

$$\frac{\omega^{ml}}{\omega^{xl}} = \frac{1}{\tau(1-\tau^{1-\sigma})^{\frac{1}{\sigma-1}}} \left(\frac{f_m - f_x}{f_d}\right)^{\frac{1}{\sigma-1}} \quad (3.10)$$

Comparing the above equations and since $\varphi^{ml} > \omega^*$, it implies $1/(\tau(1-\tau^{1-\sigma})^{\frac{1}{\sigma-1}})((f_m - f_x)/f_d)^{\frac{1}{\sigma-1}} > 1$, then it follows that $\omega^{ml} > \omega^{xl}$. In other words, only the medium productive firms with low technology undertake FDI.

- High-tech Exporters: Firms with productivity range of $\omega^{xh} < \omega < \omega^{mh}$ export and upgrade their technology, h. The cutoff productivity of high technology exporters ω^{xh} is defined by $\Pi_h^x(\omega^{xh}) = \Pi_l^m(\omega^{xh})$,

$$(1 - \tau^{1-\sigma}\gamma^{(\sigma-1)})(\omega^{xh})^{\sigma-1} = f_h + f_x - f_m - f_d \quad (3.11)$$

Firms upgrade their technology to have higher profits (since demand is elastic, $\sigma > 1$) but they pay more fixed cost.

To compare high technology exporters and low technology FDI cut offs

$$\frac{\omega^{xh}}{\omega^{ml}} = \frac{(1-\tau^{1-\sigma}\gamma^{(\sigma-1)})}{1+\tau^{1-\sigma}} \frac{1}{\gamma^{\sigma-1}-1} \left(\frac{f_h + f_x - f_m - f_d}{f_m - f_x}\right)^{\frac{1}{\sigma-1}}. \quad (3.12)$$

For $\omega^{xh}/\omega^{ml} > 1$, the sunk cost of technology relative to sunk cost of FDI must be high enough considering the RHS of (3.12).

- High-tech FDI: The most productive firms ($\omega^{mh} < \omega$) engage in FDI and upgrade their technology level. Their cut off productivity, ω^{mh}, can be expressed in terms of ω^* using the difference condition between being FDI and utilizing low or high technology, $\Pi_h^m(\omega^{mh}) = \Pi_h^x(\omega^{mh})$,

$$B(\omega^{mh})^{\sigma-1}\gamma^{\sigma-1}(1-\tau^{\sigma-1}) = f_m - f_x \quad (3.13)$$

To compare of high technology FDI and low technology domestic non-exporter firms, we use (3.5) to derive

$$\frac{\omega^{mh}}{\omega^*} = \left(\frac{\gamma^{\sigma-1}(1-\tau^{\sigma-1})}{\gamma^{\sigma-1}-1} \frac{f_m - f_x}{f_d}\right)^{\frac{1}{\sigma-1}}. \quad (3.14)$$

The RHS of (3.14) must be larger than 1 to allow a high technology FDI active in the market. To compare compare cut off productivity of high technology FDI and high technology exporters,

$$\frac{\omega^{mh}}{\omega^{xh}} = \left(\frac{\gamma^{\sigma-1}(1-\tau^{\sigma-1})}{1+\tau^{(1-\sigma)}}\right)^{\frac{1}{\sigma-1}} \left(\frac{f_h + f_x - f_m - f_d}{f_m - f_x}\right)^{\frac{-1}{\sigma-1}}, \tag{3.15}$$

Since $\tau > 1$ inequality (3.15) is always true and high technology foreign owned firms are always more productive than high technology exporters. A FDI firm's investment should be high compared to the fixed cost of exporting and fixed cost of production for the domestic market. The level of their technology depends on γ. Having larger productivity allows them to supply the foreign market and adopt higher technology to cover their fixed costs. In addition, the higher γ, the higher is the share of firms undertaking FDI and adopting high technology.

In monopolistic equilibrium, firms set prices and the number of products is defined by the free entry condition. Free entry means the total expected profits is equal to the fixed entry cost f_e,

$$f_e = [1 - F(\omega^*)]\frac{1}{\delta}\Pi, \tag{3.16}$$

where $[1 - F(\omega^*)]$ is the probability of survival, Π are per-period expected profits of surviving firms, and δ is an exogenous probability of exit. The cumulative distribution function of survival is defined as $F(\omega) = 1 - \omega^k$. After solving for the free entry, following Bustos (see appendix A for details on the equilibrium, definition of expected profits and details of calculations), the equilibrium cut off productivity of domestic non-exporter firms is

$$\omega^* = \left(\frac{f_d}{\delta f_e}(\frac{\sigma-1}{k-\sigma-1})\right)^{\frac{1}{k}} \Delta^{\frac{1}{k}} = B\Delta^{\frac{1}{k}}, \tag{3.17}$$

where $\Lambda = \left(\frac{f_d}{\delta f_e}(\frac{\sigma-1}{k-\sigma-1})\right)^{1/k}$, and Δ is a function of fixed costs and trade ice-berg cost as described in appendix A. Similar to the domestic cut off productivity, cut off productivity the other groups of firms are

$$\omega^{xl} = \Lambda\Delta^{(1/k)}\tau\frac{f_x}{f_d}^{(\frac{1}{\sigma}-1)}, \tag{3.18}$$

$$\omega^{ml} = \Lambda\Delta^{1/k}\left(\frac{1}{1-\tau^{1-\sigma}}\frac{f_m - f_x}{f_d}\right)^{(\frac{1}{\sigma}-1)}, \tag{3.19}$$

$$\omega^{xh} = \Lambda\Delta^{1/k}\frac{1}{1+\tau^{1-\sigma}}\frac{1}{\gamma^{\sigma-1}-1}\frac{f_h - f_x}{f_d}^{(\frac{1}{\sigma}-1)}, \tag{3.20}$$

and

$$\omega^{mh} = \Lambda\Delta^{1/k}\frac{1}{\gamma^{\sigma-1}-1}\frac{f_h - f_d}{f_d}^{(\frac{1}{\sigma}-1)}, \tag{3.21}$$

respectively.

Equations (3.20) and (3.21) show that increasing γ (or in other words, if firms can set much lower prices by adopting technology) decreases the cut off productivity of adopting high technology (ω^{xh} and ω^{mh}), and the share of firms that upgrade technology increases. If the fixed cost of exporting increases, then the share of firms with FDI increases (since their cut off productivity decreases) and the share of exporters also decreases. If the sunk cost of adopting high technology increases, it means it is difficult to adopt technology and only few firms with very high level of productivity adopt high technology. Then if f_h increase, since $\partial\Delta/\partial f_h > 0$ and $k > \sigma - 1$, all the cut off productivities decrease. Comparing cut off productivities shows that variable trade cost directly affects cut off productivities of exporters and FDIs using low technology but not FDIs adopting high technology.

3.2.4 Effect of opening to trade on a firm's decision

Reduction in trade costs increases export profits, more firms enter the export market, exit productivity cut off increases and the share of high/low technology exporters increases, as shown in Bustos (2011).[6] However, reduction in trade costs decreases FDI revenues and induces more foreign firms to leave the market, to the advantage of exporters. Expected profits from FDI decrease, i.e, $\partial\Pi_m/\partial\tau > 0$. By inducing more entry of foreign exporters into the industry, trade liberalization reduces the price index and thus firms that only supply the domestic market loose revenue. When the variable trade costs (τ) fall, the least productive firms cannot compete with the other firms and exit from the market. The fraction of surviving exporters ($\Omega_{xl} = (\omega^{xl}/\omega^*)^{-k}$ share of low-tech exporters, $\Omega_{xh} = (\omega^{xh}/\omega^*)^{-k}$ share of high-tech exporters) increases. The fraction of surviving of firms that use technology l doing FDI ($\Omega_{ml} = (\omega^{ml}/\omega^*)^{-k}$) and the fraction of surviving of firms that use technology h doing FDI ($\Omega_{mh} = (\omega^{mh}/\omega^*)^{-k}$) decrease.

Thus, the model shows that reduction in variable trade cost induces more FDI firms to exit the market and the number of firms undertaking FDI and upgrade technology h decreases. However, the number of high technology FDI firms that leave the market is smaller than the number of foreign-owned firms with low technology. This is because the variable trade cost directly affects cut off productivity of FDIs using low technology but indirectly affects the cut off productivity of FDIs with high technology. As the cut off productivity of those exiting the market increases, the number of firms in the market decreases.

For some FDIs that adopt high technology before liberalization, adoption of high technology after trade costs decrease is not profitable. We cannot define this for comparative statistics, but since investments are irreversible, then some firms that should leave the market may change their strategy and produce with low technology in home market or continue to supply the foreign market with low technology, as their productivity is very high. After trade liberalization, the cut off productivity of exporters decreases and this makes adoption of the new technology profitable for the most productive exporters, as they would have more income. However, firms supplying the domestic market or supplying the foreign market via FDI lose revenue, and few of them can upgrade technology.

[6] As mentioned previously, we assume $f_m > \tau^{\sigma-1} f_x > f_d$ and $f_h > f_d$. For the details see Appendix A

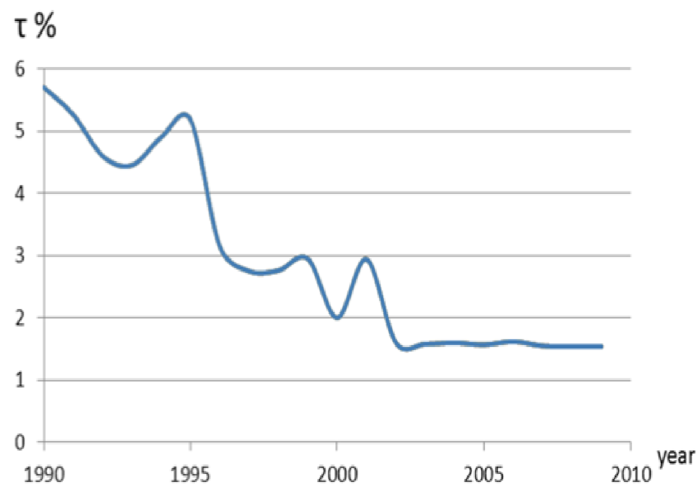
3.3 Data Description

Two data sets are described that are used for empirical estimations. Trade data was supplied from WTO and World Bank statistics on European industry tariffs. Firm level dataset (ESEE) have been used and extensively detailed in previous chapters, so we omit the details and only mention specific relevant information.

3.3.1 Trade reduction costs

Figure 3.2 shows tariff rate data from World Bank and WTO trade statistics. There is a period of tariff reductions from 1995 to 2002, in which the Spanish weighted average tariff decreased from 5.8% to almost 1.6%, then a relatively constant tariff in manufacturing sectors (1.6%)[7].

Figure 3.2: Spanish weighted manufacturing tariffs 1990–2009



Sources: World Bank & WTO

Weighted average tariffs of each industry for 1995 (before tariffs reduction) and 2002 (after tariffs reduction) are presented in Figure 3.6 in Appendix B. As it shows beverage and food industries have the most reduction in tariffs. The European Union Market, which was formally established some time previously, also came into force on 1 November 1993 for Spain. There are also other trade agreements between Spain and other countries, including: at the bilateral level, the EU negotiated framework cooperation agreements with Argentina (1990), Brazil (1995), Paraguay (1991), and Uruguay (1992); and since 1995, the New Transatlantic Agenda was the basis for bilateral

[7]The weighted average tariff is the average of effectively applied tariffs weighted by the product import shares corresponding to each partner country. Manufactured products are commodities classified in SITC revision 3 sections 5–8, excluding division 68.

relations with USA.[8] These show the source of economic openness and also of trade shock on performance.

3.3.2 Industry data

As mentioned above, we employ ESEE for firm level data.[9] Since ESEE are used in previous chapters, we omit descriptive statistics and only emphasize on the statistics of firms in the international market. A firm is defined to be an exporter if it sells any positive magnitude of its production in a foreign market. In each year, an index was created that showed if a firm was an exporter (1) or not (0) [10], exporters are firms with any positive amount of export. Domestic non exporters are firms that do not export nor are foreign owned (index d=1 if domestic non exporters and 0 otherwise). Foreign owned firms (FDIs or MNEs) are defined based on the OECD Benchmark Definition of FDI[11], they are firms with at least 10% of foreign ownership.[12] ESEE reports if a firm has any positive expenses in R&D activities and undertakes any process or product innovation. In this study, a firm which undertakes process and/or product innovations is defined as a high-tech firm (high-tech exporters/FDIs) otherwise it is a low-tech firm.

Table 3.1 reports the total number firms and exporter, FDI, and high-tech FDI shares for each year. Approximately from 2187 firms in 1990, 17% are FDI, and 35% are domestic non exporters. Exporters share averages 63.5%, growing from 47% in 1990 to 65% in the second period.[13] These shares are compatible with other papers and data sets, e.g. Frainas(2003), among others.[14] In the theoretical model, it is predicted that the share of exporters increases after trade openness. Comparing the first (1990–1995) and second (2001–2004) period after tariffs reduction, exporter share increased from 56% to 65% on average. FDI share decreased from 17% in 1991 to 4% in 2001 and to 6%–7% after 2002, as the theoretical model predicted. There is some lag between the tariff reduction and its effect on the firm's status in foreign markets. However, the foreign owned fraction clearly decreases, given that lag. Since most of firms' capitals are irreversible, FDIs cannot change contemporaneously and be compatible with the tariff reduction. High-tech FDI ratio is the fraction of High tech firms in total firms which undertake FDI. There is not a huge change in the share of

[8] http://www.comercio.mineco.gob.es/en/comercio-exterior/omc-otros-organismos-internacionales-comercio/pages/la-organizacion-mundial-de-comercio-omc.aspx

[9] see for details: http://www.fundacionsepi.es/esee/sp/spresentacion.asp

[10] We are used the same index as Bernard et al. (2007), Epifani (2003) and Mayer & Ottaviano (2008).

[11] OECD Benchmark Definition of Foreign Direct Investment, 2008: Direct investment enterprises are corporations, which may either be subsidiaries, in which over 50% of the voting power is held, or associates, in which between 10% and 50% of the voting power is held.

[12] see also Farina Jose (2003) and Gaudalupe et al. (2011)

[13] Mayer & Ottaviano (2008), show that the share of exporters is approximately 65%, 60%, 45%, 75%, and 40% for France, Germany, Hungary, Italy, and Norway, respectively. The higher rates for France, Germany, and Italy reflect the biases towards relatively large producers. Ferragina and Quintieri (2000) reported that, for a sample of the Italian manufacturing firms (Mediocredito Centrale), the average export rates for1995-1997 was approximately 40%. The participation rates for Sweden were similar to Italy (71% for export) for firms with more than 10 employees. Belgium exporters comprise 41% of all firms (Muuls and Pisu, 2007).

[14] Also see Castellani et al. (2008).

Table 3.1: Total number of firms, Export and FDI shares

Year	N. firms	Exporters%	Nonexport FDI%	High-Tech FDI %
1990	2187	47	17	10
1991	2059	51	15	12
1992	1977	52	13	12
1993	1869	53	12	11
1994	1876	56	10	12
1995	1702	59	8	13
1996	1716	60	9	12
1997	1920	62	8	12
1998	1776	64	6	13
1999	1751	62	7	12
2000	1867	65	6	12
2001	1723	65	4	12
2002	1708	64	7	13
2003	1819	64	7	12
2004	1931	65	6	13

high-tech FDIs during the period, it is 10-12 % in 1990-1994 and is 12-13 % after 1995. As the model predicted, the reduction of high-tech FDI is smaller comparing to the low-tech ones.

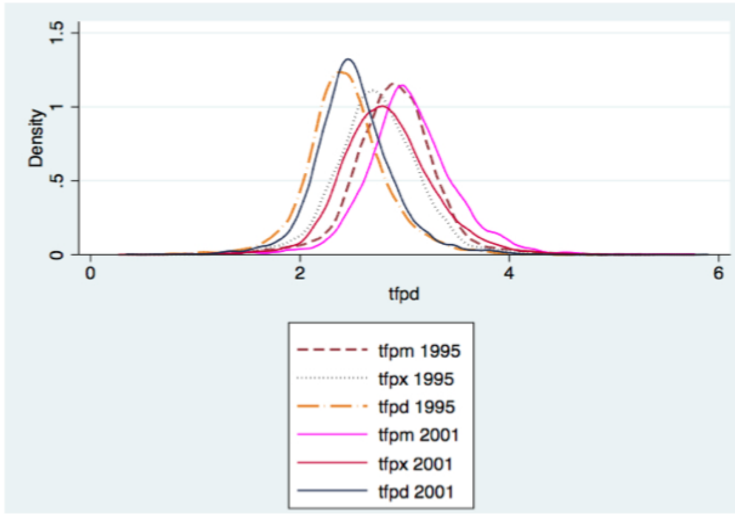
3.4 Empirical Work

Following Olley and pakes (1996) total factor productivity (TFP) is computed (as in the first chapter). Typical TFP in log-value is defined as

$$\omega_{it} = q_{it} - \hat{\alpha} k_{it} - \hat{\beta} l_{it} - \hat{\gamma} m_{it}, \tag{3.22}$$

where ω_{it} is the TFP of firm i at time t; and q_{it}, k_{it}, m_{it}, and l_{it} are the log of output, stock of physical capital, materials, and employment, respectively. We omit previously detailed method of productivity estimation, and turn directly to descriptive statistics. To show the productivity differences before and after the period of tariffs reduction, we first emphasize some details of TFPs. The estimated TFP of three types of firms, domestic non-exporter (tfpd), exporters (tfpx) and FDIs (tfpm) before and after trade liberalization is shown in Figure 3.3. TFP of all three types of firms increased: low productive firms cannot compete and exit the market, and so the average productivity increases. On average FDIs are the most productive firms, and exporters are more productive than non-exporters. In other words, an expected drawn TFP of an FDI firm is higher than an exporter and in return, an expected drawn productivity of an exporter is higher than a domestic non-exporter firm.

Figure 3.3: TFP density before and after reduction in the trade cost



A stylized representation of TFP distribution of Spanish manufacturing firms for 1994 (before tariffs reduction) and 2002 are presented in Figure 3.4 and Figure 3.5 respectively, similar to Mayer and Ottaviano (2008)[15], y is density and x is TFP. This figure is utilized to present the effect of decreasing trade cost on marginal TFP of firms. A long and thin left tail of very unproductive firms is assumed statistically negligible, and ω^* is adjusted to 1. The emerging downward slope shows that the share of high productivity to other firms is small. There are three thresholds, the first separates exporters from domestic non-exporter firms (ω^{xl}), the second separates horizontal FDIs from exporters (ω^{ml}), and the third separates the high-tech exporters and FDIs from other firms (ω^h).

The most productive firms are those which adopt a high level of technology, and the productivity of FDIs is higher than exporters, $\omega^{xl} < \omega^{ml} < \omega^h$. This explains the effect of decreasing tariffs on cut-off productivities, as shown in Figure 3.5 for year 2002. The reduction in tariff costs has decreased marginal cut-off the TFP of exporters and increased cut-off productivity of FDIs, as predicted by the theoretical model. Productivity of domestic non-exporters and foreign-owned firms decreases. To check if the outcomes of the model and our data, we divided firms into three groups: domestic non-exporter, exporter, and foreign-owned, and estimated the effect of reduction in tariffs for status of firms in each category. In this study, we focused on domestic non-exporter, FDI, and high-tech FDI categories. During the period of tariff reduction, FDI firms share decreased from 17% to 7% as discussed above, while there was not a significant effect on high-tech FDI firms. To test the predictions of the theoretical model, we estimate the effects of a linear regression of tariff to the FDI status. The Probit model for market selection (for FDIs) is

[15]The stylized representation is obtained by fitting the best Pareto distribution to the actual distribution. See appendix A and Del Gatto, Mion, and Ottaviano (2006) for details.

Figure 3.4: Pareto distribution of estimated total factor productivity (1994)

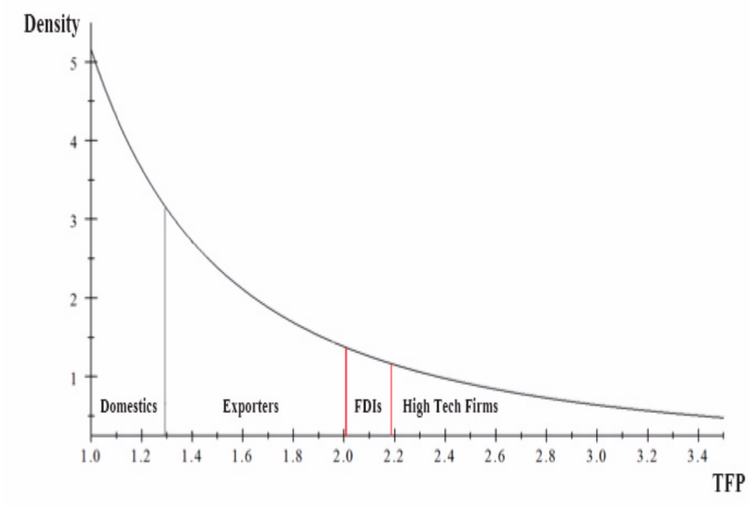
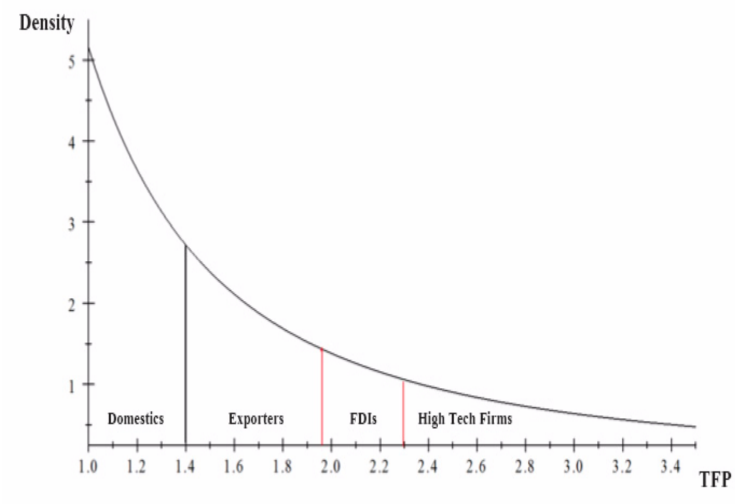


Figure 3.5: Pareto distribution of estimated total factor productivity (2002)



$$fdi_{ijt} = \begin{cases} 1 \quad if \quad \beta_\tau \tau_{jt} + \beta_0 + \alpha_{ij} + \lambda_{st} + \varepsilon_{ijt} > 0 \\ 0 \qquad Otherwise \end{cases} , \tag{3.23}$$

where fdi is a dummy variable that shows the status of a firm in supplying foreign markets by engaging in FDI (1 if firms engage in FDI and 0 otherwise), τ_t is the average weighted tariff rate of industry j, λ_{st} is the sector dummy variable at time t, α_{ij} is the fixed effect of the unobserved characteristic of firm i in industry j, ε_{ijt} is the error term, t is the time index, j the industry index, and i the firm's index. This regression with firm fixed effect α_{ij} cannot be estimated consistently by the Probit model as it has the incidental parameters problem, as described by Bustos (2011). However, it can be estimated using linear probability model

$$fdi_{ijt} = \beta_\tau \tau_{jt} + \beta_0 + \alpha_{ij} + \lambda_{st} + \varepsilon_{ijt}. \tag{3.24}$$

Regression (3.24) has the firm's fixed effect and cannot be consistently estimated directly. Hence, we use the differences to eliminate the fixed effects

$$\Delta fdi_{ij} = \beta_\tau \Delta\tau_j + \Delta\lambda_s + \Delta\varepsilon_{ij} \tag{3.25}$$

The final equation can be estimated consistently using the OLS method. The results of estimation are reported in Table 3.2, at the second column as regression (1). The reported standard errors are clustered by the industry level. The standard errors are clustered by industry level. The coefficient of the tariffs changes is positive and significant, $\beta = 0.07$ ($t = -2.67$). This implies that reduction in Spanish tariffs by 1% increases exit of FDI firms from the market by 6%.

Since capital stock is irreversible and there is normally a sunk FDI costs, current FDI status might depend on lagged FDI status, and a potential problem of the specification may be accrued. FDI is also likely to be positively correlated with its previous status and tariffs rate. To solve this, a robust test of (3.25) is

$$\Delta FDI_{ij} = \beta_\tau \Delta\tau_{jt} + \beta_{ij}\hat{\alpha}_{ij} + \Delta\lambda_s + \Delta\varepsilon_{ij}, \tag{3.26}$$

where $\hat{\alpha}_{ij}$ is the characteristic of firm i in industry j at initial levels before reduction in tariffs (year=1991), such as size (measured by the number of workers), materials and sales per worker (reported as Firm Control in the tables). This robust check is reported in the second column of Table 3.2. It implies that reduction in the tariffs rate by 1% on average increases exit of FDIs from the market by 4%.

As mentioned previously, a firm that has performed process and/or product innovations is a high-tech firm otherwise it is a low-tech one. To verify the differences between low and high tech firms we separate FDIs to low and high tech FDIs and run the previous regressions. The effects of tariff reduction on changes of the low/high tech FDIs status are reported in Table 3.3. Fraction of low-tech FDIs decreases by 7% (the second and the forth columns). However, the effect of tariffs reduction on high-tech FDIs is negative and insignificant (the first and the third columns). It means trade openness in Spain mostly affect FDI with low level of technology while high-tech FDIs have not affected. This may shed a light on the importance role of technology for surviving in the foreign market. These findings support the prediction of the theoretical model.

To investigate the effect of the reduction in Spanish tariffs on domestic non-exporters, we run the same regression for domestic non-exporters and Table 3.4 reports the results. Regression (1) in Table 3.4 is OLS estimation from (3.25) for domestic non-exporters. The results imply that a 1% reduction in tariffs decreased the domestic non-exporter firms by 8%. Results for the low and high technological domestic non-exporters are presented in column (2) and (3), respectively. The effect is much higher for low technology domestic non-exporters (10%, regression (2)) rather than high technology domestic non-exporters (4%), regression (3). Table 3.7 in Appendix B reports the

Table 3.2: Change in FDI status to tariffs reduction (1995–2002)

	(1)	(2)
Δ tariffs	0.06	0.04
	(0.02)**	(0.01)**
Cons.	3.39	2.36
	(1.12)**	(0.89)*
Firm Control	No	yes
Industry dummies	yes	yes
Observation	2025	1782
R-squared	0.03	0.03

Notes: * indicates significant at 10%; ** significant at 5%; This table reports the regression of the change in the FDI status to the tariff changes between 1995 and 2002. Regression (1) reports equation (3.25) and regression (2) is a robust check of (1), equation (3.26). Firm Controls are total factor productivity, materials, and sales per worker for 1991. Standard errors are in ().

Table 3.3: Change in FDI status (high and low technology) and Tariffs reduction 1995–2002

	(1)	(2)	(3)	(4)
Δ tariffs	-.01	0.07	-.017	0.07
	(0.13)	(0.02)**	(0.13)	(0.01)**
Cons.	-0.87	4.51	-0.80	4.2
	(0.61)	(1.23)**	(0.81)	(1.10)**
Firm Control	No	No	yes	yes
Industry dummies	yes	yes	yes	yes
Observation	187	806	169	675
R-squared	.15	.13	.10	0.08

Notes: * indicates significant at 10%; ** significant at 5%, Standard errors are in (); This table reports the regression of change in the FDI status (for high and low technology firms) on tariff changes between 1995 and 2002. Regressions (1) and (3) are for high technology FDIs from Equations (3.25) and (3.26), Regressions (2) and (4) are for low technology FDIs for the same equations, respectively. In regressions (1) and (2) we did not consider firms initial level controls.

same regression; the effect of tariff reductions on the status of domestic non-exporter firms when we include industry dummies and initial firms status for low/high-tech domestic firms (robustness check). All the domestic non-exporters are included in regression (1) but in regressions (2) and (3) only low and high technology domestic non-exporters are included, respectively. For all the domestic non-exporters, when we include industry and firm controls, domestic firms decreased 16%

Table 3.4: Domestic non-exporters and Tariff changes 1995–2002

	(1)	(2)	(3)
Δ tariffs	0.08	0.10	0.04
	(0.05)*	(0.02)**	(0.07)*
Cons.	4.99	6.2	3.1
	(1.03)**	(1.23)**	(1.18)*
Industry dummies	yes	yes	yes
Observations	2387	1109	806
R-squared	0.03	0.05	0.03

Notes: * indicates significant at 10%; ** significant at 5% Standard errors are in (); This table reports the regression of change in status of domestic non-exporter firms against tariff changes between 1995 and 2002. Regressions (1) contains all the domestic non-exporter firms, whereas (2) and (3) are for low and high technology domestic non-exporter firms, respectively.

and 19% respectively. Column (3) reports there is a negative effect from tariff reductions for low technology domestic non-exporters but it is not significant.

For comparison reason, we run more robustness checks considering initial firms status before tariffs reduction. Table 3.5 reports the effect of tariff reductions on two different groups: FDI firms which were initially non exporters in 95-96 and those which were foreign-owned in 1995-1996 (before tariff reduction period). Tariff reductions decrease fraction of foreign-owned firms by 4%–6% on average, see Table 3.2. Considering the initial FDI status as non-exporters in 95-96, reduction in FDIs are similar to all the FDIs, fraction of FDIs that are non-exporters in 95-96 decrease by 5%–6%. Whereas, the effect is larger for foreign-owned firms that are initially FDI in 1995-1996, the fraction of foreign-owned firms which are initially FDI in 95-96 dropped by 23%–28% from 1995 to 2007.

We also run similar regressions for domestic firms which are initially non-exporters in 95-96. The effect of tariff reductions on domestic non-exporter firms, which initially supply the domestic market for 1994-1995 and have not been exporters, is reported in Table 3.6. Reduction for domestic non-exporter firms is similar considering their initial status as domestic non-exporters in 95-96 in the regression and there is no significant differences between effect of trade openness on domestic non-exporters' initial status and full sample of domestic non-exporters. This implies that initial status of domestic non-exporters is not important in verifying the effect of tariff reductions on firms status. However, FDI initial status is significantly important in surviving for FDI firms.

Table 3.5: Change of FDI status and tariffs changes 1995-2002

	non-exporter in 95-96		FDIs in 95-96	
	(1)	(2)	(3)	(4)
Δ tariffs	0.06	0.05	0.28	0.23
	(0.03)**	(0.03)*	(0.05)**	(0.04)*
Cons.	3.54	3.8	17.3	13.9
	(1.04)**	(1.13)**	(2.28)**	(1.87)*
Firm Control	no	yes	no	yes
Indus. dum.	yes	yes	yes	yes
Obs.	806	570	470	284
R-squared	0.07	0.08	0.15	0.15

Notes: * indicates significant at 10%; ** significant at 5%; This table reports the result of regressing the change in the FDI status to changes in tariffs between 1995 and 2002. (1) and (3) are for estimating Equation (3.25), and (2) and (4) for robustness check, Equation (3.26). Firm level controls are TFP, capital intensity and labor intensity in 1991.

Table 3.6: Domestic non-exporters and Tariffs changes 1995-2002

	Full sample of Domestic non-exp.			Domestic non-exp. in 95-96		
	(1)	(2)	(3)	(4)	(5)	(6)
Δ tariffs	0.08	0.10	0.05	0.10	0.09	0.07
	(0.05)*	(0.02)**	(0.32)	(0.05)*	(0.05)*	(0.18)
Cons.	5.49	6.2	5.1	5.8	9.03	4.04
	(1.96)*	(2.13)**	(3.31)	(1.08)*	(2.17)*	(0339)
Indu. dums.	yes	yes	yes	yes	yes	yes
Obs.	2387	1092	1012	1460	777	732
R-squared	0.03	0.04	0.06	0.08	0.05	0.07

Notes: * indicates significant at 10%; ** significant at 5%, Standard errors are in (); This table reports the result of regressing the change in the domestic non-exporters status on tariffs reduction between 1995- 2002. (1) and (3) are for the full sample of domestic non-exporters and (2) and (4) for low tech domestic non-exporters, and (3) and (6) for high tech domestic non-exporters.

3.5 Conclusion

We developed a model of international trade in which firms can jointly decide to supply the domestic market, export, or engage in FDI and choose their level of technology. Firms are heterogeneous in productivity and after deciding to enter or exit the market, they can pay a sunk cost to upgrade their technology. In equilibrium, the least productive firms leave the industry as their profit needs to be larger than the entry cost. Other low productivity firms choose to supply only the domestic market. More productive firms supply the foreign market via export or FDI. The most productive firms tend to upgrade to a high level of technology.

Our model predicts that after trade openness, exporters tend to supply the foreign markets more than FDI firms, the fraction of exporters increases. Cut off productivity of FDIs increases after tariff reductions but FDIs with high technology will be less affected than those with low level technology. Low-tech FDIs leave the market more than FDIs with high level of technology. Upgrading the level of technology may help the FDI firms to overcome reduction in their profits and survival after tariffs reduction.

We employed Spanish manufacturing dataset to investigate the predictions of our model. Firms were categorized into domestic non-exporter, exporter, and FDI types. Since information on a firm's innovation activities was included in the dataset, they were subdivided into high and low technology types. High technology firms were those which performed product and/or process innovations. Trade data was sourced from import tariff statistics of WTO and the World Bank. This showed a period of reduction in average weighted tariffs in Spain from 1993–1997. This tariff reduction was employed to probe the effect of trade openness on firm status in foreign markets.

Domestic non-exporters also leave the market after tariff reductions. Their share decreased by 7%–19% for a 1% decrease in weighted average tariffs. During the period of tariff reduction, low technology FDI firms decreased 10%, but high technology FDI firms were little affected. There was also no negative effect of trade openness on FDIs with high technology. Since there was no significant effect of tariff reduction on high technology FDI firms, it may point out that upgrading to a higher level of technology helps FDIs to overcome the negative effects of tariff reduction and continue to compete with other firms in the market.

3.6 Appendix A Theoretical Calculations

Equilibrium.– As mentioned in the Theoretical section, Π are per-period expected profits of surviving firms and δ is an exogenous probability of exit. Thus, a firm's profits can be one of the followings

- $\Pi_l^d = \pi_l^d(\omega)$,
- $\Pi_h^d = \pi_h^d(\omega)$,
- $\Pi_l^x = \pi_l^d(\omega) + \pi_l^x(\omega)$,
- $\Pi_h^x = \pi_h^d(\omega) + \pi_h^x(\omega)$,
- $\Pi_l^m = \pi_l^d(\omega) + \pi_l^m(\omega)$, or
- $\Pi_h^m = \pi_h^d(\omega) + \pi_h^m(\omega)$.

In equilibrium, firms set prices and number of products is defined by free entrance. Free entry means total expected profits is equal to the fixed entry cost (f_e):

$$f_e = [1 - F(\omega^*)]\frac{1}{\delta}\Pi \tag{3.27}$$

where $[1 - F(\omega^*)]$ is the probability of survival, Π are per-period expected profits of surviving firms and δ is an exogenous probability of exit. $\Pi = \Pi_d(\breve{\omega}^d) + p_x\Pi_x(\breve{\omega}^x) + p_m\Pi_m(\breve{\omega}^m)$,where Π_d are expected profits from domestic sales. $p_x = [F(\omega^m) - F(\omega^x)]/[1 - F(\omega^*)]$ is the probability of exporting conditional on surviving and Π_x expected exporting profits. $p_m = [1-F(\omega^m)]/[1-F(\omega^*)]$ is the probability of doing FDI conditional on surviving and Π_m expected FDI profits. After solving for the free entry as Bustos (2011), cut off productivity obtained as follows. Expected profits can be presented as

$$\Pi = \Pi_d(\omega^d) + p_{xl}\Pi_{xl}(\omega^{xl}) + p_{ml}\Pi_{ml}(\omega^{ml}) + p_{xh}\Pi_{xh}(\omega^{xh}) + p_{mh}\Pi_{mh}(\omega^{mh})$$

where $\Pi_d(\omega^d)$ are profits from domestic production and its sales in the home country

$$\Pi_d = \frac{1}{\sigma}E(P\rho)^{\sigma-1}(\omega^d)^{\sigma-1} - f_d - f_h\frac{1 - F(\omega^h)}{1 - F(\omega^*)}$$

and ω^d is the productivity of domestic non-exporter firms

$$\omega^d = (\int_{([\omega^*<\omega<\omega^h)} \frac{\omega^{\sigma-1}(g(\omega))}{1 - F(\omega^*)}d\omega + \int_{(\omega^h<\omega)} \gamma^{\sigma-1}\frac{\omega^{\sigma-1}(g(\omega))}{1 - F(\omega^*)}d\omega)^{(\frac{1}{\sigma}-1)}$$

For the exporting firms, we have the same only $[F(\omega^{ml})-F(\omega^{xl})]/[1-F(\omega^*)]$ is the probability of exporting conditional on surviving and $\Pi_{xl}(\omega^{xl})$ is expected exporting profits. $[F(\omega^{xh})-F(\omega^{ml})]/[1-F(\omega^*)]$ is the probability of exporting conditional on surviving and $\Pi_{ml}(\omega^{ml})$ expected profits for FDIs using low technology. $\Pi_{ml}(\omega^{ml}) = (\omega^{ml}(\omega^*))^{\sigma-1} - f_m$ and ω^{ml} is the expected productivity level of FDI firms

$$\omega^{ml} = (\int_{(\omega^m<\omega<\omega^{xh})} \frac{\omega^{\sigma-1}(g(\omega))}{1-F(\omega^*)} d\omega)^{(\frac{1}{\sigma}-1)}$$

$[F(\omega^{mh}) - F(\omega^{xh})]/[1 - F(\omega^*)]$ is the probability of doing FDI with high technology conditional on surviving and $\Pi_{mh}(\omega^{mh})$ expected profits for FDIs using high technology.

$$\omega^{mh} = (\int_{(\omega^{mh}<\omega)} \gamma^{\sigma-1} \frac{\omega^{\sigma-1}(g(\omega))}{1-F(\omega^*)} d\omega)^{(\frac{1}{\sigma}-1)}$$

To solve for the free entry condition (equation 3.27) we need to solve for the expected profits Π.

$$\Pi = \frac{\sigma-1}{k-\sigma-1} f_d \Delta \tag{3.28}$$

$$\Delta = 1 + \tau^{-k} \left(\frac{f_x}{f_d}\right)^{\frac{1-k}{\sigma-1}} + \frac{1}{(1-\tau^{1-\sigma})}^{\frac{-k}{\sigma-1}} \left(\frac{f_m - f_x}{f_d}\right)^{\frac{\sigma-1-k}{\sigma-1}} + \frac{1}{\left(1+\tau^{(1-\sigma)}(\gamma^{\sigma-1}-1)\right)^{\frac{k}{\sigma-1}}} \left(\frac{f_h - f_d}{f_d}\right)^{\frac{\sigma-1+k}{\sigma-1}}$$
$$+ \left(\frac{1}{(\gamma^{\sigma-1}-1)^{\frac{-k}{\sigma-1}}} \frac{f_h - f_d}{f_d}\right)^{\frac{\sigma-1-k}{\sigma-1}}$$

By substituting the solution for expected profits (equation 3.28) in the free entry condition (equation 3.27) we can solve for the exit cutoff:

$$\omega^* = \left(\frac{f_d}{\delta f_e}(\frac{\sigma-1}{k-\sigma-1})\right)^{1/k} \Delta^{1/k} = B\Delta^{1/k} \tag{3.29}$$

which $B = \left(\frac{f_d}{\delta f_e}(\frac{\sigma-1}{k-\sigma-1})\right)^{1/k}$

By substituting the solution for the exit cutoff (equation 3.29) in equations (3.7), (3.9) and (3.14) a solution for the exporting and FDI adoption cutoffs can be obtained.

Effects of Trade Openness

It can be shown that expected profits from export after openness to trade increase, that is $\partial\Pi_x/\partial\tau < 0$.

$$\frac{\partial\Pi_x}{\partial\tau} = \frac{-kf_d(\sigma-1)}{k-\sigma-1}\left[\tau^{-k-1}\left(\frac{f_x}{f_d}\right)^{1+\frac{-k-1}{\sigma-1}} + \frac{\tau^{-\sigma}}{(\gamma^{\sigma-1}-1)^{\frac{-k}{\sigma-1}}}\left(\frac{f_h-f_d}{(1+\tau^{1-\sigma})f_d}\right)^{1+\frac{-k}{\sigma-1}}\right] \tag{3.30}$$

As $\sigma > 1$ and $k > \sigma - 1$ then $\partial\Pi_x/\partial\tau < 0$

On the other hand, a reduction in trade costs decrease FDIs revenues and induces more firms to leave the market in advantage for exporters. Expected profits from FDI decrease, that is $\partial\Pi_m/\partial\tau > 0$.

$$\frac{\partial\Pi_m}{\partial\tau} = k\,f_d\frac{\sigma-1}{k-\sigma-1}\left[\tau^{-\sigma}(1-\tau^{1-\sigma})^{(\frac{k}{\sigma-1}-1)}\left(\frac{f_m-f_x}{f_d}\right)^{1-\frac{k}{\sigma-1}}\right] > 0 \tag{3.31}$$

By inducing more entry of foreign exporters into the industry trade liberalization reduces the price index and thus firms only serving the domestic market loose revenues. As a result, the least productive firms make negative profits and exit.

More formally, we show in that when variable trade costs (τ) falls, and not all firms export or do FDI. The fraction of surviving exporters ($\Omega_{xl} = (\omega^{xl}/\omega^*)^{-k}$) ($\Omega_{xh} = (\omega^{xh}/\omega^*)^{-k}$) increase. The fraction of surviving of firms that use technology l doing FDI ($\Omega_{ml} = (\omega^{ml}/\omega^*)^{-k}$) and the fraction of surviving of firms that use technology h doing FDI ($\Omega_{mh} = (\omega^{mh}/\omega^*)^{-k}$) decrease. This can be seen in equations (3.18) to (3.21).

The price index falls, that is $\partial P/\partial\tau > 0$, and welfare increases. This can be directly seen from equation () where the sign of $\partial P/\partial\tau > 0$ is the opposite of the sign of $\partial\Delta/\partial\tau$.

The exit productivity cutoff increases, that is $\partial\omega^*/\partial\tau < 0$. This can be seen from equation (3.29) where the sign of $\partial\omega^*/\partial\tau < 0$ is the same as the sign of $\partial\Delta/\partial\tau$.

The productivity cutoff for exporting decreases, that is $\partial\omega^{xl}/\partial\tau > 0$. Differentiate equation (3.18) with respect to τ

$$\frac{\partial\omega^{xl}}{\partial\tau} = \left(\frac{f_d}{\delta f_e}\frac{\sigma-1}{k-\sigma-1}\right)^{1/k}\left(\frac{f_x}{f_d}\right)^{(1/\sigma-1)}\frac{\partial(\tau\Delta^{(1/k)})}{\partial\tau} \tag{3.32}$$

It's obvious as τ decreases and $\partial\Delta/\partial\tau < 0$.

The productivity cutoff of exporters adopting technology h decreases, that is $\partial\omega^{xh}/\partial\tau > 0$. It's obvious with a look to equation 3.20.

The productivity cutoff for adopting technology h doing FDI increases, that is $\partial\omega^{mh}/\partial\tau < 0$. It's because $\partial\omega^{mh}/\partial\tau < 0$ as it has the same sign as $\partial\Delta/\partial\tau$.

Pareto distribution of TFP

According to Mayer T. & Ottaviano G. (2008), after estimating firm level TFP, we can fit its distribution to a Pareto distribution by estimating the shape parameters Ψ's. We consider firm level productivity as a random variable ω and as mentioned previously with an observed cumulative distribution $F()$. If the variable is Pareto distributed with skewness Ψ and range $[\omega_0, \infty)$, then its cumulative distribution is:

$F(\omega) = 1 - (\frac{\omega_0}{\omega})^{\Psi}$

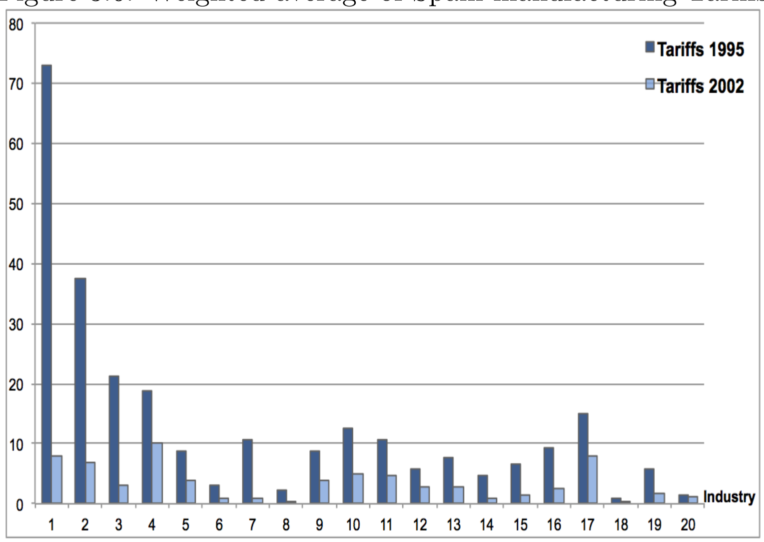
By using a Ln transmission, the equation above can be rewritten as:

$ln(1 - F(\omega)) = \Psi ln(\omega_0) - \Psi ln(\omega)$

Norman, Kotz and Balakrishnan (1994) show that the OLS estimation of the coefficient parameter in the regression of $ln(1 - F(\omega))$ on $ln(\omega)$ is a consistent estimator of Ψ and its R^2 is near to one. Having Ψ, it allows to achieve ω_0 from the constant part of the regression.

3.7 Appendix B Figures and Tables

Figure 3.6: Weighted average of Spain manufacturing Tariffs



source: WTO- World Bank, Weighted average of Spanish manufacturing Tariffs in each 20 industries in 1995 and 2002.

Table 3.7: Change os Domestic non-exporters status and Tariffs reduction, 1995-2002

	(1)	(2)	(3)
Δ tariffs	0.16	0.19	0.14
	(0.04)**	(0.03)**	(0.31)
Cons.	5.6	9.1	–17.1
	(0.08)*	(.03)**	(0.81)
Industry dummies	yes	yes	yes
Firm Controls	yes	yes	yes
Observations	905	564	175
R-squared	0.11	0.12	0.03

Notes: * indicates significant at 10%; ** significant at 5%; This table reports the result of regressing changes in status of domestic non-exporters on changes in tariffs between 2002 and 1995. Regression (1) contains all the domestic non-exporter firms but (2) and (3) are for low-tech and high-tech domestic non-exporter firms. Considering the initial status of firms to be domestic non exporters at 1995.

Bibliography

[1] Alvarez, F. and R. Lucas, 2007: General Equilibrium Analysis of the Eaton- Kortum Model of International Trade, Journal of Monetary Economics, 54(6), 1726-1768

[2] Amiti, M. and J. Konings, 2007: Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia, American Economic Review, 97(5), 1611-1638

[3] Arkolakis, C., A. Costinot and A. Rodriguez-Clare, 2012: New Trade Models, Same Old Gains?, American Economic Review, 102(1), 94-130.

[4] Atkeson, Andrew, and Ariel Tomas Burstein. 2010. Innovation, Firm Dynamics, and International Trade. Journal of Political Economy, 118(3): 43384.

[5] Aw, Bee Yan, Mark J. Roberts, and Tor Winston. 2007. Export Market Participation, Investments in R&D and Worker Training, and the Evolution of Firm Productivity. World Economy, 30(1): 83104.

[6] Aw, Bee Yan, Mark J. Roberts, and Daniel Yi Xu. 2011. R&D Investment, Exporting, and Productivity Dynamics: Dataset. American Economic Review, aer.101.4.1312.

[7] Bajona, C., M.J. Gibson, T.J. Kehoe, and K.J. Ruhl, 2008: Trade Liberalization, Growth, and Productivity, working paper

[8] Balassa, B., 1986: Intra-Industry Specialization: A Cross-Country Analysis, European Economic Review, 30(1), 27-42.

[9] Baldwin, John R., and Wulong Gu. 2003. Export-Market Participation and Productivity Performance in Canadian Manufacturing. Canadian Journal of Economics, 36(3): 63457.

[10] Bernard, A. B., J. Eaton, J. B. Jensen, and S. Kortum (2003). "Plants and Productivity in International Trade." American Economic Review 93(4), 12681290.

[11] Bernard, A. B. and J. B. Jensen (1999). "Exceptional Exporter Performance: Cause, Effect, or Both?" Journal of International Economics 47(1), 125.

[12] Bernard, A.B, J. B. Jensen, and P.K. Schott, 2006: Trade Costs, Firms and Productivity, Journal of Monetary Economics, 53(5), 917-937

[13] Binswanger, Hans P. 1974. The Measurement of Technical Change Biases with Many Factors of Production. American Economic Review, 64(6): 96476.

[14] Branstetter, Lee, and Jong-Rong Chen. 2006. The Impact of Technology Transfer and R&D on Productivity Growth in Taiwanese Industry: Microeconometric Analysis Using Plant and Firm-Level Data. Journal of the Japanese and International Economies, 20(2): 17792.

[15] Bustos, Paula. 2011. Trade Liberalization, Exports, and Technology Upgrading: Evidence on the Impact of MERCOSUR on Argentinean Firms. American Economic Review, 101(1): 30440.

[16] Chaney, T., 2008: Distorted Gravity: the Intensive and Extensive Margins of International Trade, American Economic Review, 98(4), 1707-1721

[17] Collard-Wexler, A., De Loecker, J. and Asker, J. (2011) "Productivity volatility and the misallocation of resources in developing economies." Mimeo, NYU.

[18] Constantini, James A., and Marc J. Melitz. 2008. The Dynamics of Firm-Level Adjustment to Trade Liberalization. In The Organization of Firms in a Global Economy, ed. Elhanan Helpman, Dalia Marin, and Thierry Verdier, 10741. Cambridge, MA: Harvard University Press.

[19] Damijan, Joe P.,C rt Kostevc, and Sa?o Polanec. 2008. From Innovation to Exporting or Vice Versa? LICOS Discussion Paper 204.

[20] Das, Sanghamitra, Mark J. Roberts, and James R. Tybout. 2007. Market Entry Costs, Producer Heterogeneity, and Export Dynamics. Econometrica, 75(3): 83773.

[21] De Loecker, J., 2007: Do exports generate higher productivity? Evidence from Slovenia, Journal of International Economics, 73(1), 69-98

[22] De Loecker, J. (2011) "Product differentiation, multi-product firms and estimating the impact of trade liberalization on productivity," Econometrica 79, 14071451.

[23] De Loecker, J., Goldberg, P., Khandelwal, A. and Pavcnik, N. (2012) "Prices, markups and trade reform." April 2014, revision requested by Econometrica.

[24] Doraszelski, U. and Jaumandreu, J. (2012) "Measuring the bias of technical change." Mimeo, The Wharton School.

[25] Doraszelski, Ulrich, and Jordi Jaumandreu. 2008. R&D and Productivity: Estimating Production Functions When Productivity is Endogenous. Harvard Institute of Economic Research Discussion Paper 2147.

[26] Greenaway, David, and Richard Kneller. 2007. Firm Heterogeneity, Exporting and Foreign Direct Investment. Economic Journal, 117(517): F13461.

[27] Griliches, Zvi. 1979. Issues in Assessing the Contribution of Research and Development to Productivity Growth. Bell Journal of Economics, 10(1): 92116.

[28] Eaton, J., S. Kortum and F. Kramarz, 2011: An Anatomy of International Trade: Evidence from French Firms, Econometrica, 79(5), 1453-1498.

[29] Fajgelbaum, P., G. Grossman and E. Helpman, 2011: Income Distribution, Product Quality and International Trade, Journal of Political Economy, 119(4), 721-765.

[30] X Fan, MJ Roberts, DY Xu, S Zhang, (2012), "A Structural Model of Demand, Cost, and Export Market Selection for Chinese Footwear Producers", National Bureau of Economic Research

[31] Fattal, R. N., 2011: Entry, Exit and Misallocation Frictions, Manuscript, University of California, Los Angeles.

[32] Fieler, A.C., 2011: Nonhomotheticity and Bilateral Trade: Evidence and a Quantitative Explanation, Econometrica, 79(4), 1069-1101.

[33] Foster, L., Haltiwanger, J. and Syverson, C. (2008) "Reallocation, firm turnover, and efficiency: Selection on productivity or profitability?" American Economic Review 98, 394425.

[34] Foster, L., Haltiwanger, J. C. and Syverson, C. (2012) "The slow growth of new plants: Learning about demand?" NBER 17853.

[35] Gibson, M.J., 2006 Trade Liberalization, Reallocation, and Productivity, work- ing paper.

[36] Grubel, H.G. and P.J. Lloyd, 1971: The Empirical Measurement of Intra- Industry Trade, Economic Record, 47(4), 494-517.

[37] Hallward-Driemeier, Mary, Giuseppe Larossi, and Kenneth L. Sokoloff. 2002. Exports and Manufacturing Productivity in East Asia: A Comparative Analysis with Firm-Level Data. National Bureau of Economic Research Working Paper 8894.

[38] Harrigan, J., 1994: Scale Economies and the Volume of Trade, Review of Economics and Statistics, 76(2), 321-328.

[39] Heckman, James J. 1981. The Incidental Parameters Problem and the Problem of Initial Conditions in Estimating a Discrete Time-Discrete Data Stochastic Process and Some Monte Carlo Evidence. In Structural Analysis of Discrete Data with Econometric Applications, ed. Charles Manski and Daniel McFadden, 17995. Cambridge, MA: MIT Press.

[40] Helpman E., Melitz M. J., Yeaple S. R. (2003) "Export versus FDI," NBER 9439

[41] Hopenhayn, H. (1992) "Entry, exit, and firm dynamics in long run equilibrium," Econometrica 60, 11271150.

[42] Hopenhayn, H. and Rogerson, R. (1993) "Job turnover and policy evaluation: A general equilibrium analysis," Journal of Political Economy 101, 915938.

[43] Jovanovic, B. (1982) "Selection and the evolution of industry," Econometrica 50, 649670.

[44] Katayama, H., S. Lu and J.R. Tybout, 2009: Firm-level productivity studies: Illusions and a solution, International Journal of Industrial Organization, 27(3), 403413

[45] Krugman, P., 1980: Scale Economies, Product Differentiation and the Pattern of Trade, American Economic Review, 70(5), 950-959.

[46] Levinsohn, J., and A. Petrin (2003) "Estimating production functions using inputs control for unobservables," Review of Economic Studies 70: 317-342

[47] Markusen, J.R, 1986: Explaining the Volume of Trade: An Eclectic Approach, American Economic Review, 76(5), 1002-1011.

[48] Markusen, J.R., 2010: Putting Per-Capita Income Back into Trade Theory, NBER Working Paper No. 15903.

[49] Melitz M. (2003) "The Impact of Trade on Aggregate Industry Productivity and Intra-Industry Reallocations," Econometrica, 71(6): 1695-1725.

[50] Melitz, M. and G. Ottaviano (2007) "Market Size, Trade, and Productivity," Review of Economic Studies

[51] Olley, G. S., and A. Pakes (1996) "The dynamics of productivity in the telecommunications equipment industry," Econometrica 64: 1263-1297

[52] Park, A., D. Yang, X. Shi and Y. Jiang, 2010: Exporting and Firm Performance: Chinese Exporters and the Asian Financial Crisis, The Review of Economics and Statistics, 92(4), 822-842

[53] Restuccia, D., and R. Rogerson, 2008, Policy Distortions and Aggregate Productivity with Heterogeneous Establishments, Review of Economic Dynamics, 11(4), 707-720.

[54] M. J. Roberts, and J. R. Tybout. 1997. The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs. American Economic Review, 87(4): 54564., and James R. Tybout. 1997. The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs. American Economic Review, 87(4): 54564.

[55] Mark Roberts, Daniel Xu, Shengxing Zhang and Xiaoyan Fan, "A Structural Model of Demand, Cost, and Export Market Selection for Chinese Footwear Producers", December, 2011, R&R at Review of Economic Studies

[56] Ruhl, K.J. (2003), "The International Elasticity Puzzle," NYU Stern School of Business.

[57] Syverson, C. (2011) "What determines productivity?," Journal of Economic Literature 49, 326365. Forthcoming.

[58] Tybout, James R. & Westbrook, M. Daniel, 1995. "Trade liberalization and the dimensions of efficiency change in Mexican manufacturing industries," Journal of International Economics,Elsevier, vol. 39(1-2), pages 53-78, August.