Productivity, size and exporting dynamics of firms: Evidence for Mexico

Cardoso-Vargas, Carlos Enrique

Ministry of Finance of the Federal District. Mexico

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Carlos-Enrique Cardoso-Vargas*

Abstract

This paper examines the relationship between size and productivity on the export dynamics of a developing country like Mexico. The theoretical framework that guides the empirical evaluation is based on a simple model inspired by Melitz (2003). The results suggest that differences in size and productivity of firms indicate who will be able to internationalize and which markets can sell. According to estimates there are other feasible locations to replace the neighboring market of North America as the main buyer; however, the limiting factor for achieving this goal would be the low productivity of firms. In particular, it is that if transport costs are doubled, as is expected in destinations beyond the area of North America, would imply an increase in productivity of the firms of at least 9%. Finally, we find that the financial crisis caused a selection effect with respect to firms with higher productivity, while those firms that reported very low levels of productivity ceased its export activities

I. Introduction

Although the strategy of higher internationalization in export markets is not something new, it is one of the most recent issues within the agenda of public policies both in developed and developing countries. Nowadays, it is widely known that drawing on a broad portfolio of host countries helps to attenuate the volatility in export income (Haddad et al. 2009), added to the fact that a stable flow of foreign resources results in higher growth levels for the countries (Hesse, 2008). In addition, an ample access to different foreign

* Director of Fiscal Policy in the Ministry of Finance of the Federal District. Mexico. The views and conclusions presented in the document are exclusively the Responsibility of the author and do not necessarily reflect those of Ministry of Finance of the Federal District. I appreciate the valuable comments from Rosella Nicollini and Josep Lluis Roig, I also appreciate the support received by staff of the Ministry of Economy and the Institute of Statistics and Geography for the preparation of this document.

markets contributes to the learning of exporting firms that can generate positive externalities for the rest of the domestic firms (Al-Marhubi, 2000).

Thus, although the advantages to take on this kind of strategy are evident, the way to achieving it is not that clear. The decision of internationalization of an economy implies knowing the possible factors that allow firms to surpass national boundaries and sell their products in other markets, as well as the required endeavors to access diverse destinations. Empirical studies of the past years document the role that size and productivity of companies have in such a process (Bernard and Jensen, 1995; Robert and Tybout, 1997; Bernard and Jensen, 1999; Bernard et al, 2007).

This evidence is retaken in the Melitz (2003) to show that the relation between productivity-exports is the result of a self-selection process where only the most productive firms can access external markets[2]. The idea is that if there are heterogeneous firms in terms of productivity and fixed costs in the access to foreign markets, only the most productive firms will be able to face the costs associated with selling abroad and finding the exporting activity profitable[3].

There is a wide variety of works in this literature that use the Melitz model; some of them have focused on broadening the theoretical framework and some others on assessing the predictions arisen from the model, in terms of the productivity-exports. In the latter, the research is mainly focused on developed countries, as in the works of Helpman et al. (2004) and Hanson and Xiang (2008) for the United States of America, Crozet et al. (2011) for France and Lawless (2009) for Ireland. The studies examining said relation in developing countries are few, despite the fact that in the past years these countries have increased their

[2] Besides the hypothesis of self-selection in the literature studying the relation between productivity and exports, there is a line of study that addresses another premise, which is denominated as *learning-by-exporting*. It asserts that exporting firms are more productive due to the knowledge they acquire owing to their exposure and higher competition within the foreign markets. For a summary of these works, see Greenaway and Kneller (2005).

[3] For a further review regarding the theoretical and empirical evidence used by the model of heterogeneous firms, consult Redding (2011) and Melitz and Redding (2012).

importance in the world economy[4]. The great constraint is usually the inexistent or null access to detailed information of foreign trade and production transactions at company level that is necessary for carrying out this type of research.

Mexico represents a case of interest for such an assessment, not only due to the importance that its exports have internationally[5], but also because it is an economy with foreign sales that represent almost 30% of its Gross Domestic Product (GDP)[6] and whose sales are over 80% focused on the neighbor market of the United States of America[7].

This paper studies the relation between productivity and size in the exporting dynamics of firms. The conceptual framework being used to test this relation is based on a simple model inspired by Melitz (2003). We especially examine if the differences in productivity and size of exporting firms explain to which foreign markets they can sell, in which order they access those markets and what is the endeavor required on the part of the firms to reach other destinations. The answers to these aspects are of great importance to understand the export dynamics not only of Mexico, but countries which have opened towards the world and that seek to consolidate their presence abroad. They have decided to do so mainly because of the implications of implementing policies centered not only on the internationalization of more firms or the increase in foreign sales of the traditional exporting firms, but also the diversification of export markets.

In this document, we also empirically assess a prediction of the Melitz model, taking into consideration the international crisis of 2008 and we answer if this event differentially affected firms with diverse productivities. This is relevant since this event caused changes

[4] According to the World Trade Organization (WTO), between 1990 and 2008 the volume of foreign sales recorded by the developing countries grew at a higher pace than the exports of developed countries or the world exports altogether. In addition, between 2000 and 2008 the exports of the developing countries almost doubled while the world exports only rose 50% (WTO, 2010).

[5] The WTO ranks it as the 14th main exporter worldwide, above developed economies such as Spain, Australia and Switzerland; as well as the main Latin American exporter.

[6] Mexican exports represented 25.4% of their Gross Domestic Product in 2003 to 30.0% in 2010 (World Bank, 2013).

[7] From 2003 to 2010, sales to the United States represented in average, 83% of its total exports. From the remaining 17% of the foreign sales, 15% focused on 40 host markets and 2% comprised the exports to 196 countries (INEGI, 2014).

in the exporting activity and trade patterns worldwide, due to which the effect could be assimilated differently among the firms.

In order to address these affairs we created a panel of data by means of merging the information contained in the Annual Industry Survey (*Encuesta Industria Anual, EIA*), carried out by the National Institute of Statistics and Geography (*Instituto Nacional de Estadística y Geografía, INEGI*) of manufacturing (non-maquiladora) firms installed in Mexico and the detailed data on export trade operations that are registered by the Mexican customs from the Ministry of Economy. The advantage of this source of information is that it appropriately reflects the link between productivity and exporting activity, as established by the theoretical model used. As well, the structure of the panel allows us to control the shock estimations common in firms over time, as well as the shocks between firms of the same industry.

This paper is related to the research of Hanson and Xiang (2008), and Lawless (2009) with regard to the empirical assessment of diverse hypotheses of the Melitz (2003), but it is set apart from them in some aspects. The analysis draws on a detailed database that gathers foreign trade information from the customs records and production in a panel format at firm level for a span of six years. Unlike the previously mentioned works, this paper studies is the relation between productivity and size in terms of exporting activity in a developing country highly concentrated on the destination of its foreign sales.

The results confirm the mentioned hypothesis in the Melitz (2003) that the largest and most productive exporting firms can deal with transportation costs and enter farther markets. In this regard, we found that an increase of 10% in the size of firms increases the probability of exporting with respect to not exporting in 4.31%; as well, a change of the same magnitude in the productivity of firms contributes to an increase of 3.73% in such probability. Additionally, we observed that the installed firms in Mexico with a low productivity access the North American market firstly; whose closeness to Mexico does not involve high transportation costs. As firms are more productive, they access the Latin American market, and later the European Union and finally the Asian economies. These results point out that a constraint in the diversification of sales regarding the North American market is the low productivity of firms.

On the other hand, we have found that the productivity requirements necessary for the firms to be able to access other farther markets hold a close relation with the scale economies to be generated within each firm and the transportation costs of the destinations they seek to sell to. Particularly, we have found that if transportation costs doubled, this would mean an additional requirement in productivity on the part of the exporting firms in approximately 9%. When assessing if the global crisis of 2008 had a differentiated impact on the firms, we found that this event caused a selection effect with respect to the highly productive firms as predicted by the Melitz model. The following year after the crisis had started, the demand for productivity was higher for the exporting firms, and therefore the companies with less productivity ceased their exporting activity.

This paper is presented as follows: Section II describes the relevant literature, Section III develops the model and the hypotheses to be assessed are derived. Section IV illustrates the manner in which the empirical approach of the model's variables is performed as well as the statistical techniques to be used. Sections V and VI, mention the origin of data and the construction of variables, and the results of the empirical assessment of the model's hypotheses, respectively. Section VII examines the changes in productivity of the firms before an external shock. Finally, Section VIII establishes the conclusions of this paper.

II. Relevant literature

Melitz's international trade model is based on a classical model of monopolistic competition, in which there are diverse varieties of products that are elaborated in various countries by companies that show growing profits to scale. The firms are heterogeneous in terms of productivity and deal with fixed costs in order to be able to sell to every foreign market and only the most productive firms have the capacity to sell both within the domestic and foreign markets.

Based on this assertion, ample literature has emerged extending its theoretical contributions and/or assessing its hypotheses. Firstly is the work of Chaney (2008) who, using a theoretical framework like Melitz (2003) with fixed export costs and a productivity

distribution Pareto, shows that a high elasticity makes exports per firm (intensive margin) be more sensitive to changes in trade barriers, making the extensive margin be less sensitive.

On the other hand, Arkolakis (2010) develops an augmented version of the Melitz model where the export costs are no longer fixed and depend on the number of consumers whom a firm decides to reach in a certain host market, and therefore they are endogenous to the company. With a trade model with heterogeneous firms and a linear demand, Melitz and Ottaviano (2008) derive the predictions of the standard model of Melitz and show the effect between market size and trade caused by the competition of the firm. Their results indicate that larger and more integrated markets display a higher average productivity and low mark-ups.

In the second approach, we have the work of Hanson and Xiang (2008) who examine two versions of the Melitz´s model, one of which considers the existence of fixed global export costs, that is to say, once the firms export and assume said costs, they establish a distribution network in which they incorporate more countries and deal with variable charges only due to the addition of those new markets. The second version involves the existence of bilateral fixed costs, so firms incur an additional charge every time they want to incorporate a new country in their distribution network. The evidence found by the authors with their data is in favor of the existence of globally fixed costs.

On the other hand, Lawless (2009) uses a panel of Irish companies based on a survey of exporting companies and assesses empirically five hypotheses derived from a simple Melitz-like model. The results show little evidence in the hypothesis stating that firms access the different host countries in a strict order according to their productivities and the transportation costs of the host markets. On the contrary, it finds support for another four hypotheses asserting that the most productive firms can sell at a larger number of markets; that the companies that most contribute to sales growth are the traditional exporting firms; that most of the firms starting to export do so to one single destination and later they add countries to their portfolio; that the firms' exports growth mainly derives from sales made to countries which traditionally export, rather than with the newly incorporated markets.

This document is also related to the works of Bricongne et al. (2012) and Eaton et al. (2011a) concerning the analysis of the differentiated effects that the international crisis of 2008 had on exporting companies. Bricongne et al. (2012), using data from monthly exports from June 2000 to April 2009 of all the exporting companies located in France, assert that as a result of the international collapse, the great exporting firms reduced the variety of their products exported in the markets they served. In the case of small firms, the effect manifested as a contraction in the number of markets they could access and in companies which quit the exporting activity.

III. Theoretical Framework

In this section we introduce a theoretical framework that serves as the basis of our empirical analysis, which is inspired by a model carried out by Melitz (2003). In our case, we assume that the world comprises countries and that in each country there are two sectors: one sector of tradable goods and another one of non-tradable goods. The non-tradable sector produces a homogeneous good ($\bar{M}$) with constant yields and in perfect competition, a good that we regard as numerary. On the other hand, in the tradable goods sector there is a continuum of companies ϵ (0,1) and each of them produces a differentiated good (M) under growing yields and in imperfect competition, which is exchanged with the other countries.

The demand side

The consumers in country j have preferences for the consumption of both goods. The representative individual utility function is defined as a Cobb-Douglas function as follows:

$$U_j = \bar{M}_j^{1-\mu} M_j^{\mu}, \quad 0 < \mu < 1 \qquad [1]$$

Terms (1 - μ) and μ represent the proportion of the expenditure on non-tradable and tradable goods, respectively, that consumers located in j make. As well, M_j is a good that comprises different varieties of tradable goods with a constant elasticity of substitution (CES) among them.

$$M_j = \left[\int_0^1 [q_i(\omega)]^\rho d\omega\right]^{1/\rho}, \quad 0 < \rho < 1 \qquad [2]$$

In this expression $q_i(\omega)$ represents the amount of the variety ω elaborated by firm i and consumed in j. We assume that the elasticity of substitution between varieties is $\sigma = \frac{1}{1-\rho} > 1$. When the firms sell their products to the rest of countries, they incur transportation costs. We consider these costs as *iceberg* costs, where if a unit of the good is sent to another country, only a fraction reaches its final destination, and therefore, $p_{ij}(\omega) = p_i(\omega) * \tau_{ij}$ where $p_i(\omega)$ is the price in country i and $\tau_{ij} > 0$ are the transportation costs. Additionally, considering that the available income of consumers in country j for the two types of products is R_j and resolving the maximization of the representative consumer utility of [1], we obtain the demand in j for the variety produced in country i.

$$q_{ij}(\omega) = \frac{p_{ij}(\omega)^{-\sigma}}{P_j^{1-\sigma}} \mu R_j \qquad [3]$$

In which P_j represents the index of prices of tradable goods in region j which depend on the prices of the varieties produced in i and sold in j.

$$P_j = \left[\int_0^1 p_{ij}(\omega)^{1-\sigma}\, d\omega\right]^{\frac{1}{1-\sigma}} \qquad [4]$$

The supply side

The companies of tradable goods compete in a frame of a monopolistic competition and obtain benefits π_i assuming that the only factor is labor.

$$\pi_i = p_i q_i - w_i l_i \quad [5]$$

Where w_i and l_i are the salary and the number of hired workers, respectively. In every country there is a continuum of massive consumers/workers that offers its unit of work time inelastically. The technology used by the firms is represented by a production function, which comprises a fixed part and a variable part, and where we standardize salaries to one.

$$l(\omega) = f_{ij} + \frac{q_{ij}}{\varphi(\omega)} \quad [6]$$

Where $f_{ij} > 0$ correspond to fixed costs for producing and selling to j, which we regard as destination-specific and the same for all the firms. These costs include the entry costs as well as the operation, promotion, and distribution costs of the good exported to j. The marginal costs specific of every firm are $\left(\frac{1}{\varphi(\omega)}\right)$, where the term $\varphi(\omega)$ corresponds to the specific productivity of each firm. Additionally, qij represents the number of product sold from i to j. Maximizing the benefits of the firm in i that produces and exports to j, we obtain the sale price optimum for country j as in Melitz (2003).

$$p_i(\omega) = \frac{1}{\rho\varphi(\omega)} \quad [7]$$

With the term $\rho = \frac{\sigma-1}{\sigma}$. Replacing [3] and [7] in [5] we can find the net benefits obtained by the firm in i that exports to j the variety ω.

$$\pi_{ij}(\varphi) = \left(\rho\varphi P_j\right)^{\sigma-1} {\tau_{ij}}^{-\sigma} \frac{\mu R_j}{\sigma} - f_{ij} \quad [8]$$

As in Melitz (2003) this suggests a free entrance in the market, therefore, the condition of cero benefits for the company in i that wishes to export at the productivity level φ_{ij}^* equals:

$$\left(\rho\varphi_{ij}^* P_j\right)^{\sigma-1} {\tau_{ij}}^{-\sigma} \frac{\mu R_j}{\sigma} = f_{ij} \quad [9]$$

From the above we can observe that a minimum productivity level is required (*cut-off*) φ_{ij}^{*} for which $\pi_{ij}(\varphi_{ij}^{*}) = 0$. Therefore, firms with a productivity of φ over φ_{ij}^{*} will be able to serve market j, while a firm with a productivity φ under φ_{ij}^{*} will not be able to do so because the costs of exporting to destination j will be higher than the benefits it could obtain by selling to that market. From expression [9] we can express the probability of exporting (E_{ij}) from i to j as:

$$P[E_{ij} = 1] = P\left[\left(\rho\varphi_{ij}^{*}P_j\right)^{\sigma-1}\tau_{ij}{}^{-\sigma}\frac{\mu R_j}{\sigma} \geq f_{ij}\right] \qquad [10]$$

Applying logarithms on the right side of expression [10], we obtain:

$$P[E_{ij} = 1] = P\left[(\sigma-1)ln\varphi_{ij}^{*} + ln\left(\frac{\mu R_j}{P_j{}^{1-\sigma}}\right) + (\sigma-1)ln\rho - (\sigma)ln\tau_{ij} - \ln(\sigma f_{ij}) \geq 0\right] \qquad [11]$$

Given σ > 1, then the first term on the right side of [11] establishes that the decision of exporting to a specific market j on the part of a firm in i depends positively on its productivity level, and therefore more productive firms will have the capacity to serve farther markets. Similarly, the probability of exporting will also increase due to the preferences of consumers in the host country with respect to the imported goods, and decreases by the transportation costs and the fixed costs that are specific of each host market. Considering the requirement of workers that the firm uses [6], together with [3] and [7], we find the next expression:

$$l(\omega) = \left(\varphi(\omega)P_j\right)^{\sigma-1}\left(\frac{\rho}{\tau_{ij}}\right)^{\sigma}\mu R_j + f_{ij} \qquad [12]$$

From [12] we observe that $\frac{\partial l(\omega)}{\partial \varphi(\omega)} > 0$, with which the most productive firms will also be the largest in terms of work. This link states that the largest firms have more possibility of

complementing and be vertically integrated to generate scale economies, in comparison with the smaller firms. A second implicit hypothesis in [11] is that the existence of different productivity levels among firms and destination-specific transportation costs, determine the markets where the different companies will be able to serve, that is to say, the firms will export to different markets in a specific order or hierarchy in relation to their productivity and the transportation costs to each destination. Expressing the condition of the cero benefits in equation [9] as:

$$\varphi_{ij}^{*} = \left(\frac{\mu R_j}{P_j^{1-\sigma}}\right)^{-\frac{1}{\sigma-1}} \rho^{-1} \tau_{ij}^{\frac{\sigma}{\sigma-1}} \left(f_{ij}\sigma\right)^{\frac{1}{\sigma-1}} \qquad [13]$$

When applying logarithms to this expression, we have:

$$ln\varphi_{ij}^{*} = -\left(\frac{1}{\sigma-1}\right) ln\left(\frac{\mu R_j}{P_j^{1-\sigma}}\right) - ln\rho + \left(\frac{\sigma}{\sigma-1}\right) ln\tau_{ij} + \left(\frac{1}{\sigma-1}\right) ln\left(\sigma f_{ij}\right) \qquad [14]$$

From this we obtain a third hypothesis regarding the productivity requirements of the firms to export. This presumption establishes that the demand for productivity to export to a destination *j,* will be higher as higher the transportation costs and the fixed costs associated with the exporting activity are; contrastively, said requirement will be smaller the bigger the expenditure on imported goods in real terms is on the part of the host country. This is to say, in order to export to a market *j* the firms must have a minimum productivity level that exceeds the fixed and variable costs associated with their foreign sales. The modification of said costs sets a new minimum productivity level so that firms can export obtaining positive benefits. On the other hand, a higher demand for imported products allows the access of exporting firms with a low productivity.

IV. Empirical Approach

For the estimation of the hypotheses established in the previous equations we take into account various aspects. The model from which we derive this equation considers that the companies produce a single differentiated variety. In order to approach this specification in the empirical assessment we regard as a representative of this variety the main product of

export (6 digits of the Harmonized System[8]) and the different host markets of those goods for each of the firms.

As a proxy of the term (φ_{ij}^{*}) we used the labor productivity calculated as the total sales over the number of workers at firm level, the expression $\left(\frac{\mu R_j}{P_j^{1-\sigma}}\right)$, we approach it to the GDP of the host country in real terms. In order to take into consideration the component (ρ) we incorporated the fixed effects of the subsector in the estimations and as the proxy of the transportation costs we considered the physical distance between Mexico and the country where the good is sold, which we calculated by applying the great-circle formula[9]. Finally, in order to approximate the fixed costs (f_{ij}) we incorporated the fixed effects of the geographical areas[10]. In order to control within our assessment the existent relation between the size and productivity of the company that is described explicitly in [12], we incorporate in the estimations the number of workers at form level as a proxy of the size of firm.

The method of estimation that we used to assess the hypothesis regarding the decisions on exports expressed in [11], occurs through a logistic regression. Since it is considered that the exporting activity of firms involves a learning process, where the benefits increase rapidly (due to starting to export), they later decrease their growth rate to finally remain constant as the firms reach their maturity as exporters. Such behavior can be modeled by means of a logistic distribution with respect to time. Mansfield (1961) points out that the use of this distribution represents the most convenient manner to represent this kind of processes.[11] For the second hypothesis of equation [11], with reference to the order or hierarchy in which the firms export to the markets, we use again a logit estimation and as

[8] The Harmonized System (HS) is a nomenclature of products implemented by the World Customs Organization, whose purpose is the establishment of a classification of the goods that are traded worldwide.

[9] The distance of this great circle is the shortest trajectory between two points over a spherical surface, taking into consideration the location (longitude and latitude) of these points. Unlike the Euclidian distance, which measures the distance between two points in a straight line, this measure replaces the straight lines for arches; making it possible to obtain more approximate distances between two locations considering the geography of the earth.

[10] The geographical areas considered refer to the continents of America, Europe and Asia.

[11] Mansfield (1961) utilizes a logistic distribution to assess the adoption of new technologies over time. As well, Anderson and De Palma (1992) show the links between the logit function and a CES function as the one used in the theoretical model.

robustness check of the results a multi-logit model. For the assessment of the last prediction we utilized the method of Ordinary Least Squares (OLS) incorporating different fixed effects at subsector level, at geographical area level, year and in some cases at firm level. Meanwhile, for the assessment of [16] as well as considering the technique of OLS we carried out quantile estimations.

Another aspect that emerges in the assessment of our specifications is related to a problem of endogeneity. Equation [11] reveals that the probability of exporting is conditioned to the productivity level of the firms. Nonetheless, Bernard and Jensen (1999) discuss that the firms that export can also become more productive. This problem makes the parameters be more biased. In order to settle this issue of double causality between the capacity of exporting and productivity, we follow Bernard and Jensen (2004) and we lag by one period the dependent variable.

Additionally, in the empirical assessment of the equations we hold that the dependent variable that includes the individual observations is estimated in relation to aggregate variables at country level. Moulton (1986, 1990) demonstrates that when micro data are regressed with respect to aggregate variables, the standard errors obtained are underestimated since the correlation between the individual observations (in our case the firms) is not considered in the group or cluster to which the aggregate variable makes reference. In order to account for this issue in all the regressions we corrected the standard errors clustering at municipality level where the exporting firms are located spatially.

V. Data and variables

The information used in this paper comes from the foreign trade data from the Ministry of Economy, whose original source is the Mexican customs. The extract of information comprises the variables: name of firm, main product of export (tariff code in 6 digits in the harmonized system), code of the host country and year[12]. The temporality of this exporters base (EB) comprises year 2003 to 2010.

[12] In Mexico, the information concerning the values of imports and exports at the firm level is not public.

This base merged with data from the Annual Industrial Survey (*Encuesta Industria Annual, EIA*) elaborated by Mexico's *Instituto Nacional de Estadística y Geografía* (INEGI). The EIA comprises information referring to occupied personnel, production, sales and remunerations of manufacturing establishments (excluding the maquiladora industry) with more than 15 employees, within 21 manufacturing subsectors. The span used in the EIA goes from year 2003 to 2009 and the size of the sample encompasses more than five thousand establishments. The information of labor productivity (sales[13]/number of employees) and size of company (number of employees) was obtained from this source.[14]

From the merger between the EB and the EIA, firms that coincide in both sources of information were located. From the EB-EIA base, firms having more than one establishment were eliminated since it is not possible to identify which sources of trade correspond to each of their locations. Besides, in order to avoid the excess of null flows, the database was restricted to consider only those countries whose export movements altogether represent 98% of the total flows, with which finally our database includes 3,448 firms, 77 export destinations and 7 years.

The location data (longitude and latitude) of the capital cities of the countries[15] that come from the database of the CEPII (*Centre d´Etudes Prospectives et d´Informations Internationales*)[16] were used for the computation of the great-circle formula. The figures of the GDP in real terms of the host countries were extracted from the World Bank's database. Table 1 shows the descriptive statistics of the final database used for carrying out the empirical assessment of the hypotheses, which represent an imbalanced panel since the

[13] The sales figures were expressed in real terms, using the producer price index and their source is the Banco de México and INEGI.

[14] In order to maintain confidentiality, the crosses of information, calculations and estimations presented in this paper, were carried out in two stages. The first one consisted of elaboration computer programs that were later run by INEGI staff. The second stage dealt with processing the information at INEGI premises and under the supervision of its staff.

[15] For the calculation of the distance between Mexico and the United States, we considered the distance between the municipality where the firm is located and the centroid that makes reference to the mean position in the United States.

[16] http://www.cepii.fr/anglaisgraph/bdd/distances.htm

observations were lost due to the imperfect crosses between the EB-EIA base and the rest of the co-variables.

For the construction of the dependent variable of [10] we considered the exporting status of each of the firms to the various destinations and years of our database. Therefore, the exporting status is built as a binary variable where 1 represents that firm *i* exported to a country *j* in year *t* and 0 the absence of said trade operations. Meanwhile, in the estimation of [13] and [15], only the positive flows that companies carried out with the different markets during the reference span are considered.

Table 1 shows differences in the productivity of firms and the distance between the different geographical areas, representing not only the transportation costs but also the exchange costs. The mean of the productivity of companies and the costs are higher when the host markets are farther away. Same as in productivity, the mean of the size of the companies is higher when markets are farther from Mexico. The figures also exhibit inequalities in the exports where the mean seems to be lower in the farthest destinations.

Table 1. Descriptive statistics of the variables used

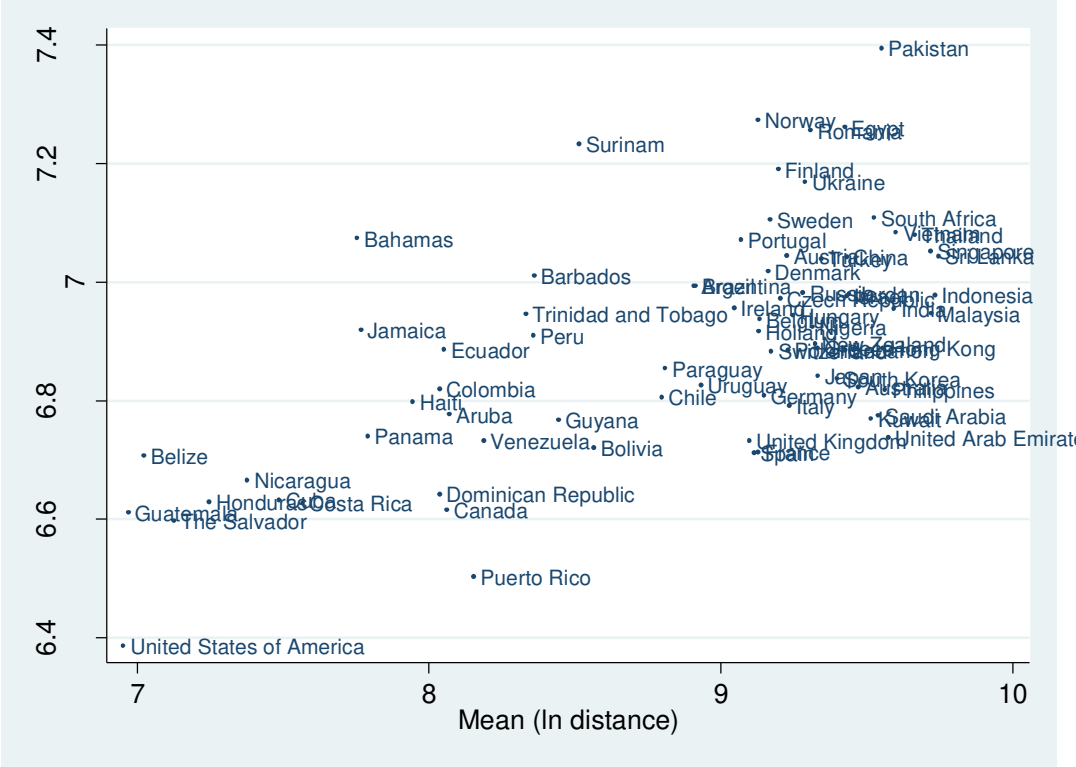
by area geográficas[1/]

Africa	**Mean**	**Standard dev.**	**Min**	**Max**	**N**
Ln GDP country-destination	7.76	0.64	5.99	8.24	395
Ln distance	9.48	0.07	9.31	9.53	395
Ln productivity	7.11	1.01	2.63	10.8	338
Ln employment	5.80	1.17	1.95	8.84	339
America	**Mean**	**Standard dev.**	**Min**	**Max**	**N**
Ln GDP country-destination	8.81	1.25	5.94	10.56	39,999
Ln distance	7.65	0.67	6.21	8.93	40,189
Ln productivity	6.63	0.95	1.81	14.21	33,552
Ln employment	5.40	1.13	0.69	8.86	33,990
Asia	**Mean**	**Standard dev.**	**Min**	**Max**	**N**
Ln GDP country-destination	8.78	1.53	6.17	10.62	5,357
Ln distance	9.51	0.13	9.28	9.75	5,702
Ln productivity	6.94	0.97	2.63	10.6	4,697
Ln employment	5.70	1.22	1.10	8.86	4,769
Europe	**Mean**	**Standard dev.**	**Min**	**Max**	**N**
Ln GDP country-destination	9.89	0.56	6.71	10.64	7,606
Ln distance	9.16	0.06	9.05	9.34	7,606
Ln productivity	6.84	1.05	2.63	10.92	6,333
Ln employment	5.64	1.24	0.69	8.86	6,394
Pacific	**Mean**	**Standard dev.**	**Min**	**Max**	**N**
Ln GDP country-destination	9.98	0.21	9.58	10.14	870
Ln distance	9.44	0.06	9.32	9.47	870
Ln productivity	6.82	0.88	3.98	10.36	739
Ln employment	5.70	1.29	1.10	8.66	746

[1/] The areas were constructed using the catalog of geographic areas of the World Bank.

What is more with regards to this relation between productivity and transportation costs, Figure 1 shows the countries to which companies export according to the mean of the logarithm of productivity in connection with the mean of the logarithm of distance during the span considered. In Figure 1, it can be observed that the manufacturing firms with a low productivity export to closer markets in distance, for example North America and the closest Latin American countries; in addition, the firms with a higher productivity export to farther markets, such as those located in Europe and Asia; this is how the productivity level of the firm reflects its capacity to access host markets.

Figure 1. Relationship between productivity and distance of exporting firms



VI. Results of the empirical assessment

In this section we examine the relation between size and productivity in relation to the exporting activity, contrasting empirically the hypotheses derived from the simple model inspired by Melitz (2003) based on the information described in Section III.

The questions related to what markets firms can sell to and in which order the access such destinations were assessed through the estimation of the hypotheses concerning the decisions on export and the choice of markets. Regarding the demands for productivity so that firms can export, we valued them with the use of the prediction of productivity requirements.

VI.1 Decisions on export and the order in choosing markets

Table 2 reports the results of the estimation of equation [11], referring to the export decisions of the firms. The first column shows the estimation obtained considering the total number of host countries in our sample. The sign of coefficients goes along with those obtained in the equation [11] and are significant at 1%. The findings reflect the differences in productivity and size of exporters and the kind of markets (close or far) that the companies will be able to access. Firms with a higher size can generate higher scale economies and be more productive, which allows them to bear high transportation costs to farther places as in Melitz (2003) while exporting firms with a smaller size are likely to sell to closer markets whose benefits derived from exporting may be enough in order not to be negative. In particular, we found that an increase of 10% in the size of the companies increases the probability of exporting in relation to not exporting in 4.31% [exp(0.442*10%)-1]; similarly, a change in the same magnitude over the labor productivity contributes to a rise of 3.73% in said probability.

The second hypothesis of [11] establishes a specific order or hierarchy in which the companies can serve an external market, being determined by its productivity level and transportation costs. Eaton et al. (2011b) and Lawless (2009) with data of French and Irish firms, respectively, do not find evidence that supports a strict compliance of such hierarchy. Unlike these authors and based on what Figure 1 shows, in our case we proved that the companies export in a specific order to large geographical areas according to how distant they are. Therefore, with our sample we built different groups of countries with different levels of distance in relation to the Mexican market, as North America, Latin America, the European Union and Asia. With these groups we estimated separately the same regression of the first column.

The access to each market has a specific cost associated with their distance, so the firms in order to obtain benefits from trading with the countries of the Asian group must generate larger scale economies and be more productive. On the contrary, we have North America,

whose proximity to Mexico makes transportation costs smaller and exporting firms with a low productivity can access this market.

Overall, we found that the elasticity of productivity is almost the double in the case of firms that export to Asia with respect to those which sell to North America. In addition, the results show that the choice made by the firms that export from Mexico reflects an order that starts with the North American market, followed by Latin America, the European Union and Asia.

In terms of the order, there is a constraint of these latest regressions since the results can be affected by the presence of mature firms that traditionally export. In order to isolate this effect and confirm the results we estimated a multi-logit model to assess the choice that firms make with respect to the markets when commencing to export. In order to do this, from our sample we selected the firms that started their exporting activities during the span of study. As chosen markets we selected the main economies of each of the country groups, the United States of America (USA) for North America, Brazil for Latin America, Germany for the European Union and Japan for Asia. In accordance with the previous regressions, we made the choice in relation to the firm´s size, productivity, GDP and transportation costs.

Table 2. Logit estimation of the decision to export

Dependent variable: $Export\ status\ dummy_{ijt}$

	(1)	(2)	(3)	(4)	(5)
	All	North America	Latin America	European Union	Asia
$Ln\ Size_{it}$	0.442**	0.362**	0.459**	0.467**	0.466**
	(14.81)	(11.97)	(11.05)	(8.70)	(8.15)
$Ln\ Productivity_{it}$	0.366**	0.204**	0.361**	0.467**	0.520**
	(9.49)	(6.99)	(6.53)	(7.32)	(9.29)
$Ln\ GDP_{jt}$	0.312**	0.281**	0.448**	0.778**	0.300**
	(26.35)	(5.02)	(35.64)	(28.43)	(6.09)
$Ln\ distance_{ijt}$	-1.275**	-1.248**	-1.153**	-1.304**	-1.167**
	(-56.07)	(-10.10)	(-26.34)	(-2.89)	(-2.64)
$Constant$	-5.623**	-3.354	-9.953**	-18.77**	-7.324
	(-10.15)	(-1.35)	(-15.37)	(-4.14)	(-1.37)
Fixed effects year and subsector					
Pseudo R2	0.207	0.185	0.140	0.146	0.125
Observations	999,108	45,414	408,726	408,726	158,949
Destinations	79	2	18	18	7

The statistics are built using standard errors clustered at the level of municipality. The independent variables that vary over time were lagged period. Marks **, * and + indicate a level of significance of 1%, 5% and 10%, respectively.

Table 3 shows the results of the multi-logit estimation where the choice of comparison is the USA being the external market closest to Mexico. The findings reflect that as the firms have a higher productivity they will be more likely to choose as a host market of their sales countries like Brazil rather than the USA; similarly, if this growing tendency in productivity continues, the firms will prefer to export to Germany rather than the USA, obtaining positive benefits. This hierarchical pattern is similar to the one found in the previous estimations.

On the other hand, the results show that the size of the market is not significant in the choice the firms make, this can be due to the fact that the market potential that these destinations have is very similar, and therefore this is not a discriminatory factor for the firms when choosing a market. In light of these findings, Brazil can represent the closest and most feasible market to replace the USA.

Table 3. Multilogit estimation on the choice of destination market
(Alternative base or reference USA)

Dependent variable: $Export\ status_{ijt}$

	Alternatives		
	Brazil	Germany	Japan
$Ln\ Size_{it}$	0.252+	0.214*	0.242+
	(1.96)	(2.48)	(1.95)
$Ln\ Productivity_{it}$	0.570**	0.697**	0.0781
	(3.02)	(5.29)	(0.53)
$Ln\ GDP_{jt}$	0.00242	0.00369	0.00109
	(0.02)	(0.04)	(0.01)
$Ln\ distance_{ijt}$	0.0255	0.0390	0.0114
	(0.10)	(0.19)	(0.05)
$Constant$	-9.509**	-9.276**	-4.172
	(-2.83)	(-3.88)	(-1.52)
Fixed effects year and subsector			
Pseudo R2	0.203		
Observations	2700		

Statistical in parentheses. The dependent variables time varying period were lagged on period. Marks **, * and + indicate a level of significance of 1%, 5% and 10%, respectively

VI.2 Productivity requirements

Table 4 shows the findings in the empirical assessment of the third hypothesis of the theoretical model derived from equation [14], concerning the productivity requirements of the exporting firms. The sign of the coefficients is consistent with those obtained in expression [14] and are significant for at least 5%. The results in column 1 of Table 4 show that the largest firms in size which also export to large markets will have higher productivity levels. This can be explained because markets with a high purchasing power generate intense competition among exporting firms from different countries in order to place their products, and therefore as they are more productive, the companies can set a lower price, adjusting their profit margins in order to cope with such competition.

In addition, the results reveal that the smaller firms in size will also be able to export to larger markets provided these are close destinations, as asserted by previous predictions.

Nonetheless, this sort of firms are very sensitive to the competition of other firms since they will not be able to adjust their productivity level quickly by increasing their size, and they will not have the capacity to adjust their profit margin, either.

Table 4. Productivity requirements and characteristics of the markets

Dependent variable: $Ln\ productivity_{ijt}$

	(1)	(2)	(3)	(4)
$Ln\ Size_{it}$	0.0719**	0.0729**	0.0719**	0.0728**
	(3.23)	(3.27)	(3.22)	(3.27)
$Ln\ GDP_{jt}$	-0.0120*	-0.0121*	-0.0120*	-0.0121*
	(-2.13)	(-2.13)	(-2.12)	(-2.13)
$Ln\ distance_{ijt}$	0.0917**	0.0914**	0.0916**	0.0914**
	(5.69)	(5.70)	(5.69)	(5.70)
$Constant$	6.098**	6.132**	6.096**	6.133**
	(21.82)	(22.21)	(21.68)	(22.09)
Fixed effects				
Subsector	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Geographical area	Yes	Yes	Yes	Yes
Year x subsector	No	Yes	No	Yes
Year x geographical area	No	No	Yes	Yes
R2	0.284	0.288	0.284	0.288
F statistic	41.14	121.6	38.34	137.5
Observations	43,120	43,120	43,120	43,120

Statistical in parentheses. The statistics are built using standard errors clustered at the level of municipality. The independent variables that vary over time were lagged period. Marks **, * and + indicate a level of significance of 1%, 5% and 10%, respectively.

With the aim to refine the results of the first estimation of common shocks to all the firms of the same subsector, in the regression in column 2 we incorporated fixed effects of subsector-year. The results of this estimation do not show significant changes with respect to column 1. The subsector-year fixed effects take into account the existing dynamics at subsector level; however, this does not control those common shocks that firms encounter by exporting to a same geographical area over time, for example, the variations in exchange rate, modifications in the trade policy of the host country or changes in consumers' preferences. What is more, in column 3 we considered fixed effects of geographical area-

year; the results of the coefficients do not reflect changes regarding those reported in column 1.

Finally, in the last regression we considered both the fixed effects of subsector-year and geographical area-year, and we found again that the magnitude of the parameters is similar to those of the first estimation, suggesting that the simple incorporation of the fixed effects of year, subsector and geographical area already control the common shocks among companies of the same subsector that also export to the same geographical area.

VII. Assessment of the predictions before a shock in global demand

The international economic crisis of 2008 triggered due to the collapse of the housing bubble in year 2006 in the United States of America, provoking the so-called subprime mortgage crisis in late 2007. The repercussions of the mortgage crisis began to appear seriously in early 2008, firstly disseminating across the US financial system and then worldwide.

The GDP worldwide suffered a great contraction. Then, in 2008 the US economy –which represented 25.4% of the Gross World Product–, accumulated a decrease in its production of 5.1%; the Japanese economy, which contributed with 8% of the world product, was falling at an annual rate of 12.1; on the other hand, the European economies had experienced recessive behavior from the third quarter of 2008 and aggravated in the fourth quarter and the results were even more negative in 2009 (World Bank, 2011).

This decrease in aggregate demand modified the exporting dynamics of the countries and trade patterns worldwide, affecting the exporting firms in different ways. Bricongne et al. (2012) document that the big firms were affected with a reduction in the intensive margin and a reduction in the number of products offered to each host market, whereas the small exporters could no longer serve many markets or ceased their activity.

In terms of equation [14], related to the hypothesis about the productivity requirements to export, a decrease in consumers' preferences in host market j will cause —ceteris paribus— the firm to adjust its productivity level on the rise in order to be able to continue

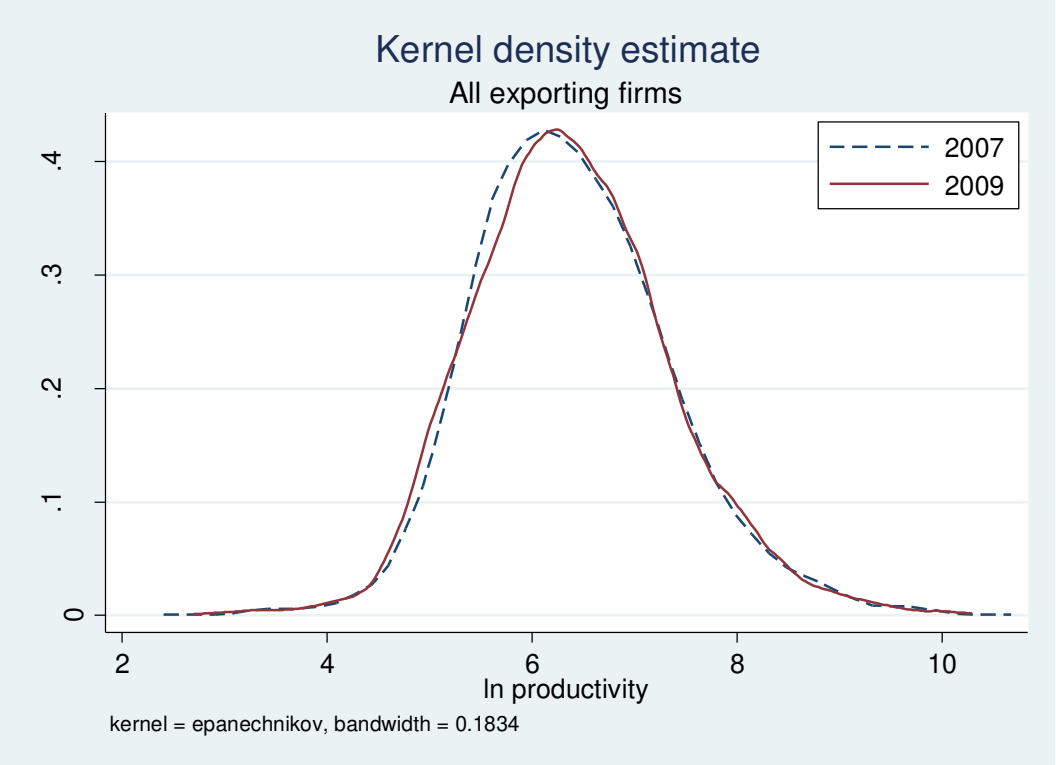
obtaining positive benefits coming from its foreign sales to that market. In fact, with a negative shock in demand, there will be a new minimum *cut-off* (φ_{ij}^{**}) so that $\varphi_{ij}^{**} > \varphi_{ij}^{*}$, and therefore companies with a productivity lower than φ_{ij}^{**} will no longer be able to continue exporting to destination j, while those firms with a productivity level over or same as φ_{ij}^{**} will continue selling to said market. Similarly, the new firms that wish to start exporting to market j will assume the new *cut-off* level generated after the shock. Additionally, a shock in demand may induce higher competition due to the existence of a wide variety of elaborated goods by other exporting firms of other countries with different productivities. Along these lines, the firms with a higher level to that of the new *cut-off* will be able to face higher competition for the existent demand.

To evaluate the changes in productivity of the firms, we estimated the density functions by means of the kernel method. This non-parametrical technique allows us to make inference on the productivity distribution of the exporting companies considered. In the estimation of the density functions we took into consideration year 2007 as it was the previous year before the crisis started, and 2009 as the year when the crisis reached its peak.

Figure 2 presents the density functions of probability for all the firms that exported in those years under consideration. As it can be seen, the lowest part of the distribution in 2009 is moved to the right with respect to 2007. This suggests that the firms that exported in 2009, recorded a minimum productivity level *(cut-off)* higher than that of the firms that sold abroad in 2007, all of which is consistent with the hypothesis of equation [14] in presence of a negative shock in demand.

When observing the rest of the levels of both distributions, we found that the distribution in 2009 shows a median (6.254) slightly displaced to the right with respect to 2007 (6.117), suggesting that a certain group of firms increased their productivity as a result of the shock in demand. A slightly different behavior is found in productivity levels (in logarithms) four to six, where it seems that levels four and five concentrate firms that record less productivity in 2009 than in 2007; contrastively, in levels five to six there seems to be again firms that increased their productivity level.

Figure 2. Distributions kernel productivity of exporting firms



Despite the fact that the kernel method is quite intuitive to observe the changes in both distributions, it has the disadvantage of not making it possible to prove the statistical significance of such inequalities. Moreover, we carried out overlapping tests[17] (overlapping coefficient) to various deciles in the distributions estimated. Table 5 shows the results in the application of two different tests, which are widely consistent. The findings in the lowest part of both distributions confirm that both distributions differ and this discrepancy is significant at least at 5%.

[17] Bradley (1985) and Inman and Bradley (1989) address the use of the overlapping tests as an intuitive measure of substantially similar between two probability distributions.

Table 5. Test of equality of distributions productivity of the year 2007 and 2009

(p-value)

Decil	Mann-Whitney test	Kolmogorov-Smirnov test
10	0.015	0.002
20	0.000	0.000
30	0.921	0.919
40	0.013	0.046
50	0.201	0.614
60	0.043	0.027
70	0.216	0.038
80	0.591	0.806
90	0.902	0.361
All	0.994	0.556

The Kolmogorov-Smirnov test evaluates the equality of the two distributions based on two samples. The Mann-Whitney test evaluates equal distributions using test Wilcoxon rank sum (Wilcoxon 1945; Mann and Whitney, 1947).

These results on one hand confirm the prediction that the firms would increase their productivity in presence of a shock; however, we also found that a certain group of firms experienced a drawback in said variable. The decrease in the productivity of some firms can be the result of an imbalance between sales and employment. This is to say, the smaller exporting firms in size could not adjust to the amount of employment with relation to a decrease in their sales.

VIII. Summary and conclusions

The relation between productivity and exports has been the subject of both theoretical and empirical studies. This document assesses the relation between size and productivity of firms in connection with exports by means of the use of disaggregate data of production and trade of manufacturing (non-maquiladora) companies settled in Mexico. Through a theoretical model inspired by Melitz (2003), we examined said relation and answered various questions regarding Mexico's exporting dynamics. Same as in other studies, the evidence found shows that the productivity of firms is relevant in the exporting activity. In our case we found that the size and productivity of firms allows explaining the kind of markets they can access. Larger and more productive exporting companies are more likely to sell in farther markets. This result comes from the fact that these larger companies can generate bigger scale economies and be more productive, allowing them to deal with transportation costs for sending their products to farther destinations.

These differences in size and productivity of Mexican firms allow us to establish an order in which they can access diverse foreign markets. Firms with a low productivity and less capacity to generate scale economies will choose as the first destination of their foreign sales the region of North America. As their productivity and size increase, they are more likely to enter first the Latin American market, and later the European Union countries and finally the Asian economies. These differences are evident when comparing the elasticity of productivity over the possibility of exporting to Asian markets (0.520), which is nearly three times higher than the elasticity obtained for the North American market.

Thus, the demands for productivity on the part of the exporting firms have shown they have a direct relation with the capacity to generate scale economies and transportation costs for the destinations they seek to access. The results point out that if transportation costs doubled, the firms would have to increase their productivity requirements 9%. When the international crisis of 2008 is analyzed, we can find that this event differently affected the exporting firms in Mexico. The results show a selection effect with respect to firms with higher productivity, and therefore the firms with low productivity ceased their exporting activity.

The effects of this crisis on the exports of firms can be magnified by the great dependency on the North American market. This allows reflection regarding the need Mexico has to diversify its export destinations. According to our multi-logit estimation, there are other highly potential markets that may replace the USA, such as European Union economies and Asian economies.

A policy to access such markets with a high purchasing power, according to our results, should be based on improving labor productivity inside firms and on increasing their size. The first aspect can be achieved with a funding strategy to exporting firms for training, guidance, infrastructure acquisition and logistics improvement, allowing them to reach more efficient productive processes. For the second feature, mergers, acquisitions, absorptions and cooperation agreements between companies are recurrent ways of gaining magnitude, and therefore this strategy should be based on promoting these activities among exporting firms that can perform them.

There are still aspects for future research regarding the relation between productivity and exports. It is necessary to research the role played by policies focused on increasing productivity and size of domestic exporting firms. So far, too little attention has been drawn to this issue, despite the existence of countries like China where the government directly supports the consolidation of small firms in larger clusters. Another aspect in the relation productivity-exports is controlling the property of firms. Due to its closeness to the USA, Mexico has many manufacturing plants with foreign capital. This is relevant because the decisions made by foreign capital firms come directly from their head office and cannot be aligned to the purpose of diversifying export markets.

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