Innovation and international trade: a non-linear relationship

Joost Heijs* y Guillermo Valdiviezo**

Summary

This paper identify the main determinants of the exports of firms with special attention to the role of innovation. Previous studies shows a linear positive relationship between innovation and the export probability or intensity.

Data for Mexico and Spain shows a non-linear relationship (an inverted “U”). The less innovative firms have lower export intensities, followed by the most innovative firms, while firms with a “medium innovative level” have the highest export intensity. For each country two models were estimated. First a traditional linear model is estimated and its results coincide with the existing literature and show that our data set is not atypical. The TOBIT model that reflects the nonlinear relationship has a higher explanatory power. In other words its superiority in relation to the linear model is justified from an econometric point of view.

Keywords

Innovation; export intensity; export probability

JEL: D21; F10

La relación entre la innovación y el comercio internacional: Una relación no lineal.

Resumen

Este trabajo identificar determinantes de exportación empresarial Los estudios previos reflejan una relación lineal entre la innovación y la probabilidad y/o intensidad de exportación..

Nuestros datos (de México y España) reflejan una relación no-lineal con forma de "U" invertida. Donde las empresas menos innovadoras tienen una intensidad exportadora más baja, seguido por las empresas más innovadoras, mientras que las empresas con un nivel medio de innovación son las más exportadores. Para cada país se estimaron dos modelos. Primero , se estima un modelo lineal cuyos resultados coinciden con las publicaciones existentes, mostrando que nuestro conjunto de datos no es atípico. Nuestro modelo TOBIT no lineal. tiene un poder explicativo superior al modelo lineal tradicional. En otras palabras, su superioridad se justifica desde un punto de vista econométrico.

Palabras clave

Innovación y competitividad; probabilidad de exportación; intensidad de exportación

JEL: D21; F10

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I. INTRODUCTIÓN

Recent literature on competitiveness stresses the importance of technological innovation to sustain economic growth and social welfare on country and on firm level. The question is whether innovation is also an important factor to explain the competitiveness of enterprises located in countries with intermediately developed technology or in developing countries with a low level of technological progress whose competitive advantages are based on low wages and a labour intensive production system producing standardised low-tech products. The aim of this paper is to study the aspects that influence the export behaviour of the firms with especially attention to the innovative behaviour for manufacturing establishments located in Mexico and Spain. Our main conclusion is that innovative behaviour is related to the export intensity measured as the amount of exports in relation to the total sales of the firm. This conclusion is the same as the results of the existing literature that shows such relationships, both for developed and developing countries. All the econometric studies (For a revision of 55 publications see Valdiviezo, 2012[1]) we have located define this relation as linear. However this paper shows -with empirical data for the Mexican and Spanish case- that the linear modelling could be wrong (See Estrada/Heijs, 2005/2006, Valdiviezo, 2012). Initially we expected a non-linear relationship in which the firm needs a minimum level of R&D or innovation (critical mass) to compete on the world-market. Therefore the export intensity will grow in parallel with the innovation effort to a certain level at which this intensity remains more or less stable. Using a TOBIT model to analyse the explanatory factors of the export intensity, our data reflect a non-linear relationship in the form of an inverted "U" between innovative behaviour and the export intensity. The less innovative firms have a lower export intensity, followed by the most innovative firms; while the firms with a "medium" level of innovative behaviour are the most competitive firms on the world market (i.e. they have the highest export intensity). For each country two models were estimated. First a traditional linear model is estimated and its results coincide with the existing literature and shows that our data set is not atypical. Secondly we estimate an alternative non-linear model. This model is econometrically significant and, more important, has a higher explanatory power than the traditional linear model. In other words its superiority in relation to the linear model and therefore its use is justified from an econometric point of view.

2.- METHODOLOGICAL AND EMPIRICAL REMARKS

2.1.- DATA AND STATISTICAL METHODS

The dataset for Mexico used in this article is based on the "Encuesta Nacional de Innovación" of Mexico of 2001 with data for 1.610 firms. For Spain the "Encuesta de Estrategias Empresariales de España (2002) of 1.707 industrial firms is used. Both surveys include detailed information of the behavior in several aspects of the firms (the structure of the firms, their strategy and innovative behaviour, financial balances etc,). The export behaviour is conceptualised as the export intensity defined by the percentage of the sales sold in export markets and as a statistical method we used a TOBIT model. Taking into account the empirical evidence we detected that the main variables that influence the export intensity are the structural characteristics of the firm (size, foreign capital, sector and probably age). Moreover, many studies point out that innovative behaviour of the firms -reflected in a diverse and broad range of indicators of the innovation processes and results- is also correlated with the export intensity. In other

[1] This revision based of 55 different studies only includes those studies that analyse the role of innovation as an explanatory factor of exports (The Spanish version can be obtained by joost@ccee.ucm.es)

words a large number of studies (see footnote 1) indicate that more innovative firms seem to be more competitive. Although the empirical evidence is not totally conclusive, it seems that both in developed and in developing countries innovative activities do influence export intensity. With a few exceptions all studies show that innovation has in some way a positive impact on export behaviour. Only in some cases specific variables show a negative relationship. However this negative relationship coexists in most cases with other variables of the innovative behaviour that have a positive impact. In fact only 8 of the 45 studies do not find any positive relationship between the innovative behaviour and the export probability or propensity. Seven studies[2] did find only non-significant relationships and one single study Zhao and Zou (2002) did find only a negative impact (in other words without any other variable of the firms` innovative behaviour that shows a positive impact). The explanation of the exceptions is not easy and can be outside the scope of this analysis. First of all because not all studies include complete information about the sample of firms[3], Moreover, it is not always easy to define what innovative firms are and how the studies measure this aspect[4]. The indicators for innovative activities used in developed countries (such as number of patents or R&D expenditures) which are very useful in cases such as Spain are not satisfactory in the case of developing countries like Mexico. Probably it is more appropriate to use in such countries other kinds of indicators such as the acquisition of modern production systems (the vintage model), the technical assistance of foreign firms or –instead of the R&D expenditures- the efforts in engineering. In fact, the 55 studies analysed for this paper used a broad range of different independent variables that seem to reflect the same economic reality –especially the variety of indicators for innovative activities- which could lead to different conclusions. The literature does not reflect a well-defined opinion about which indicator of the innovative level of a firm should be used. Therefore, we decided to use in this paper a broad variety of different indicators related to four aspects of the innovation process: acquisition of technologies; innovative intensity or efforts, the innovative results, and some qualitative aspects of the innovative behaviour. As will be seen later in the models for Spain and Mexico, estimated in this study, we use different variables to measure the same aspects.

2.- THE GLOBAL RESULTS OF THE MODEL

The models for Spain and Mexico confirm that the structural variables (size, the sector to which the firms belong or the ownership of the firms by foreign enterprises) are important to explain the export intensity. Therefore the inclusions of those variables are important as a control to analyse the impact of the innovative behaviour. The conventional model for the Spanish case (see table 2) shows us that a higher innovative effort measured by intensity of R&D (number of R&D employees by the total employment) and better R&D results (number of patents and product innovations) increases the export intensity. In the case of Mexico a higher level of innovative behaviour also intensifies the exports by sales, in this case reflected by two specific variables of the results of innovation: the certification of ISO 9000 and the existence of innovations on international levels. This Mexican model (Table 3, based on a stepwise method) includes those two variables as the most powerful ones. Also some alternative models were estimated excluding the variables that express the results of the innovative behaviour. In this case the R&D efforts as a percentage of sales are statistically significant and do partially explain export intensity.

[2] Javalgi et al, 2000; Rankin, 2001; Roberts and Tybout, 1997; Rasiha and Gachino, 2005; Zeufack, 2001.
[3] Do they include only large or small firms; do they include only firms of a certain type of sectors etc.
[4] See Jaramillo, Lugones and Salazar (2000) or Benavente (2002)

Table 2- The determinants of the export intensity: the conventional (lineal) versus the alternative (non-linear) model For Spanish manufacturer firms (Tobit Model)

		Linear model		Non-linear model	
Indicators		**Coef.**	**P>|t|**	**Coef.**	**P>|t|**
Structural characteristics of the firm	Size	0,000	0,000	0,000	0,000
	Size²	-0,000	0,000	-0,000	0,000
	Age	0,003	0,001	0,003	0,003
	Age²	-0,000	0,006	-0,000	0,013
	Part of a group of firms or holding	0,134	0,000	0,136	0,000
	Participation of foreign capital	0,127	0,000	0,124	0,000
	Region	-0,031	0,2 NS	-0,040	0,1 NS
	Traditional producers (reference)	SR	SR	SR	SR
	Traditional suppliers	0,060	0,023	0,055	0,035
	Specialised Suppliers	0,072	0,003	0,055	0,022
	Scale Intensive assemblers	0,196	0,000	0,179	0,000
	Science based sectors	0,026	0,5 NS	0,047	0,3 NS
Acquisition of technologies	Machinery for new products				
	Machinery for new products ²				
	External R&D expenditures				
	External R&D expenditures²				
	Investment in equipment and installations				
	Investment in equipment and installations ²				
	Investment in informatics				
	Investment in informatics ²				
Innovative efforts and intensity	R&D expenditures by sales				
	R&D expenditures by sales²				
	R&D employment by total employment	0,531	0,020	1,484	0,001
	R&D employment by total employment ²			-3,147	0,009
	Number of engineers by total employment			1,148	0,000
	Number of engineers by total employment ²			-4,602	0,000
Results of the innovation activities	Number of product innovations Number of	0,003	0,003	0,009	0,004
	product innovations ²			-0,000	0,045
	Number of patents	0,017	0,004	0,039	0,004
	Number of patents ²			-0,002	0,060
Qualitative aspects of the innovative behaviour (yes/no)	Use of number controlled machinery				
	Use of robots				
	Use of computer assisted design				
	Use of computer assisted production				
	Introduction of new machinery for the production process				
	Introduction of new organisation processes				
	Production of small batches of products				
	Cooperation in innovation	0,133	0,000	0,101	0,000
Other variables	Intensity of expenditures in publicity				
	Intensity of expenditures in publicity²				
	Constant	-0,154	0,000	-0,165	0,000
Goodness of fit	LR chi2	550		613	
	Pseudo R2	0,30		0,33	
	Log Likelihood	-663		-627	
	N	1640		1625	

Source: Own elaboration on the database ESEE (Fundación SEPI, 2002) (a) The sector traditional producers is used as the reference sector (SR); The model is based on a stepwise estimation method and the "___" means that those variables are excluded from the stepwise estimation while the variables with NS are included in the model but they are not significant

The findings of these conventional traditional estimations that model the relationship between innovation and export as linear confirm the results in the empirical literature, which probably proves that our data do not offer ad hoc results and are not the effect of an atypical sample of firms. Therefore it underpins in some way the credibility of the main findings of this paper: the existence of a non-linear relationship.

The main finding of this paper is based on the result of the alternative non-linear model. The results of the estimations of the alternative models of Spain and Mexico clearly confirm the non-linear relationship. In the case of Spain this non-linear relationship is observed by four variables. Two of them are related with the innovative intensity (the number of R&D employees and the number of engineers and in both cases relativized by the total employment) and two of them reflect the R&D results (number of patents and

number of innovations). The TOBIT model show that the less innovative firms do have lower export intensity, followed by the most innovative firms, while the firms with a "medium innovative level" are the most competitive firms on the world market in terms of export intensity. In the case of Mexico a similar non-linear relationship is found, although the model (based on a stepwise estimation) includes the number of product innovations

Table 3.- The determinants of the export intensity: the conventional (lineal) versus the alternative (non-linear) model For Mexican manufacturer firms (Tobit Model)

		Linear model		Non-linear model	
Indicators	**Variable**	**Coef.**	**P>|t|**	**Coef.**	**P>|t|**
Structural characteristics of the firm	Size	0,000	0,000	0,000	0,000
	Size²	-0,000	0,002	-0,000	0,001
	Part of a group of firms or holding	-0,043	0,068	-0,044	0,088
	Participation of foreign capital	0,260	0,000	0,257	0,000
	Traditional producers (reference)	SR	SR	SR	SR
	Traditional suppliers	0,090	0,006	0,090	0,006
	Specialised Suppliers	0,103	0,000	0,102	0,000
	Scale Intensive assemblers	0,092	0,027	0,103	0,019
	Science based sectors	0,066	0,2 NS	-0,062	0,2 NS
Acquisition of technologies	Intensity of expenditures in machinery				
	Intensity of expenditures in machinery ²				
	Intensity of expenditures in other technologies				
	Intensity of expenditures in other technologies ²				
	Intensity of expenditures in technical assistance				
	Intensity of expenditures technical assistance ²				
	Intensity of expenditures in quality control				
	Intensity of expenditures in quality control²				
Innovative efforts and intensity	Existence of an R&D department				
	Intensity of expenditures in innovation				
	Intensity of expenditures ininnovation²				
	Intensity of expenditures in patenting				
	Intensity of expenditures in patenting ²				
	Intensity of expenditures in design				
	Intensity of expenditures in design²				
	Intensity of R&D personnel				
	Intensity of R&D personnel				
	Intensity of expenditures in trainng				
	Intensity of expenditures in capacitación²				
Results of the innovation activities	Product Innovation			-0,001	0,097
	Product Innovation²			0,000	0,044
	Number of assigned patents				
	Number of assigned patents ²				
	Number of patent applications				
	Number of patent applications²				
	ISO9000 certification	0,159	0,000	0,163	0,000
	NOI[5] on firm level				
	NOI on firm level ²				
	NOI on national level				
	NOI on national level ²				
	NOI on international level	0,001	0,007	0,001	0,3 NS
	NOI on international level ²			-0,000	0,4 NS
Qualitative aspects of the innovative behaviour	Number of process innovations				
	Number of process innovations ²				
	Cooperation in innovation				
Other variables	Changes in the management				
	Intensity of expenditures in publicity Intensity of expenditures in publicity ²				
	Constant	-0,169	0,000	-0,167	0,000
Goodness of fit	LR chi2	298		303	
	Pseudo R2	0,14		0,15	
	Log Likelihood	-888		-885	
	N	1609		1609	

Sour (a) The sector traditional producers is used as the reference sector (SR); The model is based on a stepwise estimation method and the blank boxes means that those variables are excluded from the stepwise estimation while the variables with NS are included in the model but they are not significant (Source: Own elaboration on the database ENIMEX (CONACyT, 2001)

[5] Nu**mber of innovations**

(reflecting the results of innovation) as the most important explanatory variable. Also the broad number of preliminary models excluding and including different indicators for the innovative behaviour reflected the a non-linear relationship.

To ensure the robustness of the models we repeated the estimation (using again the stepwise method) several times randomly excluding 10% of the cases. Each time we found a similar result (the same variables were significant without changes in their relative importance or their sign –positive or negative effects-) with only minor changes in the values of the betas, marginal effects, correctly classified firms etc. Moreover, we repeated the models excluding some of the variables related to innovative behaviour. We always found similar results confirming the importance of the structural variables and the non-linear relationship between the innovative behaviour and the export intensity. Even in the case where only two variables related to innovative behaviour were maintained (one for the innovative effort or acquisition and the other for the product innovations), we obtained similar conclusions. These extra estimations are important to ensure the absence of multicolinearity or other econometric problems. Once we have analysed the results of both linear and non-linear models it is important to decide which model is better. As already mentioned the conventional model excludes the possibility that we used a specific non-representative sample. For both countries the parameters of the linear model that check the goodness of fit show equivalent values as found in similar studies and can be considered as more than acceptable. Comparing both models, we observe that all parameters are better in the case of the alternative model than in the case of the traditional linear one. The pseudo R^2 of Nagelkerke for Spain increases 10% (from 0.30 in the linear model to 0.33 in the non-linear model) while for the Mexican model this value went up from 0.14 to 0.15. Also the log likelihood improved in both models. For the Spanish case this parameter improved clearly (-627) in the alternative model compared with the conventional model (-663); while again for the Mexican case the improvement is smaller. Anyhow for both countries the non-linear model shows a better goodness of fit which brings us to the conclusion that the non-linear model seems to predict the export intensity of the Mexican and Spanish manufacturers better than the conventional model does.

3. INTERPRETATION AND COMPARISON OF OUR OWN RESULTS WITH THE EXISTING EMPIRICAL EVIDENCE

3.1 INTRODUCTION

In this section we compare and interpret our results with the existing empirical evidence. We can only carry out such a comparison for the conventional linear model because no other study -except Same authors[6]- presented an alternative model based on non- linear relationships between innovation and export behaviour (probability).

There is a rich literature that analyses the determinants or explanatory factors of export intensity or propensity. Our study detected over 50 studies that analyse this topic. Most of those analysed were developed countries although in recent years a broad number of studies also analysed developing countries. Nevertheless, in spite of such a rich variety of studies a comparison of the results is still extremely difficult. Four main problems can be mentioned based on the differences between: the kind of countries analysed; the way of conceptualising innovative firms; the dependent variable used; the diversity of the independent variables used to measure the same or similar aspects and the type of

[6] In this study they estimated the non-linear model only for the probability to export probability (To maintain anonymous reviews the reference will be included if the paper is approved by the journal). Moreover Marquez/Martinez (2009) did also find a nonlinear relationship between trade and innovation however in their case they used macro-economic data on a country level.

firms included in the model. First of all the differences between the particularities of the countries analysed in each study is an important difficulty. For example, the economic reality of developed and developing countries is totally different. Even the studies that analyse the developing countries cannot always be compared directly due to the differences between the countries characteristics (large vs. small countries; technological leader vs. followers). Moreover both type of countries has the different concepts of what is an "innovative enterprise". This concept is clearly different for developing versus developed countries, which can be considered as a second problem in comparing the outcome of the studies. Moreover the availability of data is on most occasions the reason to decide the inclusion or exclusion of certain variables rather than scientific needs or requirements. Another important aspect of the problem in comparing the empirical studies is the interaction and correlation between the broad set of variables initially included to analyse the impact of the innovative behaviour. The review of over fifty studies on the subject shows us the use of a large number of variables used as an indicator for innovative behaviour. The different outcomes can also be related with the use of different explanatory variables that presumably refer to the same aspects; and, moreover, different authors sometimes interpret the same variables differently. This problem is made clear by the differences in the relationships we found in this study for each of the different variables that reflect innovative behaviour in the case of Mexico and Spain . In this empirical study we included a broad set of indicators of the innovative behaviour (19 variables in the Mexican case and 17 variables in the Spanish case) and used a stepwise estimation method. A broad range of variables are excluded due to this statistical procedure. In our models we classified these indicators of the innovative behaviour in four blocks (the purchase of (non) incorporated innovations and technologies; the innovation effort or intensity; the innovative results and qualitative aspects of the innovative behaviour). In this paper –as will be observed later- we analysed- besides the four final models- a broad number of preliminary models (estimating over 80 models including and excluding blocks of variables of the innovative behaviour or in/excluding some specific variables), which showed us that, depending on the specific set of variables on innovation, some variables which are non-significant in one model could substitute the significant variables of certain models if these significant variables were excluded in the next experimental preliminary models. Most papers only present one model and do not refer to the preliminary models and do not include the non-significant variables in the tables of the final estimations. Therefore we cannot control them. A final problem related to the comparison of the existing empirical evidence –the sixth problem- refers to the exact type of firms included in the analysis. In fact often it is impossible to compare the existing studies because not all studies indicate the exact characteristics of the analysed sample. Taking into account the above mentioned problems it can be stated that there are only a few studies that can be considered as very similar. In this revision we compare the existing empirical evidence with the conventional linear model estimated for the Mexican and Spanish case in relation to the structural characteristics (section 3.2) and innovative behaviour (3.3). Moreover we explain briefly the existence of the non-linear relationship between innovation and the export behaviour. We did not detect any study (except one) that is comparable with the alternative non-linear model. Therefore, we try to give a more profound interpretation of the final results of the non-linear models in a separate part of the paper (section 4).

3.2 STRUCTURAL CHARACTERISTICS OF THE FIRMS

Before commenting on the influence of innovative activities on export behaviour we refer briefly to the so-called structural characteristics of the firms (size, presence of

foreign capital, sector and age of the firms) and their correlation with export behaviour. The inclusion of these characteristics in the model is very important to isolate the possible effect of innovative behaviour on export behaviour from other causes. Do to the restrictions of the space we did not include a broad description of the results of those structural variables[7] . We can mention that they do confirm the results obtained in other empiricial studies. As in all studies the size of the firm shows an inverted "U" shaped" non-linear relationship which is found in almost all studies. Regarding the age of the firm, the existing empirical data offer very confusing information for the case of Spain the non-linear form is confirmed for the export intensity while in the case of Mexico the variable age is not available and therefore not analysed. Being part of a foreign group or holding –especially in the case of modestly developed countries- is related to the firms´ position in the production chain and clearly improves the international contacts and possibilities to export. The empirical literature is not totally conclusive about the effect of foreign participation in the firm on its export intensity. Eleven studies indicate that the foreign ownership of the firm seems to have a positive effect on export intensity and also in our own empirical results for Mexico and Spain we found that firms with foreign capital do have higher export intensity than those with exclusively national capital. It seems that the determinants of the export intensity are not equal for all types of firms and sector differences can be important. Not all kinds of products can be traded freely on the international market so differences in export intensity can be explained often by differences in the sectors the firm belongs to. The inclusion of the sector as an independent variable is used to control this fact (Zhao/Li, 1997; Basile, 2001). In a complementary way some studies (like this one) analyse subsamples by sector. In our model the traditional consumer-good producing sector is used as the reference sector. In the Spanish and the Mexican model the sign of the beta coefficient for the other five sectors is positive. This means that the firms of all other sectors in both countries have a higher export intensity than the reference sector, except in the case of the knowledge-based sector because of the non-significant beta coefficient (again in both countries).

3.3. INNOVATIVE BEHAVIOUR

As already mentioned we present in this section basically our conventional linear model in comparison with the results in the existing literature, although some early results of the non-linear model will be highlighted briefly. The indicators for innovative behaviour (19 in the case of Mexico and 17 in the case of Spain) are classified in four blocks (A) the acquisition or purchase of (non) incorporated innovations and technologies; (B) the innovation effort or intensity; (C) the innovative results and (D) the qualitative aspects of the innovative behaviour). The "conventional model" (see table 3 - based on a stepwise estimation method) for Spain shows us that a higher innovative intensity (R&D employment as a percentage of the total employment) increases export intensity. Also the number of product innovations, the number of patents and technological cooperation is positively related with the export intensity. For the Mexican case two variables of the linear model show that the innovative behaviour has a positive impact on the export intensity: the number of ISO9000 certifications and the number of new or improved products which are innovative on international level. However this finding does not mean that the variables of the other three blocks of variables that reflect the innovative behaviour (such as the acquisition of (non)incorporated technologies and innovations) in the case of Mexico do not have a positive effect on the export intensity. As discussed in the beginning of this section, our models include a large number of variables that reflect

[7] Estrada/Heijs 2003 provided to a working document (of 35) pages with details and reasons to include those variables as explanatory determinants.

certain aspects of the innovative behaviour and there exists a high level of correlation or colinearity between them. Therefore we used the stepwise method to estimate our TOBIT model. In this paper we present for each country two final models (linear and non-linear) in which a few specific variables of the innovative behaviour show a statistically significant relationship with the export intensity. However, initially a large number of preliminary models were estimated including and excluding the different blocks or groups of variables of the innovative behaviour. In these preliminary models the variables that reflect the R&D expenditures by sales were statistically significant (as well as for the linear and the non-linear estimations) and therefore explain the export intensity. Also the variables reflecting the purchase of innovation and technologies were statistically significant in some of the preliminary models. The final models based on a stepwise estimation method reflect that the indicators of the R&D results (in the case of Mexico and Spain) and R&D efforts (in the case of Spain) have the highest explanatory weight, but this fact does not deny a relationship of the export intensity with other indicators of the innovative behaviour.

In the conventional linear model for the case of Spain we found a positive effect between innovation behaviour and export intensity defined by four variables of three of the four blocks of variables: the personnel in R&D by total employment (innovation efforts), the number of patents, the number of innovations (innovation results) and the fact that the firm cooperates in innovation (yes/no – qualitative aspects of the innovation). Also in our alternative non-linear model these three variables are statically significant. In the case of Mexico the linear model includes two variables of the innovative behaviour as statistically significant, both related to the results of the innovation (the ISO9000 certification and the number of innovations at international level). In the case of the non-linear models, however, a third indicator is included. In this case the number of product innovations is statistically significant and confirms the non-linear relationship between innovation and export intensity. In the case of the linear conventional models the empirical evidence seems to confirm this result although a minor number of studies did not find a statistically significant relationship between innovation and export.

The PhD study on which this paper is based repeated all the estimations for subsamples (restricted models) by six mentioned sectors of the Pavitt taxonomy. These additional estimations of our TOBIT model confirm the existence of sectoral differences. These "restricted" models show that the non-linear relationship between innovative efforts and export intensity in the case of Spain was confirmed for each of the sectors except the knowledge based sectors. In the case for Mexico only two sectors reflect the non-linear models: The scale based assemblers and the knowledge based sectors. A second set of restricted models was estimated for subsamples by size[8]. In this case the non-linear relationship was confirmed for the small and medium sized enterprises in Spain and Mexico, while in the case of the largest firms the relationships seems to be linear. In the case of Spain the non-linear relationship was confirmed in the three subsamples for the firms with up to 500 employees. While the fourth subsample (over 500 employees) did not confirm the non-linearity. In the case of Mexico the subsamples from 251-500 employees and the one with over 500 employees rejected the hypothesis of non-linearity. In conclusion the non-linear relationship also exists in smaller subsamples by size and by sectors, albeit not for all of them. Moreover the set of sectors that confirm whether a model is non-linear or not is different for Spain and Mexico.

[8] 1 to 75 employees; 76-250 employees, 251 -500 employees over 500 employees

After this overall view on the relationship between the innovative behaviour and the export intensity we will analyse each of the four blocks of variables that characterise the innovative behaviour: purchase of innovation, innovative efforts, innovative results and other qualitative indicators.

The acquisition of technologies as a determinant for export behaviour is analysed by a large number of studies using a broad range of different variables or indicators. The studies include, on the one hand, the investment in *incorporated* technologies (procurement of new machines and equipment), the capital intensity, the improvements in the production processes (automation, vintage model) as well as the acquiring of *non-incorporated* technologies (licenses, royalties for know-how, technological services or consultancy, etc.). These last ones are used more frequently in the case of developing countries. Most studies in the developed countries and in the developing countries (see table 1) show a positive relationship between the several types of variables that reflect the *acquisition of (non)incorporated technologies*- versus the probability or propensity to export. The studies of developing countries offer, in relationship with the export intensity, more confused results: ten of them reflect a positive relationship, eight of them show a negative relationship and four studies did not find statistically significant differences. The same confusing results, although less distorted, were found in studies that analyse export probability. Also our own models show some confusing results for this case. The beta coefficients of the variables used to express the acquisition of innovation included in the final models presented in this paper for Mexico and Spain are statistically non-significant. Neither were they statistically significant in the preliminary models including and excluding the different blocks of variables of the innovative behaviour. However analysing the non-linear models for subsamples by sector it can be highlighted that the acquisition of innovation is statistically significant in the subsamples of the science based sectors (in the case of Mexico), in the scale intensive assembling sectors (Spain and Mexico) and in the sector of the sectors of specialised suppliers (Spain). In other words in the most innovative sectors the acquisition of innovations has a non-linear relationship with the export intensity. These sectoral differences are also found by the existing literature. The literature offers different interpretations of those results. First, in developing countries a non-significant or a negative effect could be expected due to its abundant labour market and low wages (Kumar/Siddhartan, 1994). In a low wage country a higher capital intensity (and the purchase of capital goods) is not per se an advantage to compete on the international market or could even imply a certain disadvantage. On the other hand the positive influence of purchasing incorporated technologies on export behaviour is explained by the existence of learning and the scale effects related to the introduction of new machinery and equipment (Wakelin, 1998; Van Dijk, 2002). This second interpretation could be supported by the fact that the acquiring of incorporated technologies has a positive effect on export propensity especially in high-tech sectors (Raut, 2003; Kumar/Siddhartan, 1994), since they are complex sectors where learning is an important aspect. In fact, the study of Kumar/Siddhartan (India, 1994) reflects a negative relationship between capital intensity and export propensity in low and medium technology sectors and a positive one in two high-tech sectors (electrical engineering and drugs and the pharmaceutical industry). This means that a higher degree of capital intensity (as a measurement for incorporated technologies) does not improve the export behaviour of low or medium tech firms or, even has a negative effect, while for some of the high tech sectors investment rates do spur export behaviour. In these sectors labour-intensive processes appear to be inefficient despite low wages (Kumar/Siddhartan, 1994). On the one hand the paper of van Dijk, (2002) confirms the positive impact of capital investment on exporting in high

tech and medium tech sectors. On the other hand, he offers very heterogeneous results in relation to the low-tech sectors. His interpretation of the positive effects in some of these sectors is that supplier-dominated sectors seem to require a certain degree of automation even for firms operating in relatively low technological industries to break into foreign markets.

To conclude; acquisition of technologies seems to increase export intensity in certain (more advanced) sectors and that fact could partially explain the confusing results in the existing literature analysing developing countries. This fact is confirmed by our own model. Taking into account the final models included in this paper, the estimations of subsamples by size and sector and the preliminary models, the relationship between the acquisition of innovations and the export intensity exists only for a few sectors. Moreover our study confirms that the relationship is non-linear because the alternative non-linear models that include these variables improve the goodness of fit of the model. Moreover this relationship is probably not equal for all countries, or at least some differences were observed between the Mexican and Spanish case. In the conventional linear model for the case of Spain we found a positive effect between ***innovative effort or intensity*** (expressed by the percentage of the personnel in R&D by total employment), while in the case of Mexico none of the variables of this block is included as statistically significant. Apparently these results do not confirm the empirical evidence -of developed and developing countries. However, as mentioned above, in the preliminary models (excluding the results of innovation) some variables of the innovative intensity are statistically significant for both cases (Spain and Mexico).

The variables reflecting ***the acquisition of technologies*** -used in this paper- are mainly related to the innovation process, while the ones used for the *results of innovative activities* are related to product innovation. The conventional models for Spain and Mexico reflect a linear relationship between the results of the innovation process and export intensity. In the case of Spain this relationship is confirmed by the number of new products and the number of patents, while in the case of Mexico this relationship is confirmed by the number of product innovations on an international level and the ISO9000 certification. Moreover the block of variables that reflect the results of the innovation process do confirm the non-linearity of the impact of innovation on the export propensity. Most restricted models based on subsamples by sector confirmed the importance of innovative results for the export intensity for all sectors in the Mexican case and in the Spanish case for 3 of the 5 sector subsamples. In this case no statistically significant relationship was found for the science base sectors and the scale intensive assemblers. Most existing empirical studies (eight studies) confirm the (linear) relationship between the results of the innovation process and the export intensity. However five studies do consider it as non-significant and one study found a negative relationship. The confusion in the empirical literature is maybe not so surprising because the developed countries compete on the world market not by price competition; rather they penetrate the world markets by good quality and highly innovative products. In fact the low wage countries offer cheap technologically standardised products with an acceptable quality. Moreover as mentioned above there exist clear sector differences which can also shine some light on the differences in the empirical literature.

The existing literature includes a ***heterogeneous group of qualitative aspects of the innovative behaviour*** such as the qualification of the human capital and the staff of the firms, the existence of cooperation in innovation, the level of diversification versus specialisation, or the existence of process innovations. Most of these variables included in the models were statistically significant and therefore confirm the importance of the

innovation to explain the export probability and intensity. Looking only to the empirical studies that analyse the export intensity (the subject of this article) it can be stated that 11 studies that analyse developed countries do confirm the positive impact of such qualitative variables, 4 of them found non-significant results and only one study found a negative results. The studies for developing countries offer a more confusing panorama. Six studies confirm the positive impact although 3 of them showed non-significant relationships and another three of them found negative relationships. Our own models also include some qualitative aspects of the innovative behaviour of the firms such as the cooperation in innovation or the use of certain types of process innovations. In the final estimations –based on the stepwise method- presented in this paper, almost all those variables were excluded from the model due to the fact that other variables (correlated with them) had a higher explanatory power. In the case of Spain none of these variables are statistically significant and in the case of Mexico the fact that the firm cooperates in terms of innovation has a positive impact on the export intensity. In some of the preliminary models of Spain cooperation was also statistical significant. On the contrary they were also excluded by the estimations of all subsamples by size and by sector except in the case of traditional producers of consumer goods in the case of Spain. In this sector the cooperation has a positive influence on the export intensity.

4.- THE CONVENTIONAL LINEAR MODEL AND THE EMPIRICAL EXISTING LITERATURE: FINAL REMARKS

The main conclusion of this paper is that innovation is important to explain export behaviour in the Mexican and in the Spanish case and -very important. The results of the conventional linear models show that innovation would be a method to achieve the international standards of the world market and therefore it is necessary to compete more intensively in the export markets. The existing empirical literature shows such a linear relationship both in developed and developing countries. However, the relationships in both type of countries are not always the same, probably due to the contrast between the importance of innovation for the production process and international competitiveness reflected in firms' innovative strategies, especially in the case of product strategy. Based on a simplified statement most firms in developing countries have a product specialisation strategy -based on low wages and process innovations of standardised and incrementally improved products- to compete on the world market while the enterprises of the developed countries and of some specific sectors of developing countries do have a product innovation strategy. The rich literature about this subject offers sometimes confusing empirical evidence. The differences in those results could partially be explained by several causes mentioned in section 3.1. Especially the interaction and correlation between the broad set of variables initially included to analyse the impact of the innovative behaviour. If, as in our study, a broad set of indicators of the innovative behaviour (19 in the Mexican case and 17 in the Spanish case) are used in combination with a stepwise estimation method, a broad range of variables are excluded due to this statistical procedure. The preliminary models (including and excluding blocks of variables or some specific ones) did show us that, depending of the specific set of variables on innovation, some variables which were non-significant in one model could substitute the significant variables that were excluded in the next experimental models.

Anyhow if the objective of the study is to analyse the role of the innovation as an explanatory factor of the export intensity (as in our paper) there is no problem because any kind of variable or indicators of the innovative behaviour is enough to underpin the importance of the innovative behaviour for exporting, a fact that has been proved in almost all existing empirical studies. However, if you want to find out which aspects of the

innovative behaviour have more impact on exports than other aspects of this innovative behaviour the problem would be very important. A last, sixth, problem in interpreting the results in the light of the existing literature is the inclusion of different types of firms in the samples used to analyse the impact of innovation on the export behaviour (small vs. large firms; broad range of firms vs. firms of some particular sectors or only innovative enterprises, etc...). Not all studies clearly express the type of firms included in the sample or the exact description of the variables, and this made it very difficult to compare their results with other studies. Probably this is because most of the studies use data (surveys), as in our case, not especially designed for the analysis of export behaviour. Therefore additional models including subsamples of firms (by size, sector, etc...) are necessary and useful. As in our study, they show clearly that different types of firms are associated with distinct independent variables that explain their export behaviour. So an important conclusion for the comparison of the outcome of different studies and the interpretation of our own models is the need for a clear description of the enterprises included in the analysis. These differences probably explain part of the differences and sometimes the confusing contradictory results in the existing literature.

5.- CONCLUSIONS AND INTERPRETATION OF OUR RESULTS

In this paper we proved the importance of innovative activity to compete on the world market. This conclusion was confirmed by both models (the conventional and the alternative non-linear one). Also we explained briefly the difficulties in comparing results of the existing literature. In fact the sometimes apparently contradictory results could be explained by the particularities of each of the studies. This was especially so where the different studies use dissimilar kinds of samples (large versus small firms or subsamples for specific sectors). The importance of this problem is demonstrated by the differences we found in the restricted models by size or sector. We situated the results of our own conventional model in the existing literature and found that they are very similar to those of other studies and, and more important, it seems that the existing differences could be interpreted. We included this conventional model to show that our data set does not generate ad hoc results and to improve the credibility of our alternative models that shade the results of the mainstream literature.

There is no doubt about the fact that innovative behaviour is an important explanatory factor for export intensity. Analogous to the conventional literature we made it clear that innovation is important to explain export behaviour; but, in addition we state that the relationship is non-linear. The discovered impact of innovation on the export intensity reflects a non-linear effect in the form of an inverted “U” between the innovative efforts and export intensity. Our results reflect the fact that the less innovative firms and the most innovative ones have lower export intensity than the enterprises with an average innovative level. Our data not only identified the non-linearity of the relationship between innovation and export propensity, but these alternative models also show a better goodness of fit than the conventional ones. This means that the non-linear model seems to explain somewhat better the existing reality than the conventional-linear models.

We analysed four aspects of innovative behaviour –acquisition of innovations and technologies, innovative efforts, the innovative results and some qualitative aspects of the innovative behaviour-. In the case of Spain two variables of the R&D intensity (R&D employment and number engineers by total employment) and two variables of the R&D results (number of patents and number of new products) confirm this non-linear relationship while in the case of Mexico the variable that confirms that this non-linear relationship is the result of the innovation process in the form of the number of innovative products. However this finding does not mean that the R&D efforts or the

investments in external R&D and acquisition of non-incorporated R&D in the Mexican firm are non-linear. In this paper we present for each country a final model in which some specific variables reflect the innovative behaviour. However initially several preliminary alternative models were estimated and -excluding the variables of the results of innovation- these alternative models include a non-linear relationship between the R&D efforts or the efforts for acquisition of new technologies. In those alternative models (for the case of Mexico and Spain) at least one of the variables of the four innovative aspects are included as an explanatory variable, and most of them indicate an inverted "U" shaped relationship. The more innovative the firm is the higher its export intensity, although once reaching a certain innovative level the additional increase of this level is correlated with a decreasing export intensity. Concluding, the final model based on a stepwise estimation method reflects the fact that the indicators of the R&D results (in the case of Mexico and Spain) and R&D efforts (in the case of Spain) have the highest explanatory weight, but this fact do not deny the possibility of a non-linear relationship with other indicators of the innovative behaviour.

The exact interpretation of the non-linear relationship in the form of an inverted "U" between innovation and the export intensity seems to be complicated. We need to explain why (a) a low innovative level is related to a lower export intensity and (b) why the highest innovative firms show a lower export intensity than the firms with an intermediate innovative level. Moreover we should explain this fact for two different settings. On the one hand this is for the case of Mexico as a developing country with low (or intermediate) level of salaries and on the other for Spain as a developed country, a member of the European Union and a quite high level of labour costs. Below we present some possible arguments or reasons that probably can explain the non-linearity, though with our data set we could not confirm them and more future analysis is required. The first question (a) about the relatively low export intensity of firms with a low innovative effort can be interpreted for -developing and developed countries- by taking into account the particularity of innovative activities. The theory shows that innovation -especially R&D- is an activity with a high level of indivisibilities (Arrow, 1962), which requires a minimum level innovation to make it profitable. The firms with a low level of innovative activities probably do not reach the critical mass or minimum threshold that makes innovation profitable for the world market as reflected in export activities. However, firms that clearly opt for innovation activities are competitive at an international level. So, on the one hand, the firm needs a minimum level of efforts in innovation[9] and therefore the less innovate ones do not export or only export a small part of their overall sales. On the other hand, on the international markets a combination of an intermediate innovative level with low wages (as in Mexico) seems to be a valid competitive strategy. Such argumentation explains the first question but does not explain the second part of the question: why do high innovative firms export less in relation with the firms with an intermediate level of innovation?

In the case of Mexico or other developing countries with low salaries the low export level for low innovative firms could be connected to the type of products they export, related to their position in the product life cycle. The process innovation -except R&D- is often a way to increase competitiveness for standardised products. The purchase of incorporated technologies (acquisition or investment in machinery and equipment) or good human capital can bring down production costs. So the increasing levels of

[9] This interpretation is a more theoretical or abstract explanation. In our model we use the innovative intensity as explanatory variable but in fact the critical mass concept in the theory refers to the absolute expenditures as a way to reach such critical mass.

innovation firms that produce standardised product improve their competitive level and generate a higher export intensity. Again this explanation does not clarify why high innovative firms export less than firms with an intermediate level of innovation.

These above mentioned arguments probably could explain the low export intensity of less innovative firms. However, the fact that the most innovative firms -with the highest relative innovative efforts- have a lower export intensity is more difficult to understand. A feasible explanation could be the possible position of these highly innovative firms within the vertical production chain as providers of exporting firms (such as, the mass assemblers). A second reasonable explanation could be the fact that developing countries like Mexico compete on the world market by low prices and acceptable quality. They need some innovative efforts to compete -complementary to their low costs- however due to their limited innovative capacity it would be difficult to compete on the world market with a clear high-tech innovation strategy. Therefore it could be possible that the "highly innovative" Mexican firms are geared to compete in the domestic markets rather than on export markets. The firms oriented to the domestic market have to compete with the most competitive national and foreign enterprises. These firms have to be more innovative than their competitors because it is not possible to compete on low wages in the home market. Maybe for Spain a similar argumentation could be developed albeit in other terms.

Another explanation that could explain the lower export intensity of the most innovative firm could be that the most innovative enterprises do not export because the market of the highly innovative products needs -in the case of consumer goods- a high level of income, or they are providers for larger firms, so their export is indirect. However, this argument is not applicable to the Mexican case and probably also not for the case of Spain. However it could explain the lower export intensity for (small) highly innovative firms in some specific developed countries such as Germany, Japan or the USA.

We admit that the interpretations for the non-linear relationship presented in this paper are theoretical and abstract explanations and our data set does not allow us to confirm them. However, the mainstream literature also did not present any justification for the linear relationship either. Our models are technically well defined and, as explained, have a better goodness of fit than the traditional linear models, which makes us confident of the credibility of our analysis and the importance of our finding. Anyhow as far as we know this is the first study that identifies the non-linearity between the export propensity and the innovative level of the firms and, as we just said, future studies are required to confirm these findings and to explain the reasons behind the non-linear relationships

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