Export Performance and Innovation Activities in the Agrifood Industry: A Recursive Estimation Approach

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EXPORT PERFORMANCE AND INNOVATION ACTIVITIES IN THE AGRIFOOD INDUSTRY: A RECURSIVE ESTIMATION APPROACH

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Summary

Agrifood firms operate in a more global, saturated and competitive market than other manufacturing firms, and they have smaller size. These firms certainly need to define appropriate strategies related to accessing the international market and to investing in innovative activities. This two decisions are related to firms size because as Krugman states international trade is not only explained by differences in technology between countries but also by firms' desire to extend their sales in foreign markets to take advantage of the economies of scales. Therefore, it seems to exist a simultaneous relation between firm size, exports and innovative activities.

The aim of this paper is to analyse agrifood firms' decisions on these three strategies: export behaviour, innovative activities and firm's size in comparison to other manufacturing firms using some modification from the simultaneous model defined by Entorf and Pohlmeier. The study is focused on the Spanish manufactured firms taking special attention to the agri-food ones. Data come from a National Survey ("Encuesta de Estrategias Empresariales") carried out by the "Fundación Empresa Pública") from 1990.

Results indicate that agri-food manufacturing firms decision process related to their size, export share and innovative activities is not a simultaneous process. Moreover, some differences with the rest of manufactured firms have been detected, In particular, agri-food firms have lower export shares, lower size and lower innovation intensity than Spanish firms in other manufacturing sectors. Spanish firms decision process on strategic variables (size, export share and innovation) is characterized by a recursive decision process where firms firstly decide export intensity, secondly, they decide their size or total sales depending on the previous decision and, finally, they decide their innovative intensity depending on the last two.

EXPORT PERFORMANCE AND INNOVATION ACTIVITIES IN THE AGRIFOOD INDUSTRY: A RECURSIVE ESTIMATION APPROACH

1. Introduction

The economic environment that firms are facing is characterised by two important phenomena that produce significant changes in all economic activities. One of them is the globalisation process that induces an increasing in international competitiveness and in business internationalisation. Firms operating in this competitive market must undertake international strategies such as exports activities in order to survive in the market. The second phenomenon is the continuous and important development in technology that provides firms the opportunity to carry out innovative activities to differentiate their products in the market. Moreover, agrifood firms face to a more saturated market than firms operating in other sectors because, food demand is stagnated in quantities terms although some increases in expenditures can be expected due to consumers' claims for higher quality products. Consumers are demanding more processed, diverse and added-value food products, therefore, agrifood must satisfy these new requirements and product innovation becomes the means to accomplish these requirements.

Agrifood industry in Europe is characterised by the small size of the companies where more than 80% of food manufacturing enterprises employ less than 10 workers, and only 0.3% employ more than 500 (Traill, 1998). Therefore, most of food companies are Small and Medium Enterprises (SME) (less than 250 employees according to the European Commission definition), but largest firms employ 29% of the workers. Moreover, there are structural differences between countries. The United Kingdom, Denmark and Sweden have high-concentration industry, Germany and France have medium levels of concentration, and Italy, Portugal, Belgium, Greece and Ireland have low levels (Traill, 1997). In the case of Spain, agri-food industry is the first manufacturing sector and it accounts for 20% of total manufacturing output, employs 15% of total manufacturing workers and represents 16% of total manufacturing companies in 1999. However, food industry size is relatively small with almost 90% of food companies with less than 20 workers with in average 14 workers per company (Ameur, 2002).

Many authors have stated that a large firms size is essential either to undertake export or innovation activities. In the later, according to Schumpeter, larger firms can provide the required economies of scale to carry out innovation activities. In the former, many studies have tried to analyse the positive relationship between firms size and export performance (Bilkey (1979); Reid (1982); Cavusgil et al. (1979); Bonarcosi (1992)). They stated that this positive relationship is due to the economies of scale generated by larger firms and because these larger firms are in a better position to undertake the higher cost and risk associated to the export activity. On the other hand, some empirical works have tried to demonstrate the relationship between innovation and exports. The basic foundation of this relation comes from the pioneers explanations of international trade where trade is explained by differences in specialisation across countries. However, recent literature has also argued that actual international trade can be explained by differences in technology (neotechnology theories). Finally, Krugman analysed the factors affecting international trade using new assumptions taken from the

industrial economics theory (monopolistic competition, economies of scale and product differentiation). He stated that international trade is not only explained by differences in technology between countries but also by firms' desire to extend their sales in foreign markets to take advantage of the economies of scales. Therefore, it seems to exist a simultaneous relation between firm size, exports and innovative activities.

This simultaneous relationship was analysed in the eighties by some authors, Encaoua y Jacquemin (1980), Clarke y Davies (1982) and Neumann et al. (1985), assuming that firms operate in an imperfect competitive market. Those models were extended by Entorf and Pohlmeier (1990) and applied in the Spanish manufacturing sector by Orti and Miravete (1992), Labeaga and Martinez (1993) and Escribano (1995).

Agrifood firms operate in a more global, saturated and competitive market than other manufacturing firms and they have smaller size, therefore, they will certainly need to define appropriate strategies related to accessing the international market and to investing in innovative activities. In this case, to analyse the relationships between firm size, exports and innovative activities is of crucial importance. The aim of this paper is to analyse agrifood firms' decisions on these three strategies: export behaviour, innovative activities and firm's size in comparison to other manufacturing firms using some modification from the simultaneous model defined by Entorf and Pohlmeier. The study is focused on the Spanish manufactured firms taking special attention to the agrifood ones. Data come from a National Survey ("Encuesta de Estrategias Empresariales") carried out by the "Fundación Empresa Pública") from 1990.

The paper is structured as follows. Next section defines the theoretical model used to explain the relationship between exports, innovation and firm size. Section three describes data and the definition of the variables included in the model. Section four presents main econometric results and explains the econometric procedure. Finally, some concluding remarks are presented.

2. The model

The theoretical model used in this paper is a straightforward extension of a competitive fringe model frequently used in the literature (Encaoua and Jacquemin, 1980, Clark and Davies, 1982; Neuman et al., 1985) and extended by Entorf y Pohlmeier (1990).

Those authors assumed the same market structure where two different types of firms are operating. The first group consist of firms behaving as dominant in an oligopolistic market, and the second group as a competitive fringe. Each firm can sell its products in the domestic market and in the foreign market assuming that they are independent. On the other hand, firms decide the total output, how much to sell in each market and the investment on product innovative activity.

In this paper, it is supposed that firm's sales can be expanded depending on the level of the innovation activity, and the increase in sales due to the innovative activity is considered the same in both markets. In other words, total sales will increase depending of how much firms spent on product innovative activity.

On the domestic market, total demand will be served by "n" dominant firms and a competitive fringe (consisting of "m" perfectly competitive firms) that can be expressed as follow:

$$Q_j^d = \sum_{i=1}^{n}(1+s(AI_{ij}))q_{ij}^d + X_j^d$$

the demand in the foreign market is modelled equivalently by:

$$Q_j^e = \sum_{i=1}^{m}(1+s(AI_{ij}))q_{ij}^e + X_j^e$$

where:

$(1+s(AI_j))q_{ij}^d$: is the output of the dominant i firm of industry j sold in the domestic market

$(1+s(AI_{ij}))q_{ij}^e$: is the output of the dominant i firm of industry j sold in the foreign market

X_j^d: is the total output sold by the competitive fringe in the domestic market

X_j^e: is the total output sold by the competitive fringe in the foreign market

$s(AI_{ij})$: is a function expressing the increase in firm total sales due to the innovative activity.

The total output of the firm "i" in industry "j" sold in both markets is:

$$(1+s(AI_{ij}))q_{ij} = (1+s(AI_{ij}))q_{ij}^d + (1+s(AI_{ij}))q_{ij}^e$$

Profits of the ith dominant firm in industry j are defined by:

$$\Pi_{ij} = R_{ij}^d(Q_j^d, q_{ij}^d, AI_{ij}) + R_{ij}^e(Q_j^e, q_{ij}^e, AI_{ij}) - \cos ts$$

where, $R_{ij}^d()$ and $R_{ij}^e()$ are revenues obtained on the domestic and foreign markets, respectively.

Three different types of costs can be defined as:
- Production cost: given by $CP_{ij}([(1+s(AI_{ij})]q_{ij}, w_{ij})$, where AI_{ij} is the innovative activity, w_{ij} is the wage of the workers considered as the only input that varies in the short-run.
- Innovative cost: given by $CI_{ij}(AI_{ij})$
- Export activities cost: given by $CE_{ij}([(1+s(AI_{ij})]q_{ij}^e, Ex_i^e)$, that depends on the output sold abroad and on other factors related to export difficulties (market investigation, distance, etc.).

In this short-run model, decisions taken by firms are: Total sales, Export share and Innovative activity. Therefore, the endogenous variables in the model are: total sales (q_{ij}), export share ($\lambda_{ij} = \dfrac{q_{ij}^e}{q_{ij}}$) and product innovative activity (AI_{ij}).

To simplify the model we assume that revenues are additively separable in both markets. Then firm's decision problem is:

$$\Pi_{ij} = P_j^d(Q_j^d) \times \left[(1 + s(AI_{ij})]q_{ij}^d + P_j^e(Q_j^e) \times \left[(1 + s(AI_{ij})]q_{ij}^e - CP_{ij}\left(\left[(1 + s(AI_{ij})]q_{ij}, w_{ij}\right)\right.\right.$$
$$- CI_{ij}(AI_{ij}) - CE_{ij}\left(\left[(1 + s(AI_{ij})]q_{ij}^e, Ex_i^e\right)\right.$$

where: $P_j^d(Q_j^d)$ and $P_j^e(Q_j^e)$ are the inverse demand in the domestic market and the inverse demand in the foreign market, respectively, that depend on the total quantity sold in each market.

To find the optimum, each dominant firm must maximize its profit function with respect to the three decision variables. Therefore, the three first order conditions are as follows:

With respect to the first variable:

$$\left[(f^d q_{ij}^d + P_j^d)\right](1 - \lambda_{ij}) + \left[(f^e q_{ij}^e + P_j^e)\right](\lambda_{ij}) - \frac{dCP_{ij}(q_{ij}, w_{ij})}{dq_{ij}} - \frac{dCE(q_{ij}^e, Ex_{ij}^e)}{dq_{ij}} = 0$$

With respect to the second variable:

$$\left[1 + s(AI_j)\right] \times \left[(P_j^e - P_j^d)q_{ij} + \frac{dP_j^d(Q_j^d)}{d\lambda_{ij}}(1 - \lambda_{ij})q_{ij} + \frac{dP_j^e(Q_j^e)}{d\lambda_{ij}}\lambda_{ij}q_{ij}\right] - \frac{dCE_{ij}}{d\lambda_{ij}} = 0$$

With respect to the third variable:

$$P_j^d q_{ij}^d \frac{ds(AI_{ij})}{dAI_{ij}} + P_j^e q_{ij}^e \frac{ds(AI_{ij})}{dAI_{ij}} + \frac{dP_j^d}{dAI_{ij}}\left[1 + s(AI_{ij})\right]q_{ij}^d + \frac{dP_j^e}{dAI_{ij}}\left[1 + s(AI_{ij})\right]q_{ij}^e - \frac{dCosts}{dAI_{ij}} = 0$$

Once all the derivatives above are rearranged and after inserting each function in its corresponding equations, a system of equations defining the firm's optimal choice in term of these three decision variables, its exogenous firm-specific parameters and the variables defined at the industry level is obtained (see Ameur (2002) for the explanation of the derivations). The three equations that define firm's decisions on firm size, export share and innovation are the following:

$$F_1 = F_1\left(q_{ij}, \lambda_{ij}, w_{ij}, AI_j, Q_j^d, \varpi_{ij}^d, \mu_{ij}^d, v_j^d, \varepsilon_j^d, K_j^d, Q_j^e, v_j^e, \varepsilon_j^e, K_j^e\right) = 0$$
$$F_2 = F_2\left(q_{ij}, \lambda_{ij}, AI_{ij}, Q_j^d, \varpi_{ij}^d \mu_{ij}^d, v_j^d, \varepsilon_j^d, K_j^d, Q_j^e, v_{ij}^e, \varepsilon_j^e, K_j^e, Ex_{ij}^e\right) = 0$$
$$F_3 = F_3\left(q_{ij}, \lambda_{ij}, AI_{ij}, \varepsilon_j^d, \eta_j^d, \tau_j^d, \varepsilon_{ij}^e, \eta_j^e, \tau_{ij}^e\right) = 0$$

The definition of the variables is shown in table 1.

The system can be modelled econometrically as a three simultaneous equation system in the choice parameters treating all other variables as exogenous. Furthermore, the system gives some insight on how variables defined at industry level can be modelled within an econometric model based on firm level data.

3. The data

Data come from a continuous survey "Business Strategy Survey" (Encuesta de Estrategias Empresariales) carried out to manufacture firms by the "Fundación Empresa Pública" since 1990. The survey collect every year information on the number of employees by categories, sales and expenditures by type of products, exports and imports, market share, foreign investment, price policy, market characteristics and expectative, and accounting information. However, not all variables are gathered every year, some specific variables are questioned only every four years (Innovation activities, foreign investment, expected prices, system of production, marketing strategies (promotion, advertisement), distribution channels, competitors' strategies perception). This is the reason why information for the last 5 years (1994-1998) has been used, because the first and the last year contain information for all the variables.

The survey is conducted to approximately 1400 manufacture firms that are interviewed yearly. They try to maintain the same set of firms in the database, and if some firms disappear from the original database, a new firm with similar characteristics is introduced. Then, to have a homogenous database for the period (1994-1998) we have deleted some of them and we have finally considered 1358 firms every year. Therefore, total sample consists of a pool of 1358 firms in 5 years, it means a total of 6790 manufactured firms.

Firms are classified by main-product type in 21 groups according to the Economic Activities Classification at the three-digit industry level (Ministerio de Industria y Energia, 1999) (three of the groups correspond to agri-food firms). Survey information has been used to calculate the variables in the way they have to be included in the model. Variables definition and calculations can be shown in table 1.

4. Estimation and results

The model to be estimated consists of three equations with three dependent variables: total sales (q_{ij}), export share ($\lambda_{ij} = \dfrac{q_{ij}^e}{q_{ij}}$) and product innovative activity (AI_{ij}). Two of these variables are truncated to zero λ_{ij} and AI_{ij} because firms can be or not exporters, and can or not spend on innovation. Moreover, we have to estimate a simultaneous equations system with truncated variables. This type of econometric model cannot be estimated with classic simultaneous estimation methods. The most efficient method to estimate jointly the three equations system would be the maximising of the likelihood function. However, the likelihood function cannot be defined for models with more than two equations. Therefore, some authors have used different two-stage estimation procedures such as Nelson and Olson (1978), Amemiya (1974) to estimate these simultaneous equation models with truncated variables (Entorf and Pohlmeier (1990); Orti and Miravete (1992), Labeaga and Martinez (1993) and Escribano (1995)).

The simultaneous model defined by equation (1)-(2) and (3) has been estimated using the Nelson and Olson procedure and results are shown in table 2. This estimation determines that some of the endogenous variables in the model are not statistically significant explaining the behaviour of the other endogenous variables. In particular, in

the export share equation, neither firm size nor innovation activity has statistically significant effect on export share. The null effect of firm size on export share indicates that Krugman hypothesis, who states that firms export behaviour is not only due to differences in specialisation but also because firms try to take advantage of the economies of scale due to their larger size, is not accepted. Therefore, for the Spanish manufactures the size is not a factor that encourages their export intensity. On the other hand, the null effect of the innovation activity on export share is against the a priori expected hypothesis that the higher product differentiation due to the higher innovation intensity will increase firm competitive position in the foreign market and, hence, their export share. Therefore, export decision depends only on the exogenous variables. In the sales equation, export share has a statistically significant impact on firm size, but the innovation activity seems not to influence the size of the company. Finally, in the innovation equation, both, firm size and export share have shown statistically significant effects on the innovative activity.

Previous results indicate that there are not simultaneous relationships among variables, although some bilateral relations have been found. Then, Spanish firms do not take decisions related to their size, export share, and innovation activities simultaneously. Some variables seem to be related with other variables, but it has not been detected significant relationships among all the endogenous variables. The final relationships found in estimations indicate that firms decide firstly their export share depending on other explicative factors. Secondly, they decide their total sales depending on the previous decision (export share) and other exogenous variables, and finally firms will decide their level of innovation depending on both previous decisions along with some exogenous factors.

This preliminary estimation provides the empirical evidence to allow us to re-define the original simultaneous system model, following the new structure, as a recursive equation system. This system consists of three equations: i) export share depending only on exogenous variables; ii) total sales (firm size) that depend not only on the exogenous variables but also, on the export share; and iii) innovation activity that depends on both, export share and firm size, along with a set of exogenous variables.

The recursive equation system can be expressed as follow:

$$\lambda_i^* = \beta^{Ex} x_i^{Ex} + u_i^{Ex}$$
$$S_i = \beta^S x_i^S + \gamma^S \lambda_i^* + u_i^S$$
$$AI_i^* = \beta^{AI} x_i^{AI} + \gamma_1^{AI} \lambda_i^* + \gamma_2^{AI} S_i + u_i^{AI}$$

where first and the second variables are truncated to zero and can be expressed as follow:

$$\begin{cases} \lambda_i^* = \lambda_i & \text{if } \lambda_i > 0 \\ \lambda_i^* = 0 & \text{if } \lambda_i \leq 0 \end{cases}$$

$$\begin{cases} AI_i^* = AI_i & \text{if } AI_i > 0 \\ AI_i^* = 0 & \text{if } AI_i \leq 0 \end{cases}$$

This new system of equations will be estimated by maximizing likelihood function.

The likelihood function for the three recursive equation system to be maximized is[1]:

$$L\left(\beta^{EX},\ \beta^{S}, \gamma^{S}, \beta^{AI}, \gamma_1^{AI}, \gamma_2^{AI}\right) = \sum_{\lambda_i \leq 0} \ln \Phi \left(\frac{-\beta^{EX} x_i^{EX}}{\sigma_E} \right) +$$

$$\sum_{\substack{\lambda_i \geq 0 \\ AI_i \leq 0}} \left\{ \ln \Phi \left(\frac{-\beta^{AI} \times x_i^{AI} - \gamma_1^{AI} \times \lambda_i - \gamma_2^{AI} \times S_i + \Sigma_{21} \Sigma_{11}^{-1} U_1}{\sigma_{I.ES}} \right) - \ln(2\pi) - \frac{1}{2} \ln\left(\left|\Sigma_{11}\right|\right) - \frac{1}{2} Z_1' \Sigma_{11}^{-1} U_1 \right\}$$

$$- \sum_{\substack{\lambda_i > 0 \\ AI_i > 0}} \frac{1}{2} \left\{ 3 \ln(2\pi) + \ln\left(\left|\Sigma\right|\right) + U_2' \Sigma^{-1} U_2 \right\}$$

To estimate this recursive model, the above likelihood function for the system of equations will be maximized to obtain the maximum likelihood estimated parameters for all the variables introduced in the model. Results of this estimation are shown in table 3.

Estimated parameters in the export share equation show that all the coefficients are statistically significant except for three of them: total sales sold in the domestic, total sales sold in the foreign market, and the number of products manufactured by the firm. The market share in the domestic market has a negative sign and statistically different from zero which means that market share has a negative effect on export share while the market share in the foreign market has a positive and statistically different from zero effect. Those results indicate that firms with higher shares in the domestic market have less incentive to sell their products in the foreign market because their relatively importance in the domestic market is high enough, while firms with higher shares in the foreign market reach higher export share. It means that the larger their market share in the foreign market is the larger firms' export share is. So that, for the Spanish firms it is difficult to start exporting mainly for those firms with high participation in the domestic market, but once they have accessed to the international market, they allocate increasing proportion of their sales in this market.

The effect of the total demand price elasticity on the export share is positive and statistically different from zero. This indicates that positive expectations on the domestic market grown (higher elasticity) will stimulate firms to export higher proportion of their total output. Concentration ratio has also a positive effect on the export share, which indicates that firms operating in highly concentrated domestic market will search for alternative markets, less concentrated, to reach a certain level of sales and, therefore, they will have higher export share. The number of intermediaries in the distribution chain has a negative effect on the export share. In other words, if the retailers chain consist of a higher number of intermediaries, it is less likely that firms have higher exports. Finally, the closer country destination of exports is the highest firm export shares are. This is due mainly to three reasons, neighbours have more similar tastes, the access to information about foreign market structures is higher and transportation costs are lower.

In the firm size (total sales) equation, export share has a significant negative effect. This effect can be explained by the lower firms incentive to sell abroad of larger

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[1] See explanations in the annex

firms because they have more opportunities to sell their products in the domestic market. However, smaller firms cannot compete with larger firms in the domestic market and they try to sell their product in foreign markets. It was expected that the effect of the quantity sold in the domestic and in the foreign market would be negative, however, in our case, both estimate parameters have positive sign, which indicate that they have a positive effect on total sales. On the other hand, market share in the domestic market is statistically significant at 10% level while market share in the foreign market is not. The positive effect of market share in the domestic market on total sales indicates that relatively larger firms in the domestic market reach also the higher total sales in this market. Respect to employees, firms with a higher number of workers and with higher expenses in personnel will have higher total sales. Highly qualified workers in the firms do not influence total sales because the estimated parameter is statistically equal to zero. Finally, advertising expenditures have a positive effect on total firm sales that indicate that advertising is a useful marketing strategy to increase total firm sales.

In the innovation activity equation, both endogenous variables are statistically different from zero. While export share estimated parameter is negative, the total sales coefficient is positive. The negative effect of export share on innovation indicates that high export performance do not result in a higher innovation activity but on the contrary, drives a lower innovation intensity. On the other hand, the positive effect of total sales indicates that larger firms (with high sales and high revenues) will spend more money on innovation activities. This last result indicates that Schumpeter hypothesis, which states that larger firms have higher tendency to undertake innovation activities, is accepted in the case of Spanish manufacturing firms.

According to exogenous variables, results show that higher qualification of workers have not effect on the innovation activity, however, highly qualified workers undertaken innovation activities induce an increase in innovation intensity. Firms created longer time ago are less prone to carried out innovative activities. In other words, firms found more recently have a higher tendency to undertake innovative activities that firms created longer ago. To sell directly to consumers have a positive effect on innovation that indicates that firms with higher direct sales effort are also more likely to make higher efforts in product innovation to meet the more sophisticated food consumers demands. Differences in innovation intensity between firms with foreign investment and without have not been found because, the foreign investment dummy is not statistically different from zero.

Finally, to analyse the agri-food firms' behaviour in comparison to the other manufacturing firms, the main aim of the paper, the corresponding dummy variable is studied. The three agri-food dummy variables (one for equation) are statistically different from zero and negative. This indicates that agri-food firms have lower export shares, lower size and lower innovation intensity than Spanish firms in other manufacturing sectors.

5. Concluding remarks

The main result of this paper is that agri-food manufacturing firms decision process related to their size, export share and innovative activities is not a simultaneous process. Moreover, some differences with the rest of manufactured firms have been

detected. In particular, agri-food firms have lower export shares, lower size and lower innovation intensity than Spanish firms in other manufacturing sectors.

Spanish firms decision process on strategic variables (size, export share and innovation) is characterized by a recursive decision process where firms firstly decide export intensity, secondly, they decide their size or total sales depending on the previous decision and, finally, they decide their innovative intensity depending on the last two. This decision process indicates that either firm size and innovation activities influences export intensity which means that Spanish firms do not hold the Krugman hypothesis (firms access the international market in order to take advantage of the economies of scales due to their larger size) and the hypothesis of higher product differentiation will induce firms better competitive position in international markets. Moreover, firm size is explained by the export intensity but it is not affected by the innovation activity. However, the negative effect of export share on firm size denies the expected positive relation between them. Many authors have found a positive relationship that has not been accepted in the case of Spanish firms. It means that the international market is a way for smaller firms to sell their products in response to their lower possibilities in the domestic market. Once smaller firms have entered the international market, their export intensity is higher than the export share of larger firms. Finally, innovative activity depends on both export intensity and firm size. A positive relation between size and innovation has been found which means that the Schumpeter hypothesis (larger firms have higher incentives to undertake innovative activities) holds in the case of Spanish manufacturing firms. However, the negative relation found between export and innovative intensities denies the commonly accepted hypothesis that firms with higher international orientation will have higher innovation propensity.

The other exogenous factors explaining firms decisions are: i) sales shares in the domestic and foreign market; ii) total demand price elasticity; iii) concentration ratio in the domestic market; iv) the distribution chain; v) employees with different level of qualification; vi) advertising expenditure; vii) number of years operating; and viii) exports destination. Firms with higher proportion of sales in the domestic market have lower export share while firms with higher proportion of sales in the foreign market present higher export intensity. Positive firms expectations about domestic market growth generate higher sales in both, the domestic and the foreign market, but the later is higher in relative terms. Firms operating in more concentrated domestic markets have a tendency to sell increasing proportion of their sales in the international market. When firms sell their products using their own distribution chain or have less intermediaries to sell their products, both, their export and innovation intensity is higher. Higher qualification of workers do not incentive either increases in total sales or innovation intensity. However, innovative activities are stimulated in those firms with higher qualify employees undertaken innovation tasks. To spend more in advertising is an important marketing strategy because advertising stimulates firms total sales. Finally, the longer a firm has been created the lower is their innovative intensity.

Table 1. Definition of variables (endogenous and exogenous) included in the model

Variables	Definition of variables
Variables defined in the theoretical model	
Endogenous Variables	
q_{ij}	Total sales of firm i in industry j
λ_{ij}	Export share
AI_{ij}	Product Innovation: Annual expenditure on Research and Development (R&D)
Exogenous Variables	
Q_j^d	Total quantity sold in industry j in the domestic market
Q_j^e	Total quantity sold in industry j in the foreign market
ϖ_{ij}^d	Market share in the domestic market: Sales in the domestic market of i-th firm in industry j over total firms' sales in industry j
ϖ_i^e	Market share in the foreign market: Sales in the foreign market of i-th firm in industry j over total firms' sales in industry j
v_j^d	Price elasticity of the competitive fringe in domestic market (not available)
v_j^e	Price elasticity of the competitive fringe in foreign market (not available)
μ_{ij}^d	Conjectural reaction elasticity of the dominant firms in the domestic market: dummy variable, 1 if the firm believes that its sales in the domestic market are higher that its competitors; 0 otherwise
μ_{ij}^e	Conjectural reaction elasticity of the dominant firms in foreign market: dummy variable, 1 if the firm believes that its sales in the foreign market are higher that its competitors; 0 otherwise
ε_j^d	Price elasticity of total demand in the domestic market: dummy variable, 1 if the firm considers that the domestic market has grown possibilities; 0 otherwise
ε_j^e	Price elasticity of total demand in the foreign market: dummy variable, 1 if the firm considers that the foreign market has grown possibilities; 0 otherwise
K_j^d	Concentration ratio for industry "j" in the domestic market: 5 larger firm's sales over total sales in industry j in the domestic market
K_j^e	Concentration ratio for industry "j" in the foreign market: 5 larger firm's sales over total sales in industry j in the foreign market
η_j^d	Elasticity in the domestic market with respect to innovation (not available)
η_j^e	Elasticity in the foreign market with respect to innovation (not available)
τ_j^d	Innovation revenue in the domestic market: R&D expenditures over total sales in the domestic market
τ_j^d	Innovation revenue in the foreign market: R&D expenditures over total sales in the foreign market
w_i	Wage of employees
Ex_{ii}^e	Factors depending on export activities: Uexp: export share to UE countries OCDExp: export share to OCDE countries
Other variables included in the model	
Pworker	Number of permanent employees
HQworker	Percentage of highly qualified employees (engineers)
ERD	Number of engineers working in R&D
TRD	Number of technicians working in R&D
WRD	Number of other employees working in R&D
Adv	Expenditure on advertisement
#Prod	Number of products
#Int	Number of intermediaries in the distribution chain
DirSales	Percentage of production sells directly to consumers
FI	Foreign investment share on total capital
#year	Number of years the firm is operating in the market
AF	Agri-food dummy variable: 1 if the firm belongs the the agri-food sector; 0 otherwise

Table 2 Nelson and Olson estimation of the general simultaneous equations model for manufactured spanish firms

Endogenous variables	Equation 1 (q_{ij})		Equation 2 (λ_{ij})		Equation 3 (AI_{ij})	
	Estimated coefficients	t-student	Estimated coefficients	t-student	Estimated coefficients	t-student
q_{ij}	-	-	0,0008	1,6	1,45	4,1
λ_{ij}	-19,67	-12,4	-	-	-99,24	-4,46
AI_{ij}	-0,1	-1,73	0,00002	0,3	-	-
Log L / R2	0,78		1618	-	17799,5	

Table- 3 Maximum likelihood estimation of the recursive equations model for manufactures spanish firms

	Estimated coefficients	t-student
Equation 1: (λ_{ij})		
Q_j^d	-0,38E-7	1,22
Q_j^e	0,03	1,28
ϖ_{ij}^d	-0,023	-12,05
ϖ_{ij}^e	0,023	9,31
ε_j^d	0,1	2,5
K_j^d	0,0025	7,97
#Int	-0,023	-2,93
UEexp	0,0011	9,43
#Prod	0,0001	0,44
OCDEexp	0,0032	9,83
AF	-0,15	-11,46
Equation 2: (q_{ij})		
λ_{ij}	-28,23	-7,47
Q_j^d	0,00005	2,35
Q_j^e	0,00005	2,87
ϖ_{ij}^d	1,79	1,63
ϖ_{ij}^e	0,41	1,23
Pworker	0,018	2,28
Eworker	0,026	1,87
HQworker	-0,044	-1,28
Adv	0,05	3,76
AF	-4,63	-2,17
Equation 3: (AI_{ij})		
λ_{ij}	-9,92	1,75
q_{ij}	1,15	3,27
HQworker	-0,06	-1
Dirsales	13,83	1,8
ERD	1,05	2,05
TRD	9,98	1,24
WRD	1,14	3,45
FI	0,044	0,91
#year	-0,41	-4,56
AF	-34,9	-4,47
ρ_{12} = 0,96; ρ_{13} =-0,000014; ρ_{23} =0,000004-		

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ANNEX - Mathematical support

If we consider the following recursive simultaneous equations system:

$$Y^*_{1i} = \beta_1 x_{1i} + u_{1i}$$
$$Y^*_{2i} = \beta_2 x_{2i} + \gamma_{21} Y^*_{1t} + u_{2i}$$
$$Y^*_{3i} = \beta_3 x_{3i} + \gamma_{31} Y^*_{1t} + \gamma_{32} Y_{2t} + u_{3i}$$

where x_i denote the set of exogenous variables, β the coefficients to be estimated and u_i error terms for each equations. The first and third equations are truncated to zero and can be expressed as follows:

$$\begin{cases} Y^*_{1i} = Y_{1i} & \text{if } Y_{1i} > 0 \\ Y^*_{1i} = 0 & \text{if } Y_{1i} \le 0 \end{cases}$$

and

$$\begin{cases} Y^*_{3i} = Y_{3i} & \text{si } Y_{3i} > 0 \\ Y^*_{3i} = 0 & \text{si } Y_{3i} \le 0 \end{cases}$$

Error terms are assumed to have a normal distribution with zero mean and variances, σ_1^2, σ_2^2 y σ_3^2 respectively and with correlation between them terms (ρ_{12}, ρ_{13} y ρ_{23}.) supposed different from zero. Therefore, the covariance matrix can be expressed as:

$$\begin{Bmatrix} u_{1i} \\ u_{2i} \\ u_{3i} \end{Bmatrix} \approx N(0,\Sigma), \text{ where } \Sigma = \begin{pmatrix} \sigma_1^2 & \sigma_{12} & \sigma_{13} \\ \sigma_{12} & \sigma_{22}^2 & \sigma_{23} \\ \sigma_{13} & \sigma_{23} & \sigma_{33}^2 \end{pmatrix}$$

Considering that two of the three dependent variables are truncated to zero, we obtain 3 regimes depending on the possible combinations of variables shown in this diagram:

	$Y^*_{3i} = 0$	$Y^*_{3i} = Y_{3i}$
$Y^*_{1i} = 0$	Regime 1	
$Y^*_{1i} = Y_{1i}$	Regime 2	Regime 3

In regime 1, the variable Y_{1i} is not observed furthermore the contribution of this regime to the likelihood function is:

$$\Pr(Y_{1i} \le 0) = \Phi\left(\frac{0 - \beta_1 x_{1i}}{\sigma_1}\right)$$

where Φ is the standard normal distribution function

In the second regime, the first and second variables (Y_{1i} y Y_{2i}) are observed (continuous variables) and the third (Y_{3i}) is not observed. In this case, the cumulative density function of the standard bivariate normal distribution is:

$$\Pr\left(Y_{3i} \leq 0, Y_{1i}, Y_{2i}\right) = \int_{-\infty}^{0} f\left(Y_{3i}, Y_{1i}, Y_{2i}\right) dY_{3i}$$

or alternatively

$$\Pr\left(Y_{3i} \leq 0, Y_{1i}, Y_{2i}\right) = \Pr\left(Y_{3i} \leq 0 \mid Y_{1i}, Y_{2i}\right) \times f_{Y_{1i} Y_{2i}}\left(Y_{1i}, Y_{2i}\right)$$

Using the matrix partitioned, the contribution of this regime to the likelihood function can be expressed a follows:

$$\Phi\left(\frac{-\beta_{3i} X_{3i} - \gamma_{31} Y_{1i} - \gamma_{32} Y_{2i} + \Sigma_{21} \Sigma_{11}^{-1} U_1}{\sigma_{3.12}}\right) \times (2\pi)^{-1} |\Sigma_{11}|^{-\frac{1}{2}} \exp\left\{-\frac{1}{2} U_1' \Sigma_{11}^{-1} U_1\right\}$$

where:

$$U_1 = \begin{pmatrix} u_{1i} \\ u_{2i} \end{pmatrix} = \begin{pmatrix} Y_{1i} - \beta_1 X_{1i} \\ Y_{2i} - \beta_2 X_{2i} - \gamma_{21} Y_{1i} \end{pmatrix}$$

and

$$\Sigma_{2.11} = \sigma_{3.12}^2 = \sigma_3^2 - \Sigma_{21} \Sigma_{11}^{-1} \Sigma_{12}$$

In the third regime, all of the three variables (Y_{1i}, Y_{2i} y Y_{3i}) are continuous (observed), however the contribution on the likelihood function is constructed using the trivariate cumulative function that can be expressed as:

$$f\left(Y_{1i}, Y_{2i}, Y_{3i}\right) = (2\pi)^{-\frac{3}{2}} |\Sigma|^{-\frac{1}{2}} \exp\left\{-\frac{1}{2} U_2' \Sigma^{-1} U_2\right\}$$

where

$$U_2 = \begin{pmatrix} u_{1i} \\ u_{2i} \\ u_{3i} \end{pmatrix} = \begin{pmatrix} Y_{1i} - \beta_1 X_{1i} \\ Y_{2i} - \beta_2 X_{2i} - \gamma_{21} Y_{1i} \\ Y_{3i} - \beta_3 X_{3i} - \gamma_{31} Y_{1i} - \gamma_{32} Y_{2i} \end{pmatrix}$$

Finally, the likelihood function for the recursive system can be expressed as follows:

$$L\left(\beta_1, \tau, \beta_2, \gamma_{12}, \beta_3, \gamma_{13}, \gamma_{23}\right) = \sum_{Y_{1i} \leq \tau} \ln \Phi\left(\frac{\tau - \beta_1 X_{1i}}{\sigma_1}\right)$$

$$+ \sum_{Y_{1i} > \tau, Y_{2i} \leq 0} \left\{ \begin{array}{l} \ln \Phi\left(\dfrac{-\beta_3 X_{3i} - \gamma_{31} \times Y_{1i} - \gamma_{32} \times Y_{2i} + \Sigma_{21} \Sigma_{11}^{-1} U_1}{\sigma_{3.12}}\right) \\ -\ln(2\pi) - \dfrac{1}{2}\ln\left(|\Sigma_{11}|\right) - \dfrac{1}{2} U_1' \Sigma_{11}^{-1} U_1 \end{array} \right\}$$

$$- \sum_{Y_{1i} > \tau, Y_{2i} > 0} \frac{1}{2} \left\{ 3 \ln(2\pi) + \ln\left(|\Sigma|\right) + U_2' \Sigma^{-1} U_2 \right\}$$

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