Innovation, exports and technical efficiency in Spain

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Abstract.

This paper analyses the relationship between exports, innovative activities and size and their effect over firms' technical efficiency and then over their productivity. The analysis takes, also, into account other variables that could affect productivity as industrial sector, or firms' financial conditions. We use a micro panel data set of Spanish manufacturing firms, during the period 2004–2009, to simultaneously estimate a stochastic frontier production function and the inefficiency determinants. The data source is published in the Spanish Industrial Survey on Business Strategies (Encuesta sobre Estrategias Empresariales, ESEE), collected by Fundación SEPI. Our results show that exporting firms are more efficient than non-exporting firms; and that small and medium-sized firms' tent to be more efficient when they focus on international markets.

Key words: exports, firms, technical efficiency, productivity, innovative activities, R&D expenditures.

JEL: F14, L25, L60, O25

1. Introduction

In the period 1995-2007 Spain experienced the longest growth cycle in its recent history. This growth was based primarily on low value-added sectors that were heavily punished by the arrival of the crisis in 2007. More and more numerous voices calling for a change in the Spanish production model toward higher value-added sectors. The present crisis has highlighted the lack of sustainability of this model of economic growth and the need to shift to production processes with greater investment in R & D that allows companies to be more competitive in international markets. There is evidence that exporting firms invest more in R & D, are more open to develop or incorporate new technologies and are more adapted to incorporate advances in management and organization that occur globally.

There are numerous scientific studies that show that those economies that devote more resources to implement R & D activities are more productive and have better resisted the current economic crisis. Moreover, there is evidence in favor of exporting firms are more efficient and invest more in technology and training. In Spain, due to the fall in domestic demand, many companies have directed their efforts to compete in international markets as an alternative to the internal market.

There are a wide number of papers analysing the relationship between innovation and firms' productivity growth (Cohen and Keppler, 1996; Crépon et al., 1998; Griliches, 1979 and Hall and Mairesse, 1995) and also between exports and productivity (De Loecker, 2007; Kim et al., 2009; Delgado et al., 2002 and Fariñas and Martin-Marcos, 2007). Recently, some papers studied the relationship between innovation activities and exports, considering both as complementary factors that contribute together to enhance firms' productivity. See López Rodriguez and García Rodriguez, (2005) and Baldwin and Gu (2004). Golovko & Valentini, (2011) hypothesize that innovation and export are two complementary determinants of the firms' growth. Using a sample of Spanish manufacturing firms during the period 1990-1999 they obtain empirical evidence in favour of this hypothesis, that is, the positive effect of innovative activities on firms' growth is higher for those firms that participate in export markets.

The main purpose of this work is to analyse the effect of exports intensity and R & D activities in technical efficiency using data of Spanish manufacturing firms during the period 2004-2009. In a previous work, Diaz and Sanchez (2008) found that size was an important determinant of technical efficiency. Also, in Sánchez and Díaz (2013) innovation was an important determinant of efficiency for large firms but not for small and medium sized firms. Perhaps because large firms are more easily able to obtain external financing and thus finance their R & D activities and obtain product and process innovation that allows them to gain competitiveness in foreign markets. Size is also related to the ability of firms to compete in foreign markets. So we will focus on exporting companies to investigate the relationship between exports, and efficiency. As it is well known the exporting firms are more competitive than those that are not focused on foreign markets.

To obtain empirical evidence we estimate a value added production function following the methodology of the Stochastic Frontier Approach, first developed by Farrell (1957) and widely used in empirical works. Using this methodology several works have analysed technical inefficiency: Caves and Barton (1990) analyse technical efficiency for manufacturing firms in United States; Green and Mayes (1991) analyse technical inefficiency for United Kingdom; and Patibandla (1998) proves the relevance of capital market imperfections on the structure of an industry; Dilling-Hansen et al. (2003), and Kumbhakar et al., (2011) analyse the effect of R&D investment on relative efficiency; Diaz and Sánchez (2008) analyse the impact of size on efficiency; and Sánchez and Diaz (2013) focus in the effect of product and process innovation over technical efficiency, obtaining that large firms' innovation are more efficient than the small one.

2. Data and Methodology

We use the Spanish Industrial Survey on Business Strategies *(Encuesta sobre Estrategias Empresariales, ESEE)*, which includes almost all Spanish manufacturing firms with more than two hundred employees. Firms employing between ten and two hundred employees were chosen according to a stratified random sample representative of the population of small firms. Given the procedure used to select firms participating in the survey, it adequately represents the distribution of the population of Spanish manufacturing firms and their characteristics. Each year a number of additional firms were selected according to a random sampling procedure among the whole population of firms. This selection is conducted using the same proportion as in the original sample (see Fariñas and Jaumandreu (2004) for technical details of the sample).

We use the Stochastic Frontier Methodology to estimate a production frontier with inefficiency effects. Specifically, we use a panel data version of the Aigner et al. (1977) approach, following Kumbhakar and Lovell (2000), in which technical inefficiency is estimated from the stochastic frontier and simultaneously explained by a set of variables representative of the firms' characteristics.

The model can be expressed as:

$$Y_{it} = f(X_{it};\beta)\exp(v_{it} - u_i) \tag{1}$$

Where *i* indicates firms and *t* represents the period; *X* is the set of inputs; β is the set of parameters, v_{it} is a two-sided term representing the random error, assumed to be *iid* $N(0,\sigma_v^2)$; u_i is a non-negative random variable representing the inefficiency, which is assumed to be distributed independently as a $N(\mu,\sigma_u^2)$.

The mean of the inefficiency term (μ) is a function of variables that could explain the inefficiency.

$$\mu_i = \delta_0 + \delta' Z_i \tag{2}$$

Where Z is a (Mx1) vector of variables that may have effects over firm efficiency, δ is a (1xM) vector of parameters to be estimated.

Given that technical efficiency is the ratio of observed production over the maximum technical output obtainable for a firm (when there is no inefficiency), the efficiency index (TE) of firm *i* in year *t* could be written as:

$$TE = \frac{f(X_{it};\beta)\exp(v_{it} - u_i)}{f(X_{it};\beta)\exp(v_{it})} = \exp(-u_i) \tag{3}$$

The efficiency scores obtained from expression (3) take value one when the firm is efficient, and less than one otherwise.

3. Descriptive Analysis

Our sample includes 2,247 Spanish industrial firms from the ESEE Survey and refers to an unbalanced panel over the period 2004-2009. From the original sample, a number of firms have been eliminated: we have eliminated those firms for which we do not have relevant data for at least two consecutive years. Others were eliminated because they reported a value-added annual growth rate per worker in excess of 500% (in absolute value), and some were rejected because they have less than ten workers and, in both cases, they would distort the analysis. Also, we do not include firms after a merger or division process in our sample data.

We estimate a production frontier using the firm's value added as a dependent variable and capital and labour as inputs. We also include product and process innovation to consider the impact of innovative activities on the frontier. Moreover, we distinguish between sectors, using the corresponding dummies.

Simultaneously we estimate the inefficiency determinants. Our main interest lies in knowing the effect of exports on efficiency. Other determinants included in the empirical analysis are firms' size, investment over capital ratio and the proportion of external funds over value added.

Most of these variables differ when we distinguish between exporting and non exporting firms, showing the differential of those firms that have decide to participate in foreign markets.

Table I show the descriptive statistics for the whole sample and Table II and III, show respectively, the descriptive statistics for the export and non-exporting firms.

Table I: Descriptive statistics for the whole sample

	Min.	Max	Mean	Standard Deviation
VA*	110.29	10,689,161.42	162,610.05	553,841.99
K*	10.94	33,091,212.35	357,083.77	1,609,312.16
L	10.00	14,400.00	236.90	724.36
INP	0.00	1.00	0.20	0.40
INPR	0.00	1.00	0.32	0.47
Investment over capital	0.00	4.58	0.07	0.14
Leverage	0.00	209.39	2.31	5.82

(*) Euros

Table II: Descriptive statistics for export companies

	Min.	Max	Mean	Standard Deviation
VA*	110.29	10,689,161.42	230,032.77	667,084.40
K*	10.94	33,091,212.35	518,548.80	1,973,447.43
L	10	14400	331.79	876.82
INP	0.00	1.00	0.28	0.45
INPR	0.00	1.00	0.39	0.49
Investment over capital	0.00	4.58	0.07	0.13
Leverage	0.00	209.39	2.54	6.43

(*) Euros

Table III: Descriptive statistics for non-exporting companies

	Min.	Max	Mean	Standard Deviation
VA*	125.40	5,342,815.55	39,635.22	176,626.79
K*	22.01	4,666,028.29	62,581.62	276,542.82
L	10.00	5,076.00	63.83	182.02
INP	0.00	1.00	0.08	0.26
INPR	0.00	1.00	0.20	0.40
Investment over capital	0.00	3.27	0.08	0.15
Leverage	0.00	182.40	1.89	4.47

(*) Euros

It can be observed that exporting firms tend to be larger than average. The average value added of these firms is higher than that of non-exporting firms and so does the number of employees. Nevertheless, the larger standard deviation show that even small firms participate in foreign markets. This is why we consider size as one important determinant of technical efficiency in our estimated production function.

Respect to the innovative activities, exporting firms have dedicated more resources to finance R & D activities and have achieved, on average, more product and process innovations than non-exporting firms. Differences are especially evident in the case of process innovation. This is in favour of our hypothesis that innovation and exports are relating and both contribute to make firms more efficient.

No relevant differences arise when we look at the ratio of investment expenditure over capital between exporting firms and the whole sample. In turn, the percentage of external funds over value added is above the average. This fact indicates that exporting firms are more able to obtain external funds to finance their activities. The variables included in the estimation of the frontier are detailed below.

Variables of Stochastic Frontier estimations:

VA: Value added in real terms. This is the dependent variable.

CAPITAL STOCK (K): Inventory value of fixed assets excluding grounds and buildings.

L: Total employment by firm.

T: This is the time trend.

INP: Dummy that takes value 1 if there is product innovation and 0 otherwise.

INPR: Dummy that takes value 1 if there is process innovation and 0 otherwise.

Sector classification: There are seven dummy variables that take value one when the firm belongs to the corresponding sector of activity; otherwise this value is zero.

SEC1: Meat and manufacturing of meat; food industry and tobacco drinks; textiles, clothing and shoes; leather, shoes and derivatives.

SEC2: Wood and derivatives, paper and derivatives.

SEC3: Chemical products; cork and plastic; non-metallic mineral products.

SEC4: Basic metal products; manufactured metal products; industrial equipment.

SEC5: Office machinery and others; electrical materials.

SEC6: Cars and engines; other material transport.

SEC7: Other manufactured products.

Determinants of efficiency:

INVESTMENT OVER CAPITAL: This is the ratio between investment expenditure in capital goods over capital.

EXTERNAL FUNDS OVER VA: This is the ratio between external total funds over added value.

EXPORTING FIRMS DUMMY. This is a dummy variable that takes value 1 if the firm export.

SIZE: There are six dummy variables that take value one when the firm belongs to the corresponding interval of workers, zero otherwise:

- SIZE 1: Firms with no more than twenty workers.
- SIZE 2: from 21 up to 50.
- SIZE 3: from 51 up to 100.
- SIZE 4: from 101 up to 200.
- SIZE 5: from 201 up to 500.
- SIZE 6: Firms with a number of workers higher than 500 (this is the category of reference)

4. Results

The maximum-likelihood estimates of production frontier parameters defined in equation (1), given de specification for inefficiency effects defined in equation (2) are presented in table IV.

Table IV: Stochastic Frontier Estimates

Variables	Parameters	Coefficients	t-value
Constant	β_0	9.1195	0.000
T	β_1	0.1465	9.836
L	β_2	0.9489	16.86
K	β_3	-0.0680	-3.94
K^2	β_{11}	0.0311	16.83
L^2	β_{22}	0.0426	5.263
T^2	β_{33}	-0.0131	-8.68
KxL	β_{12}	-0.1343	-9.09
LxT	β_{13}	0.0234	6.873
KxT	β_{23}	-0.0176	-8.18
INP	θ_1	0.0239	1.794
INPR	θ_2	0.0297	2.876
Wood and derivatives, paper and derivatives.	γ_1	-0.1648	-5.63
Chemical products; non-metallic mineral products.	γ_2	-0.0979	-2.38
Basic metal products; industrial equipment.	γ_3	0.0500	1.575
Office machinery and others; electric materials.	γ_4	0.1100	3.691
Cars and engines; other material transport.	γ_5	0.1148	2.929
Other manufactured products	γ_6	-0.0007	-0.01

Inefficiency Model			
Constant	δ_1	8.2041	0.000
Gross investment over capital	δ_2	-1.2822	-4.99
External funds over VA	δ_3	0.0271	22.90
Export. Firms dummy	δ_4	-0.2700	-4.67
Size1: Up to 20 workers	δ_5	1.8722	11.92
Size2: From 21 to 50	δ_6	1.4538	9.584
Size3: From 51 to 100	δ_7	1.0301	7.170
Size4: From 101 to 200	δ_8	0.9063	6.805
Size5: From 201 to 500	δ_9	0.6138	5.331
Variance components			
Lambda	λ	1.0928	62.70
Sigma(u)	σ_u^2	0.3726	71.09

With the frontier approach methodology we measured the firm's technical inefficiency compared with the best observation of the sample. The value of the obtained estimates allows us to explain the differences in the level of inefficiency among firms. When we compare the technical inefficiency among firms, it is assumed that their production technology is similar, but, as technological and market condition can vary over sectors, we have included sector dummy variables in the production function in order to be able to control them. In Spain, after the financial crash, the structural aspects of competitiveness have received more attention. In this way, we analyse the intensity of investment over capital, the external funds over value added, the export projection of firms and their size to know their relevance to the degree of inefficiency in Spain.

The effect of gross investment over capital is negative and significantly different from zero, which means that this variable contributes to reduce firm inefficiency. As higher is the investment of a firm over its capital, smaller is its degree of inefficiency. Sánchez and Díaz (2013) obtain the same result, that is, the effect of gross domestic investment over capital reduces the distance to the frontier in any case. Even when we estimate a separate frontier for large and small firms this result remain.

We also found that inefficiency tends to be larger for those firms with a high ratio of external financial funds over value added. As higher is the leverage more difficult is for firms to be close to the frontier. One of the characteristic of the present economic crisis is the liquidity constraint that faces the Spanish manufacturing firms. So, in this context, as higher is the dependence of a firm to external financing, higher difficulties has it to keep its level of production. Goddar et al. (2005) offer an explanation for this effect. The effort to pay debt interest is reflected in the reduced ability to take advantage of good growth opportunities.

Firms oriented to international markets are more efficient than those mainly focused on domestic markets. To pick up this effect we have included a dummy variable for those exporting firms and we have obtained a significant and negative coefficient. This negative coefficient means that to be an exporting firm reduces the distance to the frontier of efficient firms. The exporting firms have a greater productivity and this explain why they could attract foreign capital. This correlation has been analysed by Delgado et al. (2002). Only the most productive firms could survive in the highly competitive export market.

We found a positive and significant relationship between size and technical efficiency showing that it is an important determinant of technical efficiency. In a previous work, Diaz and Sánchez (2008) obtain the opposite result for the period of 1995 to 2001. In this previous work they obtain a negative and significant relationship between size and efficiency. However if large firm's size allows for the realisation of costs advantages, the relationship between size and technical efficiency should be positive. As Chih-Hai and Ku-Hsich (2009) pointed out, empirical and theoretical works on firm's size and technical efficiency obtain ambiguous results. In this sense, different specifications and estimations should bring differences in results about size. In our empirical evidence, the differences between these two estimations are reflected in the period and in the specification of the production function to build the frontier. In this paper we have included the product and process innovation variables in the estimation of the production frontier. Both, innovation of process and product increase efficiency, overall, for larger firms.

5. Concluding remarks

The inefficiency determinants can be due to environmental or firm specific factors. Here we focus on these firms specific factors to provide an explanation to the differences in technical inefficiency across Spanish manufacturing firms. Inefficiency tends to be smaller for firms with a higher ratio of gross investment over capital. Firms that account for this kind of investment become more competitive as a consequence of having a higher efficiency in their production process.

Also, we found that exporting firms are closer to the stochastic frontier. They have to be more competitive to sell in international markets. Only the most efficient firms survive in the highly competitive international market.

Size is another determinant of technical efficiency. Even though the impact of size in technical efficiency is not clearly determined in empirical and theoretical frameworks, here we obtain a positive and significant effect over efficiency. What it means that large firms are closer to the efficient frontier.

In addition, efficiency tends to be smaller for those firms with a higher proportion of external funds over value added.

References

1. Aigner, D., Lovell, C.A.K. and P. Schmidt. 1977. Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics* 6: 21-37.
2. Baldwin, J.R. and W. Gu. 2004. Trade liberalization: export-market participation, productivity growth, and innovation. *Oxford Review of Economic Policy* 20-3: 372-392
3. Caves, R.E. and D.R Barton. 1990. *Efficiency in US manufacturing industries*. MIT Press, Cambridge, MA
4. Chih-Hai Yang and Ku-Hsich Chen. 2009. Are small firms less efficient? *Small Business* 32: 375-395
5. Cohen, W. M. and S. Klepper. 1996. Firm Size and the Nature of Innovation within Industries: The Case of Process and Product R&D. *Review of Economics and Statistics* 78: 232–243.
6. Crépon, B., Duguet, E. and J. Mairesse. 1998. Research, innovation, and productivity an econometric analysis at the firm level. *NBER Working Paper* 6696.
7. De Loecker, J. 2007. Do exports generate higher productivity? Evidence from Slovenia. *Journal of International Economics* 73: 69–98
8. Delgado, M.A., Fariñas, J.C. and S. Ruano. 2002. Firm productivity and export markets: a non-parametric approach. *Journal of International Economics* 57:397–422
9. Díaz-Mayans, M. A. and R. Sánchez. 2008. Firm size and productivity in Spain: a stochastic frontier analysis. *Small Business Economics* 30: 315-323.
10. Dilling-Hansen, M., E.S. Madsen and V. Smith. 2003. Efficiency, R&D and ownership-some empirical evidence. *International Journal of Production Economics*, 83: 85-94
11. Fariñas, J.C. and J. Jaumandreu. 2004. Diez años de encuesta sobre estrategias empresariales (ESEE). *Economía Industrial* 329: 29-42.
12. Fariñas, J.C. and A. Martín-Marcos. 2007. Exporting and economic performance: Firm-level evidence of Spanish manufacturing. *The world Economy,* 618-629.
13. Farrell, M.J. 1957. The measurement of productive efficiency. *Journal of Royal Statistical Society* 120: 251-281.
14. Goddard, J. Tavakoli, M. and J. Wilson. 2005. Determinants of profitability in European manufacturing and services. Evidence from a dynamic panel data. *Applied financial Economics*, 15: 1269-1282.
15. Golovko, E. and G. Valentini. 2011. Exploring the complementarity between innovation and export for SMEs' growth. *Journal of International Business Studies* 42: 362-380
16. Green, A. and D.G. Mayes. 1991. Technical efficiency in manufacturing industries. *The Economic Journal* 101: 523-538

17. Griliches, Z. 1979. Issues in Assessing the Contribution of Research and Development to Productivity Growth. *Bell Journal of Economics*, *The RAND Corporation*, 10(1): 92-116.

18. Hall, B.H. and J. Mairesse. 1995. Exploring the relationship between R&D and productivity in French manufacturing firms. *Journal of Econometrics* 65-1: 263-293

19. Kim, S., M. Gopinath and H. Kim. 2009. High Productivity Before or After Exports? An Empirical Analysis of Korean Manufacturing Firms. *Journal of Asian Economics* 20-4: 410-418.

20. Kumbhakar, S.C., and C.A.K. Lovell. 2000. *Stochastic Frontier Analysis*. Cambridge UK. Cambridge University Press

21. Kumbhakar, S.C., Ortega-Argilés, R., Potters, L., Vivarelli, M. and P. Voigt. 2011. Corporate R&D and firm efficiency: evidence from Europe’s top R&D investors. *Journal of Productivity Analysis* 37: 125-140

22. López Rodríguez, J. and R. García Rodríguez, R. 2005. Technology and export behaviour: A resource-based view approach. *International Business Review* 14: 539–557

23. Patibandla, M. 1998. Structure, organizational behaviour, and technical efficiency: The case of an Indian industry. *Journal of Economic Behaviour and Organization*, 34: 419-434

24. Sánchez-Pérez, R. and M. A. Díaz-Mayans. 2013. Are large innovative firms more efficient? *Theoretical and Practical Research in Economic Fields* 4- 1: 89-97