The determinants of international competitiveness: a firm-level perspective

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Abstract

This paper examines the determinants of international competitiveness. The first part addresses the issue of cost and technological competition in a sample of fifteen OECD countries. Results suggest that the countries' sectoral market shares are indeed shaped by technological innovation (proxied by investment intensity and patents) while cost advantages/disadvantages do not seem to be play any significant role. The second part aims at the identification of the underlying dynamics at the firm level. We do that for a single country, Italy, using a large panel of Italian firms, covering the period from 1989 to 2006. Results show that in most sectors investments and patents correlate positively both with the probability of being an exporter and with the capacity to acquire and to increase export market shares. The evidence on costs is more mixed. While a simple measure like total labour compensation is positively correlated with the probability of being an exporter, the unit labour cost measure shows the expected, negative correlation only in some manufacturing sectors.

Keywords: Trade competitiveness, technological innovation, firms heterogeneity.
JEL classification: F10, F14, O33

1 Introduction

The international competitiveness of a country is of great concern for both economists and policymakers. Indeed, the capacity to sell goods and services abroad is both a sympton and a cause of healty economic conditions. It is no surprise that the question concerning the determinants of a country's competitive adavantage has received a considerable attention in the literature, especially for what concerns the issue of cost competition versus technological competition.

One of the possible approaches to address this question has traditionally been to look at the aggregate relationships between trading countries. A long-standing tradition in the macroeconomic literature has usually tried to estimate the elasticities of export market shares both to costs and to technology variables, at the country and at the sectoral level, in the attempt to examine the determinants of national competitive advantages (Fagerberg, 1988; Amendola et al., 1993; Carlin et al., 2001; Laursen and Meliciani, 2010). Revealing as they are about the relative importance of cost variables (wages and unit labor costs) *vs.* different indicators of technological level (patents, investments, R&D, inter-sectoral linkages), these aggregate results are likely to hide the vast amount of heterogeneity observed at the firm level.

The present analysis will combine the traditional, macro-based evidence with a microeconomic approach. There is a robust evidence about heterogeneity in firms performances along every dimension one is able to observe (see among the others Bartelsman and Doms, 2000; Dosi and Grazzi, 2006; Dosi and Nelson, 2010), heterogeneity that holds even when only the subset of exporting firms is taken into account (Bernard and Jensen, 2004; Mayer et al., 2011; Greenaway and Kneller, 2007). One consequence of this is that estimates obtained at the aggregate level might not be isomorphic to what happens at the firm level and also that different firms might respond differently to the same shock (Berman et al., 2012). Another consequence is that it is possible to exploit the variation between firm-level characteristics to assess the determinants of trade performance. This is what will be done in the present paper.

At the micro level, the paper is concerned with the determinants of trade performance of Italian firms. In particular, the focus will be on the role of technology and innovation in explaining both the presence of a firm on the export market and the dynamics of its market shares. In this respect, this is the first large scale study on export behaviour of firms that considers also the role of innovation.[1]

The paper is organized as follows. Section 2 spells out the framework and the main research questions of the paper; section 3 presents and describes the available data; section 4 gives a brief account of the empirical evidence that holds at the macro level; section 5

[1]See the following section for a brief account of the micro literature on innovation and trade perfomance of firms. This literature usually employs small or medium scale surveys.

presents the empirical methodology and the results related to the analysis of micro data; section 6 adds further evidence on the role of product and process inovation using data from two waves of CIS surveys; section 7 concludes.

2 Theoretical framework

Competitiveness is determined by several factors. One is certainly labour costs, the labour being the - relatively more - immobile factor among countries. However, both the macro and the micro literature on international trade have debated to what extent technological innovation is a determinant of trade performance, or if most of the variation in market shares is explained by changes in labour costs. On the one hand, both technology-gap and evolutionary theories of trade usually predict that the main source of (absolute) advantage of a country comes from its relative technological position against its competitors rather than from intersectoral opportunity costs within a country (Dosi et al., 1990). On the other hand, the micro evidence on the determinants of export decision and export intensity has shed light on the fundamental dimensions of product and process innovation that may determine the export behaviour at the firm level (Wakelin, 1998; Sterlacchini, 1999; Basile, 2001; Becker and Egger, 2007; Caldera, 2010).

In the present framework, the hypothesis that technology matters will be investigated by looking at the relationship between export performance and two leading measures of innovativeness, that is investments and patents. Investments are a proxy for whatever goes under the label of "embodied technical change" and "process innovation". Patents stand mainly for the "disembodied technical change" and "product innovation".

These two forms of innovation can affect the trade perfomance in several ways. Process innovations involve the acquisition of machineries necessary to produce existing goods at a lower cost. Product innovation is related to different forms of product differentations or quality improvements, that can help firms to gain market shares in a world where consumers have a taste for differentiated and high quality products.

As mentioned above, the issue of international competitiveness has been investigated mostly at the sector and country level. In the present framework, the aggregate dimensions will be analyzed in the first place in order to reassess the empirical evidence about the importance of technology in shaping international performances. The dataset used include a representative sample of OECD countries during the years 1989-2006. The second step will consist in disaggregating the above evidence for a specific country, Italy. The disaggregation will proceed along two main dimensions. First, the issue of the presence of firms on the export markets will be analyzed. Many models of international trade (see especially Melitz, 2003) predict that what is relevant in explaining the presence of firms on international markets is their relative productivity. Here, the decision to export is made to depend both on labour productivity and wage (two components of unit labour costs) while at the same time considering the role of investments and patents.

Second, and more relevant, the analysis will explicitely address the issue of export performance of firms that decide to export in terms of market shares and their growth rates.

The empirical investigation is concluded by a section that takes into account a broader set of innovation variables from the Community Innovation Survey.

3 Data

3.1 Firm level data

Our analysis is based upon three firm-level datasets. The first is MICRO.3, a databank developed through a collaboration between the Italian Statistical Office (ISTAT) and members of the Laboratory of Economics and Management (LEM) of Scuola Superiore Sant'Anna in Pisa. Micro.3 is an integrated system of data that contains information on firms in all sectors of the Italian economy for the period 1989-2006. It has been constructed by merging three sources. The first is the yearly census conducted by ISTAT, which monitors firms bigger than 19 employees and contains standard accounting information appearing in firms' financial statement. Starting from 1998, the census only concerns companies bigger than 99 employees. In order to collect data about firms in the range of employment 20-99, ISTAT resorts to a "rotating sample" which varies every five years. This is the second source of MICRO.3. The third source is represented by the financial statement that limited liability firms have to disclose in accordance to Italian law and that ISTAT collects starting from 1998.[2] In the end, Micro.3 contains data for 148604 Italian firms, of whom 71437 are active in the Manufacturing sectors. As far as the representativeness of the sample is concerned, Micro.3 covers around 50-60 % of the value added generated by all Italian firms in the manufacturing sectors, NACE Rev. 1.1 15 to 37.

Micro.3 has been linked to a database that contains the number of patents granted to Italian firms in the US (USPTO) and in Europe (EPO). After the link, a total of 23477 patents turn out to be matched to 1735 firms in Micro.3. This relatively small number reflects the general fact that the percentage of firms which patent in any sector is a small share of the total. Other studies on similar database do confirm this trend. Malerba and Orsenigo (1999) employs a dataset which contains 15175 patents *application* by 3805 firms (Malerba and Orsenigo, 1999, p. 646), while Cefis and Orsenigo (2001), who still consider patents application, rely on 1369 firms (Cefis and Orsenigo, 2001, p. 1142). On the contrary, we consider here only granted patents as a more meaningful proxy of innovation

[2] It is possible that two different sources provide data for the same firm and variable. It is then possible to check for the reliability and consistency of the two sources. On this and on other aspects of Micro.3 cf. Grazzi et al. (2009).

activity. Notice also that the process of linking data on granted patents to other database, such as Micro.3, is usually difficult, as the classification used by the patent office and that implemented by the national office for structural business statistics are different. The comparison of the two database requires some pattern recognition techniques, which not always lead to the successful matching of all the relevant case. Indeed, when we refer to empirical works that match patent data to other sources of information the numbers get even smaller (Scellato, 2007).

The second set of micro data is COE (Statistiche del Commercio Estero), a dataset collected by ISTAT which registers the export activity of all Italian firms for the period 1998-2006.[3] The necessity to link COE to MICRO.3 limits the sample of firms to those with 20 or more employees. Depending on the years, these firms represent between 75% and 80% of italian exports.

Both Micro.3 and COE databases has been linked to the Community Innovation Survey 2000 (CIS3) and 2004 (CIS4). The CIS3 dataset is a cross-sectional survey of innovation activities performed by firms during the 1998-2000 period. The survey covers all the firms with 250 or more employees in 2000 and a sample of firms with less than 250 employees (with a minimum of 10 employees). In the end, there are 15512 firms in CIS3 [4], of which 9034 are active in manufacturing sectors. The CIS4 survey covers the 2002-2004 period and employs the same methodology as the CIS3. It offers information about 21854 firms, of which 7586 are manufacturing firms.[5] Notice that 5923 firms are present in both surveys (3194 for manufacturing) so that a total of 31443 of firms are covered in either of the two surveys (13575 for manufacturing)[6]. When linked to Micro.3, the sample is further reduced because of the 20 employees threshold. For the analysis on manufacturing sectors, we can use information about 5432 firms for CIS3 and 4206 for CIS4. 1845 are present in both surveys, so that a total of 7793 firms are covered.

3.2 Country level data

We use data for 15 OECD countries from STAN database: Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Spain, Sweden, UK and USA[7]. They account on average for 86% of total dollar exports of all OECD countries.

Concerning the covering of the different industries, the STAN database comprise all manufacturing sectors at different levels of aggregation. The table below reports our

[3]For the years before 1998, information on export activity can be recovered directly from MICRO.3.

[4]The size of the theoretical sample is higher, 29157 firms. but the final sample is reduced mainly because of a low response rate.

[5]The lower proportion of manufacturing firms over the total in CIS4 with respect to CIS3 is mainly due to the fact the CIS4 covers also the construction sector, NACE Rev.1.1 45

[6]The sectoral classification of firms refers to the two years of surveys, 2000 and 2004

[7]Data on gross fixed capital formation for Japan come from EU KLEMS database.

preferred level of aggregation, which contains 11 manufacturing subdivisions and allows us to have a nearly complete time series for each sector and each country in the sample.

Table 1: Industry aggregation

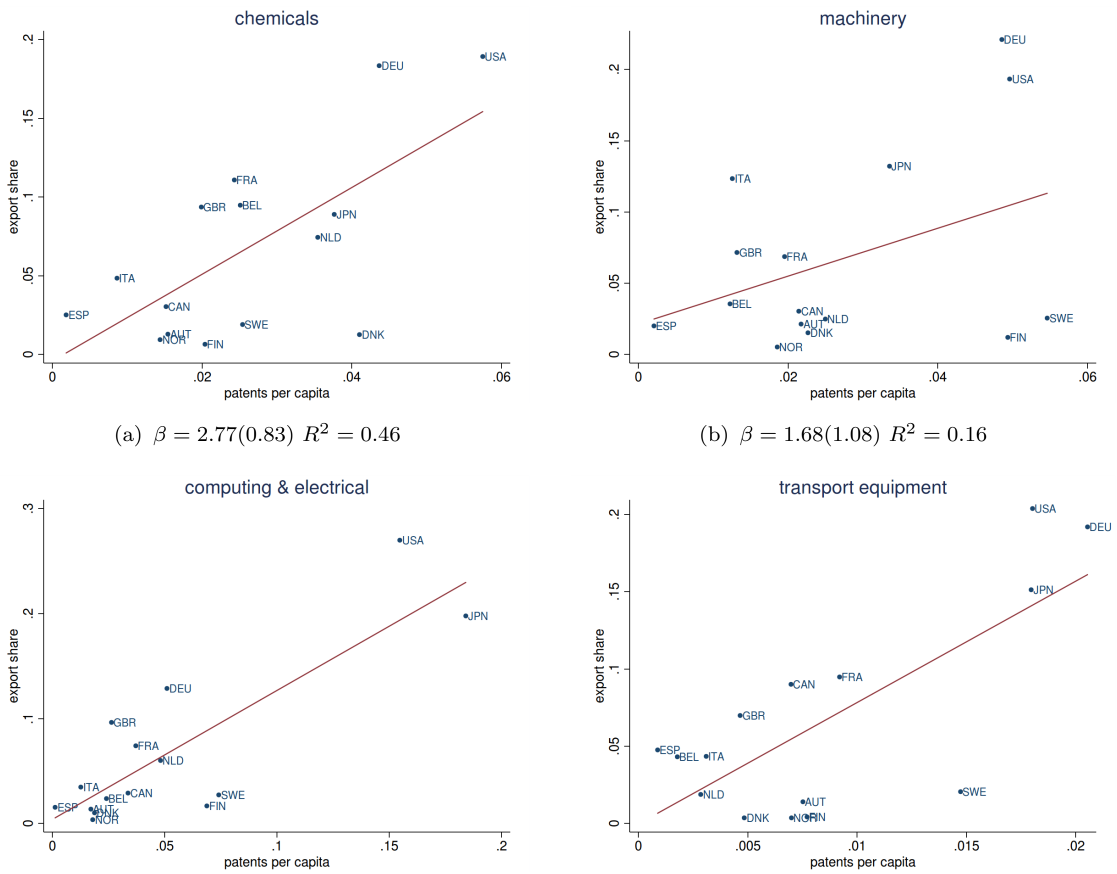
Sectors	NACE Rev. 1.1
Food, beverages, tobacco	15-16
Textiles, wearing, leather	17-19
Wood	20
Paper and printing	21-22
Coke & petroleum	23
Chemicals	24
Rubber and plastics	25
Non-metallic (mineral products)	26
Basic metals	27
Fabricated metal (products)	28
Machinery	29
Computing & electrical (machinery)	30-33
Transport equipment	34-35
Other Manufacturing	36-37

Note: The table lists the sectoral aggregation that will be used in the analysis. The Nace code corresponds to the Italian ATECO 2002 calssification. It also matches perfectly the ISIC rev. 3 classification of OECD STAN.

4 The macro evidence

In this section, we rely mainly on the theoretical and empirical framework of Dosi et al. (1990). There, the international pattern of sectoral absolute advantages/disadvantages is shown to be a fundamental determinant of sectoral competitiveness as expressed by the sectoral market shares of each country. Absolute advantages stem primarily from widespread technological asymmetries between countries which "relate in first instance to the capability of some countries to produce innovative commodities (i.e. commodities which other countries are not yet capable of producing, irrespective of relative costs) and to use process innovations more efficiently or quickly in the reduction of input coefficients" (Dosi et al., 1990, p.143).

We provide a first snapshot of the importance of innovative capability for trade patterns in Figure 1, which displays some simple scatter plots for the relationship between export shares and patents per capita, across countries and within four different industries in 1998.



(a) $\beta = 2.77(0.83)$ $R^2 = 0.46$

(b) $\beta = 1.68(1.08)$ $R^2 = 0.16$

(c) $\beta = 1.23(0.23)$ $R^2 = 0.69$

(d) $\beta = 7.86(1.98)$ $R^2 = 0.55$

Figure 1: Patents and export shares, 1998

A strong linear correlation between the two variables emerges sharply in three sectors, as shown by the R^2 reported below each plot. The high correlation also explains why in these three sectors the slope (indicated by the β, with standard error in parenthesis) of the straight line is significant at the 1% level , even if we are analyzing a cross-section of only fifteen points.

The graphical analysis of the bivariate relationship between patents and international market shares leaves no doubt that technology matters in explaining the pattern of international competitiveness among countries. The main aim of this section is to enrich this basic evidence about the sectoral absolute advantages that hold at the country level. The analysis will take the form of a simple test about the relationship between an absolute measure of competitiveness (i.e. independent of the competitiveness of other sectors within the same country), and a set of costs and technology related variables. The dependent variable, our measure of (absolute) competitiveness, is represented by export market share. Export market share for a given country i in industry j (XMS_{ij}), is calculated by taking each country's exports in the industry (in current dollars) and dividing it by the dollar sum of the industry's export from the 15 countries.

Among the regressors, the cost variable is represented by the labour cost per employee ($WAGE$) revalued into current dollars at the nominal exchange rate. The industry labour productivity ($PROD$) is proxied by value added at constant prices divided by total employment (including the self-employed).[8] The figure thus obtained is not directly comparable across countries since valued added at constant prices is an (imperfect) measure of physical output only if variations in the purchasing power of currencies are assumed to be equal to zero. In order to get a homogeneous measure across countries, sectoral productivities are converted to a common currency by using PPP exchange rate of 2000 (i.e., the reference year of the national measure of real output in STAN database).[9]

Technology variables include a measure of investment intensity and patenting activity intensity, respectively INV and $PATSH$. INV is calculated as the ratio between industry expenditures on gross fixed capital formation and value added, both at current prices. $PATSH$ is indicated by the share of national industry patents granted (both USPTO and EPO) over the sum of the industry's patents granted to the 15 countries.

The following regression was estimated for each of the 14 industries reported in Table 1:

$$\begin{aligned} XMS_{ijt} = &\beta_{1j} WAGE_{ijt} + \beta_{2j} PROD_{ijt} + \beta_{3j} INV_{ijt} \\ &+ \beta_{4j} PATSH_{ijt} + \beta_{5j} POP_{it} + \epsilon_{ijt} \end{aligned} \tag{1}$$

where each variable is taken in natural logarithms, i indexes countries, j industries

[8] STAN database contains figures both on the number of employees and on the total employment. The first number is used to get the $WAGE$ variable, since labour costs refer only to employees. The second number is used to get the $PROD$ variable.

[9] It is worth noting that measures of PPP based on national GDP pose some problems when used to revaluate industry output. The consistency check suggested by Sørensen (2001)(i.e., using different base years for making the conversions) was carried out for the regressions of this section. Results were largely unchanged.

and t time. POP stays for the total population and is added to the equation in order to control for the sheer size effect that influences the dependent variable. We are interested in the average cross-sectional coefficients over time so we report the results from pooled OLS estimation in Table 2.

The first, striking result concerns the strong significance of the patent variable across the vast majority of sectors. As expected, patented innovations appear to be important for competitiveness in sectors which are strongly dominated by patents as a mean to appropriate returns from innovation. This is the case of the chemical sector and of the electrical and non-electrical machinery. These three industries account for around 80% of total patents across countries in our sample.[10] Patenting activity, on the contrary, displays a non significant role in sectors where one could expect in principle they to be of less importance. This is the case, for example, of labour-intensive sectors such as textile or in a natural resource intensive sector like non-metallic mineral products.

The INV variable is positive and significant in almost all sectors but two (paper and chemicals). In the paper industry, the $PROD$ variable, which also captures the effects of process innovation, is significant while the chemical industry is the only one in which none of the two variables proxing for process innovation (productivity and investment) display any role.

The coefficient of the $WAGE$ variable is significant and negative in only two sectors. It is only in the paper and non-metallic minerals sector that lower cost of labor per employee appear to relevant in sustaining country's exports. On the contrary, chemicals, basic metals and transport industries report a positive coefficient on *wage*.

The results broadly agree with the conclusions of the empirical exercises performed in Dosi et al. (1990). In particular, they support the hypothesis that technology advantages dominate over cost-related factors in shaping international competitiveness. The question remains as to whether this evidence still holds when we consider *interfirm* technological and cost asymmetries. This is the issue we will address in the following sections.

[10]These three industries also report the highest patent intensity (number of patents over value added) as measured in US industries in 2000.

Table 2: Industry regressions

Dependent variable: export market share						
	WAGE	PROD	INV	PATSH	Obs.	R^2
Food, beverages, tobacco	0.445	0.833^b	0.924^a	0.208^b	249	0.36
	(0.501)	(0.362)	(0.246)	(0.088)		
Textiles, wearing, leather	−0.326	1.517^a	1.288^a	0.016	227	0.77
	(0.316)	(0.377)	(0.120)	(0.063)		
Wood	0.284	2.217^a	1.172^a	0.426^a	221	0.67
	(0.283)	(0.210)	(0.121)	(0.050)		
Paper & printing	-1.649^a	1.415^a	−0.068	0.290^a	226	0.78
	(0.213)	(0.164)	(0.085)	(0.025)		
Coke & petroleum	0.062	−0.095	0.369^a	0.384^a	200	0.49
	(0.206)	(0.095)	(0.104)	(0.052)		
Chemicals	1.594^a	0.078	0.069	0.130^b	223	0.78
	(0.252)	(0.171)	(0.133)	(0.060)		
Rubber & plastics	−0.323	0.459	0.702^a	0.238^a	223	0.78
	(0.323)	(0.323)	(0.136)	(0.067)		
Other non-metallic	-0.534^b	0.469^c	0.893^a	0.021	251	0.79
	(0.257)	(0.244)	(0.115)	(0.048)		
Basic metals	0.795^a	0.834^a	0.241^b	0.163^a	190	0.76
	(0.270)	(0.134)	(0.097)	(0.048)		
Fabricated metal	−0.341	−0.307	0.732^a	0.314^a	190	0.87
	(0.224)	(0.266)	(0.097)	(0.041)		
Machinery	−0.346	0.317	0.427^a	0.341^a	240	0.88
	(0.212)	(0.213)	(0.072)	(0.046)		
Computing & electrical	−0.190	0.006	0.258^a	0.424^a	240	0.92
	(0.179)	(0.077)	(0.073)	(0.029)		
Transport equipment	0.578^a	1.326^a	0.453^a	−0.046	251	0.91
	(0.213)	(0.122)	(0.069)	(0.041)		
Other manufacturing	−0.129	0.510^b	0.875^a	0.045	230	0.76
	(0.273)	(0.212)	(0.122)	(0.072)		

Note. Pooled OLS estimation with standard errors in parentheses. Coefficient of *POP* omitted. Year dummies included. ^{a} $p < 0.01$, ^{b} $p < 0.05$, ^{c} $p < 0.10$.

5 The micro evidence

This section investigates the firm-level determinants of international competitiveness, employing Italian firm data that match information from company accounts, export market partecipation and innovation activity. A rising stream of literature has documented wide and persistent intra-industry heterogeneity. Firms within the same industry are much different in terms of the ex-ante choice of input mix (Hildenbrand, 1981; Dosi and Grazzi, 2006), the ex post performance (see among the others Bartelsman and Doms, 2000; Syverson, 2011) and, more relevant for the present work, partecipation on the export market (see the review in Bernard et al., 2012) and innovation activity. Given the high degree of diversity of firms making up the industry one cannot take for granted that those factors driving international competetitiveness at the country-sector level are necessary the same that determine the different performance of firms in international market. This is the question addressed by the present section.

For the empirical specification, we will follow the now standard approach that decomposes the micro dynamics of export in two steps: a first step, related to the probability of the firm of being an exporter (the extensive margin) and a second step, related to the growth performance of exporting firms (the intensive margin). Each regression will be estimated sector by sector.

5.1 Selection into export markets

The main focus of this subsection will be on the factors affecting the firm's decision to enter foreign markets. As mentioned above, a large body of theoretical works, starting from Melitz (2003), predicts that firms self-select into export markets depending on their revealed productivity. While less productive firms serve only domestic markets, the most productive ones can sell their products also on foreign markets by incurring the fixed and the variable trade costs of exporting.

In agreement with the framework of the previous section, the present analysis will take into account also cost and technological variables as potential determinants of a firm's decision to export:

labour productivity: $PROD_{it} = VAC_{it}/EMP_{it}$;

average labour cost per employee: $WAGE_{it} = LABCOST_{it}/EMP_{it}$;

investment intensity: $INV_{it} = ASSETS_{it}/VA_{it}$;

patent dummy: PAT_{it}.

where VA_{it} (VAC_{it}) stands for value added (at constant prices), EMP_{it} for the number of employees, $LABCOST_{it}$ for total labour costs, $ASSETS_{it}$ for total expenditure in tangible fixed assets and PAT_i is a dummy variable taking the value of one if the firm's stock of patents is greater than zero in the referred year.

Investment intensity measures the degree to which a firm devotes his resources to the renewal and the acquisition of plants, machineries and other kinds of industrial equipment which can embody new technologies and new (cost-reducing) ways of doing things. It is a normalized measure (with respect to value added) since the amount of investments greatly depends on the size of the firm.

Some explanation is needed for the patent dummy variable. As already mentioned, only a small number of firms in our sample are actually patenting firms. Just to give an example, in 1995 there are 20206 firms in all manufacturing sample, of which only 579 (2.9%) have one or more patents. Of these small subset of patenting firms, the great majority (82%) is also exporting, compared to a much smaller percentage of exporting firms for the whole sample (58%). The main conclusion to be drawn from these statistics is that to have a patent seems to be a much more important factor in shaping the export behavior of firms, more than the number of patents in itself. This consideration motivates the use of a dummy in the following analysis.

The baseline econometric model describing the firm's decision to export is defined as a random effects probit model with variables expressed in logarithms (except patent dummy):

$$\begin{aligned} P(Exp\_dummy_{it} = 1) = \Phi(&\alpha WAGE_{it-1} + \beta PROD_{it-1} \\ &+ \gamma INV_{it-1} + \delta PATt_{it-1} + \phi EMP_{it-1} + u_i + \epsilon_{it}) \end{aligned} \tag{2}$$

where *Exp_dummy* is a dummy variable taking value of one if the firms exports, and zero otherwise. The variable EMP_{it-1} denotes the (log) number of employees and it is added to the equation in order to control for possible size effects that influence both the probability of exporting and regressors. Results from estimation of equation (2) are presented in table 3.

As compared to the macro evidence, a greater sectoral heterogeneity is detected in the values and the significance of the technological coefficients. Patents are significant in 8 out of 14 sectors. Among these, it is worth mentioning the machinery and the transport sectors, in which the highest percentage of patenting firms is registered (respectively 11% and 6.6% in 1997). A little bit more surprising is the result for chemical and electrical machinery sectors, in which patents seem to play no role (in these sectors, there were respectively 13% and 6.6% of patenting firms in 1997).

A similar distribution is observed for investment intensity, which is not significantly different from zero in seven sectors. In two of these, chemicals and basic metals, productivity is also not significant, pointing out an overall negligible role for process innovation.

The $WAGE$ variable is always positive and significant, except in the paper sector, where it is negative and significant, and in three other sectors (fuel, chemicals and basic metals) where it is not significant. Indeed wages are of course an element of cost but also

Table 3: Selection into export markets

Dependent variable: export dummy						
	WAGE	PROD	INV	PAT(D)	Obs.	firms
Food, beverages, tobacco	0.086^a	0.074^a	0.003	−0.016	14136	2941
	(0.023)	(0.013)	(0.003)	(0.082)		
Textiles, wearing, leather	0.093^a	0.118^a	0.001	0.061^a	32356	8030
	(0.013)	(0.009)	(0.002)	(0.013)		
Wood	0.209^a	0.147^a	0.014^b	0.141^c	4854	1028
	(0.061)	(0.037)	(0.006)	(0.085)		
Paper & printing	-0.093^a	0.080^a	0.017^a	−0.027	10635	2268
	(0.036)	(0.021)	(0.004)	(0.095)		
Coke & petroleum	0.309	0.270^b	−0.020	−0.152	915	158
	(0.252)	(0.106)	(0.027)	(0.281)		
Chemicals	0.006	0.001	0.000	0.003	9261	1714
	(0.006)	(0.003)	(0.001)	(0.004)		
Rubber & plastics	0.030^a	0.008^b	0.001^c	−0.013	9846	2074
	(0.007)	(0.003)	(0.001)	(0.013)		
Other non-metallic	0.226^a	-0.064^a	−0.006	0.149^a	12685	2532
	(0.047)	(0.024)	(0.005)	(0.035)		
Basic metals	0.041	0.002	0.001	0.030^a	7108	1236
	(2.651)	(0.145)	(0.036)	(0.006)		
Fabricated metal	0.178^a	0.161^a	0.018^a	0.098^a	21541	5011
	(0.030)	(0.019)	(0.003)	(0.029)		
Machinery	0.007^a	0.004^a	0.000^c	0.004^a	24312	5010
	(0.002)	(0.001)	(0.000)	(0.001)		
Computing & electrical	0.070^a	0.027^a	0.007^a	0.011	15294	3624
	(0.012)	(0.006)	(0.002)	(0.008)		
Transport equipment	0.065^a	0.012	0.004^c	0.038^a	5725	1244
	(0.019)	(0.008)	(0.002)	(0.008)		
Other manufacturing	0.032^a	0.011^b	0.001	0.027^a	12856	2891
	(0.011)	(0.006)	(0.001)	(0.007)		

Note. Random effect probit estimation. Marginal effects with standard errors in parentheses. (d) for discrete change of dummy variable from 0 to 1. Coefficient of EMP omitted. Year dummies included. ^{a} $p < 0.01$, ^{b} $p < 0.05$, ^{c} $p < 0.10$.

capture differential skills and that part of the "innovation rent" distributed to workers. This evidence is in agreement with much of the empirical work on the selection into export markets: exporting firms pay higher wages than non exporting firms.

There are two clear messages that emerge from this exercise. First, the total labour compensation a firm pays does not appear to be a hindrance to export strategy: wage is positively correlated with the propensity to export, even in labour intensive sectors like textile. It is of course hazardous to derive strong causal relationships from a single regression but the correlation is there and widespread.[11]

[11] Also in other estimations of equation (2) performed by the authors (simple OLS, fixed effect, probit), the $WAGE$ variable is almost always or positively significant or not significant.

Second, labour productivity dimension only capture a part of technological heterogeneity bewteen firms. In fact, both the degree of investment intensity (a proxy for capital-embodied process innovation) and the propensity to patent (standing mostly for product innovation) is positively correlated with the probability to export in most sectors, even among firms that have the same productivity.

Technology seems to be a crucial dimension along which firms self select into export markets. In the next section, we will investigate to what extent, among firms that export, technology and costs shape the dynamics of export volumes.

5.2 Export market shares

In this section, we analyze the determinants of export market shares of italian firms during the period 1989-2006. Once on the foreign markets, exporting firms compete with firms from other countries in order to sell more of their products and increase their market shares. As a consequence, we relate the variation in relative exports of italian firms to the variation in their relative characteristics. In order to do so, the following new variables need to be introduced:

export market share: XMS_{it};
relative wage: $RWAGE_{it}$;
relative productivity: $RPROD_{it}$;
relative investment intensity: $RINV_{it}$.

XMS_{it} refers to export market share of the firm i (in a given sector) with respect to the sectoral OECD quantity of exports. It is calculated by taking firm's exports in euro, converting them to US dollars and dividing by the sum of the industry's export from the 15 countries. The variable $RWAGE_{it}$ is constructed by taking the wage of the firm i, coverting it to US dollars and dividing by the weighted average of wages in dollars across countries. The variable $RPROD_{it}$ is the productivity of firm i divided by the weighted average of productivity across countries. The same calculation is performed for the variable $RINV_{it}$. The weights refer to the market share of each country in 1998.

The baseline model describing the determinants of export market shares rate read as follows (all variables are in logs, except the dummy for patents):

$$\begin{aligned} XMS_{it} =& \alpha RWAGE_{it-1} + \beta RPROD_{it-1} + \gamma RINV_{it-1} \\ &+ \delta PAT_{it-1} + \phi EMP_{it-1} + \epsilon_{it} \end{aligned} \tag{3}$$

Different estimation methods are in principle available to get the coefficients of equation (3). A natural choice would be to take advantage of the panel dimension of the data and to control for firm fixed effect. Unfortunately, within-group estimation fails to take into account the contribution of level variables, that is variables that does not vary or varies only in a negligible way through time within each firm. The patent dummy in equation (3) is exactly one of such variables. The small amount of patenting firms in the dataset implies that for the great majority of units (around 96%) this variable takes the value of zero in the whole time period.

Estimation of equation (3) is therefore performed through pooled OLS, while statistical inference is made robust to possible correlation in the error term induced by firm heterogeneity. The additional advantage of this solution is that the assumption on the exogeneity of the regressors is quite mild. In fact, the only condition required is that $E(e_{it}|RWAGE_{it-1}, RPROD_{it-1}, RINV_{it-1}, PAT_{it-1}, EMP_{it-1}) = 0$. Any possible feedback dynamics from changes in export market shares today to changes in the regressors today or tomorrow is not going to bias the results in any way. Results are reported in table 4.

Table 4: Export market shares

Dependent variable: export share						
	RWAGE	RPROD	RINV	PAT	Obs.	firms
Food, beverages, tobacco	0.367^a	0.852^a	0.157^a	1.073^a	9931	2310
	(0.137)	(0.084)	(0.026)	(0.405)		
Textiles, wearing, leather	−0.094	1.117^a	-0.069^a	0.799^a	23326	5778
	(0.082)	(0.057)	(0.014)	(0.138)		
Wood	0.317	0.246	0.017	1.762^a	3226	743
	(0.296)	(0.208)	(0.042)	(0.243)		
Paper & printing	-1.188^a	0.903^a	0.223^a	1.389^a	7249	1719
	(0.221)	(0.140)	(0.028)	(0.350)		
Chemicals	−0.179	0.713^a	0.278^a	0.277^b	8153	1578
	(0.139)	(0.100)	(0.029)	(0.141)		
Rubber & plastics	0.487^a	0.887^a	0.059^b	0.481^a	8492	1848
	(0.144)	(0.107)	(0.023)	(0.113)		
Other non-metallic	1.217^a	−0.134	−0.041	0.861^a	8178	1755
	(0.150)	(0.136)	(0.026)	(0.221)		
Basic metals	-0.577^a	0.989^a	0.051^c	0.210	5743	1064
	(0.140)	(0.119)	(0.029)	(0.334)		
Fabricated metal	-0.242^a	1.138^a	0.104^a	0.759^a	14647	3531
	(0.090)	(0.095)	(0.017)	(0.122)		
Machinery	0.105	0.858^a	0.029^b	0.479^a	21544	4531
	(0.069)	(0.063)	(0.012)	(0.055)		
Computing & electrical	−0.026	0.236^a	0.149^a	0.722^a	12056	2796
	(0.131)	(0.062)	(0.021)	(0.111)		
Transport equipment	0.198	0.874^a	0.131^a	0.987^a	4680	1041
	(0.206)	(0.156)	(0.033)	(0.171)		
Other manufacturing	-0.685^a	1.188^a	0.067^a	0.585^a	10562	2471
	(0.121)	(0.104)	(0.023)	(0.156)		

Note. Pooled OLS estimation with robust standard errors clustered at the firm level in parentheses. Coefficient of EMP omitted. ^{a} $p < 0.01$, ^{b} $p < 0.05$, ^{c} $p < 0.10$.

Patenting firms enjoy, on average, higher export shares, with a "premium" that goes from 0.277 log points (32%) in chemicals to 1.762 log points (482%) in wood products, and with basic metals being the only industry in which patents are not significant. Relative investment intensity and relative labour productivity show a similar pattern across sectors. They are both significant in all industries but wood products and non-metallic minerals, where they are both not significant, and textile, where investment shows a negative sign.

Relative labour compensation coefficient has a more ambiguous interpretation. In four industries (paper and printing, basic metals, metal products, other manufacturing), its negative and significant value shows that relative wages can be a factor reducing international competitiveness. However, it is either not significant or positive in the majority of sectors. As was the case with the selection equation, we can conclude that also in this case relative wage captures, at least partly, different quality of workforce composition among firms.

5.3 Market shares growth rates

The analysis presented in the previous section dealt with the determinants of *level* of export shares, exploiting variations both between firms at each point in time and through time. In this section, we aim to investigate whether technology influences the *dynamics* of export shares.

In order to do so, we take as new dependent variable the firms' growth rate of export market share. Among the regressors, we consider the same technology variables and controls as before, that is relative investment intensity, patent dummy and level of employment. The investment variable is kept in level because it already represents changes in the capital equipment of a firm (see Carlin et al., 2001). As for the patent dummy, it represents, as before, whether the firm has any registered patent in a given year.

The only relevant difference concerns the wage and the productivity variables. Labour productivity and average wage are the two "pieces" in which the unit labour cost of a firm can be decomposed. Up until now, we have avoided using the ratio of $WAGE$ over $PROD$ because it falls short of being an appropriate unit wage cost measure when taken in level. As it stands, it is more a measure of income distribution, affected by the firm's organization. On the othe hand, the growth rate of this ratio is an appropriate measure of cost-competitiveness since the characteristics influencing the distribution of revenues between wages and profits are sticky over time. In the following specification, we will use this variable.

The equation reads as follows:

$$\Delta(XMS_{it}) = \beta\Delta(RULC_{it}) + \gamma RINV_{it-1} + \delta PAT_{it-1} + \phi EMP_{it-1} + \epsilon_{it} \tag{4}$$

where $\Delta(XMS_{it})$ stands for the log difference of export market shares in two consecutive years and $\Delta(RULC_{it})$ for the log difference of relative unit labour costs. The variable $RULC_{it}$ is constructed by taking the unit labour cost of the firm i, that is $WAGE_{it}/PROD_{it}$, expressing it in US dollars and dividing by the weighted average of unit labour costs across the 15 countries.

Results from pooled OLS estimation of equation (4) are presented in table 5.

The first interesting thing to note is that the coefficient of patent dummy is still positive and significant in five sectors, three of them being the most important ones in terms of total share of italian exports.[12] This result is surprising. As mentioned in the previous section, patent dummy is a very persistent variable, which characterizes, so to say, the identity card of the firm. Results from level and growth rate equations say that patenting firms are able not only to gain higher market shares on foreign markets, but also to sustain, in some industries, higher growth rates.

[12]Chemical, machinery and transport equipment together account for around two fifth of all Italian exports.

Table 5: Export market shares: growth rates

Dependent variable: export share's growth rate					
	ΔRULC	RINV	PAT	Obs.	firms
Food, beverages, tobacco	-0.071^b	0.016^c	0.012	8805	2086
	(0.036)	(0.008)	(0.074)		
Textiles, wearing, leather	-0.078^a	0.004	0.072^b	21255	5251
	(0.022)	(0.005)	(0.032)		
Wood	0.044	0.016	−0.028	2840	646
	(0.074)	(0.015)	(0.045)		
Paper & printing	−0.017	0.038^a	0.085	6324	1508
	(0.079)	(0.010)	(0.086)		
Chemicals	-0.129^a	0.005	0.064^b	7579	1509
	(0.039)	(0.009)	(0.031)		
Rubber & plastics	0.011	0.022^b	−0.035	7917	1736
	(0.047)	(0.009)	(0.029)		
Other non-metallic	−0.032	0.015	0.051	7308	1579
	(0.045)	(0.010)	(0.037)		
Basic metals	0.007	0.006	0.061	5266	990
	(0.060)	(0.012)	(0.042)		
Fabricated metal	0.046	0.010	0.002	13040	3126
	(0.034)	(0.007)	(0.033)		
Machinery	0.020	0.021^a	0.041^a	20300	4340
	(0.028)	(0.005)	(0.016)		
Computing & electrical	0.129^a	0.001	0.095^a	11155	2603
	(0.043)	(0.007)	(0.029)		
Transport equipment	0.039	0.013	0.142^a	4204	946
	(0.080)	(0.013)	(0.045)		
Other manufacturing	−0.034	0.017^b	−0.013	9654	2287
	(0.030)	(0.008)	(0.036)		

Note. Pooled OLS estimation with robust standard errors clustered at the firm level in parentheses. Coefficient of EMP omitted. ^{a} $p < 0.01$, ^{b} $p < 0.05$, ^{c} $p < 0.10$.

Investments are also less important as compared to the level equation: they turn out to be significantly different from zero in five sectors. Notably, in only one of these (machinery) patents are significant too. It emerges a sort of complementarity between process and product innovation in affecting the firms' growth rate of export shares.

Coefficients of $\Delta RULC_{it}$ take the expected, negative sign in only three sectors. Two of them are traditional sectors, that is food and textile, where a cost-based competition is thought to be more relevant, while the last one is the chemical sector, where in principle the labour should be a less important factor. It is even positive in the electrical machinery sector, while in all other sectors is not significantly different from zero.

6 Further evidence on product and process innovation

In this section, the analysis will use data from the Community Innovation Survey 2000 (CIS3) and 2004 (CIS4).

The CIS dataset makes it possibile to look at the product and process innovation from a complementary point of view. If until now patents and investment intensity have been used to proxy for the different kinds of technological innovations, the CIS questionnaire allows us to resort directly to the answers provided by the firms to the questions raised about their innovative performance. In particular, we will use three different variables. The first one, $INPDT$, indicates whether the firm introduced new products during the relevant time period (1998-2000 for CIS3 and 2002-2004 for CIS4), the second one, $INPCS$, indicates whether the firm introduced new processes while the third one, $NEWMKT$, picks up, among the firms that introduced a new product, the ones that considered the product new also for their reference market.

Table 6 reports the differences between innovators in terms of exporting firms and export shares among exporting firms. Columns (1) and (3) report the innovation premia estimated from the regression:

$$X_i = \alpha INN_i + \beta sector_i + \epsilon_i \tag{5}$$

respectively for CIS3 and CIS4. INN is one of the two measures of innovation, product and process, respectively in the first and in the second panel, and X is the export dummy in the first row of each panel and the (log) of export share in the second row. Columns (2) and (4) estimate the same regression after adding an additional control for the size, measured by total firm employment.

Among innovators, there is a higher percentage of exporting firms, from 13.2% to 14.8% in the case of product innovation, and from 11.7% to 10% in the case of process innovation. The premia are lower when the size of the firm is taken into account, but they are still significant, both from a statistical and from an economic point of view. Among exporting firms, the ones that introduced a product or a process innovation enjoy higher export shares, with a difference, with respect to non innovating firms, that goes from 99.9% to 94.3% in the first case, and from 72.2% to 66.3% in the second case. As expected, premia are lower when the size effect is controlled for, but they are still large. A robust feature emerging from the two waves of CIS is that, on average, rents that go to firms that introduce new products are higher than the ones that go to firms introducing new processes.

Figure 2 is an additional piece of evidence, which says that differences in average

Table 6: Innovation premia

	CIS3		CIS4	
	(1)	(2)	(3)	(4)
Panel A: Product innovation premia				
Exporting firms	14.8	10.9	13.2	9.4
Export shares	99.9	42.4	94.3	38.1
Panel B: Process innovation premia				
Exporting firms	10.0	6.4	11.7	8.3
Export shares	72.2	18.1	66.3	16.7

Note. The table reports innovation premia, in percentage, estimated from equation 5. Columns (2) and (4) control for total employment. All differences are significant at the 1% level except the last one, which is significant at the 5% level.

between innovator and not-innovator are in fact spread throughout the entire distribution of export share.

We turn now to a more systematic empirical analysis following the lines addressed in the previous sections. The first equation to be estimated is the selection equation which reads:

$$\begin{aligned} Exp\_dummy_i = &\alpha WAGE_i + \beta PROD_i + \gamma INPCS_i + \delta INPDT_i \\ &+ \zeta NEWMKT_i + \phi EMP_i + \epsilon_i \end{aligned} \tag{6}$$

It is similar to equation (2), except that the dummy $INPCS$ takes the place of INV and $INPDT$ substitutes PAT, with the addition of the variable $NEWMKT$. Variables are not indexed by t since we have only a cross-section for each survey. In order to minimize simultaneity biases, the regressors and the dependent variable are measured at different time periods. Regressors refer respectively to 1998-2000 and 2002-2004 for CIS3 and CIS4 (they are averages in the case of continuous variables), while the dummy for export status refers to 2001 and 2005. Equation (6) is estimated separately for the first and the second wave, by means of probit analysis. Results are reported in table 7.

The second equation is similar to equation (3), with the same substitutions as before:

$$\begin{aligned} XMS_i = &\alpha RWAGE_i + \beta RPROD_i + \gamma INPCS_i + \delta INPDT_i \\ &+ \zeta NEWMKT_i + \phi EMP_i + \epsilon_i \end{aligned} \tag{7}$$

The variables export market shares relative wage and relative productivity are calculated over the period 2000 for CIS3 and 2004 for CIS4. Results from OLS estimation are

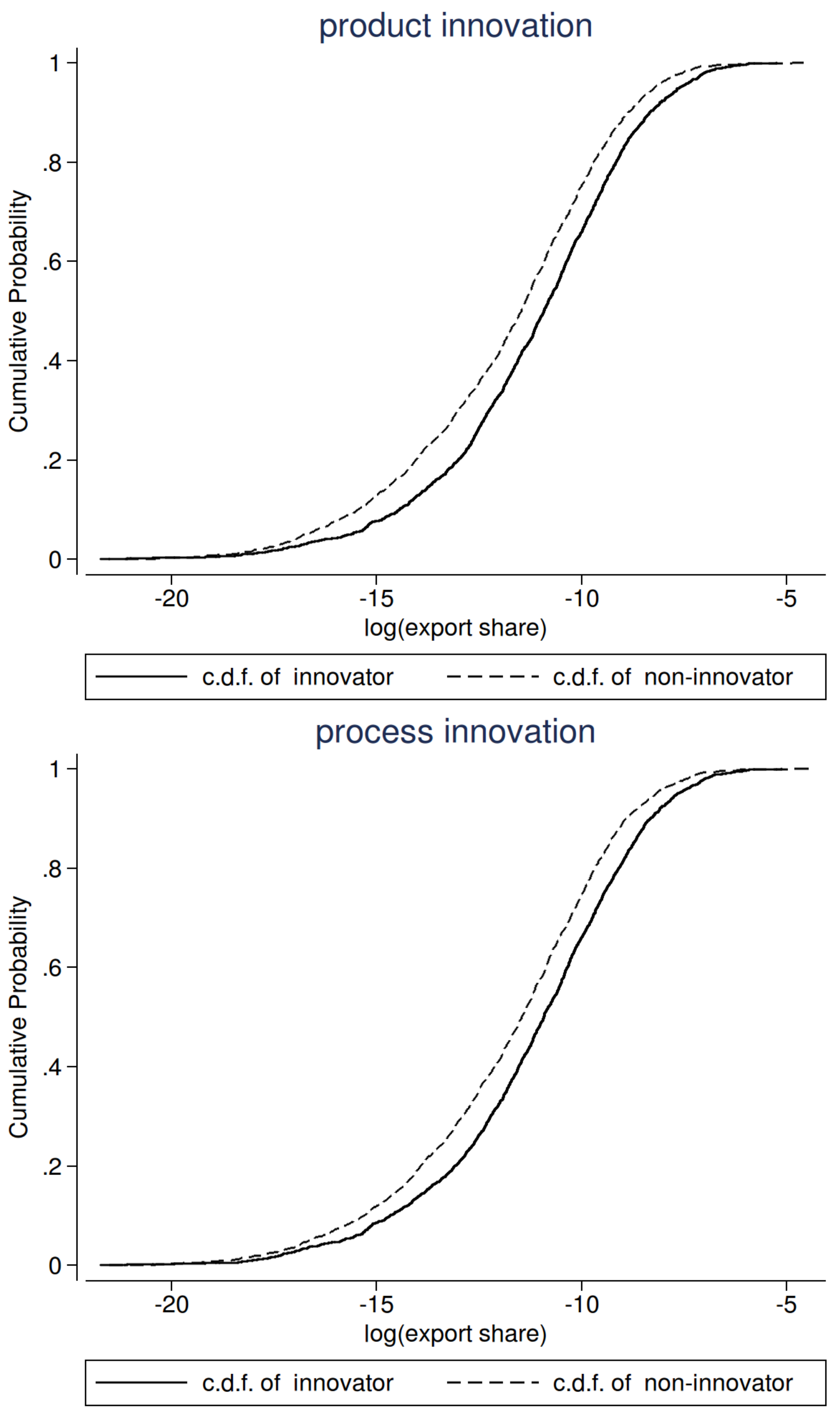


Figure 2: Cumulative distribution of (log) export share, CIS3. Innovating versus non-innovating firms.

reported

The third equation is similar to equation (4), with the same substitutions as before:

$$\begin{aligned}\Delta(XMS_i) =& \beta\Delta(RULC_i) + \gamma INPCS_i + \delta INPDT_i + \zeta NEWMKT_i \\ & + \phi EMP_i + \epsilon_i\end{aligned} \tag{8}$$

The variables expressed in growth rates, export market shares and unit labour costs, are calculated over the period 2000-2001 for CIS3 and 2004-2005 for CIS4. Results from OLS estimation are reported in table 9.

Table 7: Selection into export markets, CIS3 and CIS4

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
WAGE	-0.035	-0.035	-0.034	-0.035	0.004	0.003	0.006	0.004
	(0.027)	(0.026)	(0.028)	(0.026)	(0.030)	(0.030)	(0.031)	(0.030)
PROD	0.132^a	0.132^a	0.138^a	0.132^a	0.114^a	0.117^a	0.119^a	0.116^a
	(0.019)	(0.019)	(0.020)	(0.019)	(0.018)	(0.018)	(0.019)	(0.018)
INPDT(d)	0.085^a	0.087^a		0.058^a	0.079^a	0.093^a		0.064^a
	(0.012)	(0.011)		(0.019)	(0.012)	(0.011)		(0.017)
INPCS(d)	0.004		0.046^a		0.037^a		0.067^a	
	(0.012)		(0.010)		(0.012)		(0.011)	
NEWMKT(d)				0.038^c				0.050^b
				(0.020)				(0.020)
N	4521	4521	4521	4521	3609	3609	3609	3609
pseudo R^2	0.181	0.181	0.170	0.182	0.170	0.167	0.159	0.169

Note. Robust standard error in parenthesis. Marginal effects calculated at the mean of the continuous variables, (d) for discrete change of dummy variable from 0 to 1. Columns (1)-(4) are for CIS3 regression, while columns (5)-(8) are for CIS4 regression. Sector dummies included. ^{a} $p < 0.01$, ^{b} $p < 0.05$, ^{c} $p < 0.10$

Table 8: Export market shares, CIS3 and CIS4

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RWAGE	-0.180	-0.174	-0.150	-0.173	0.241	0.238	0.255	0.237
	(0.208)	(0.207)	(0.209)	(0.207)	(0.219)	(0.219)	(0.221)	(0.219)
RPROD	1.170^a	1.168^a	1.182^a	1.168^a	0.917^a	0.920^a	0.921^a	0.918^a
	(0.122)	(0.122)	(0.123)	(0.122)	(0.115)	(0.115)	(0.115)	(0.115)
INPDT	0.302^a	0.272^a		0.137	0.238^a	0.252^a		0.207^c
	(0.076)	(0.070)		(0.122)	(0.084)	(0.076)		(0.113)
INPCS	-0.061		0.069		0.033		0.120^c	
	(0.071)		(0.065)		(0.077)		(0.070)	
NEWMKT				0.166				0.067
				(0.117)				(0.117)
N	3150	3150	3150	3150	2609	2609	2609	2609
R^2	0.469	0.469	0.466	0.469	0.451	0.451	0.449	0.451

Note. Robust standard error in parenthesis. Columns (1)-(4) are for CIS3 regression, while columns (5)-(8) are for CIS4 regression. Sector dummies included. ^{a} $p < 0.01$, ^{b} $p < 0.05$, ^{c} $p < 0.10$

Results from tables 7, 8, and 9 that are in agreement with the ones obtained using the full sample of Micro.3 and COE constitute an important check for the robustness of our conclusions.

Table 9: Export market shares growth, CIS3 and CIS4

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔRULC	-0.208^{a}	-0.208^{a}	-0.208^{a}	-0.208^{a}	-0.115^{c}	-0.115^{c}	-0.115^{c}	-0.115^{c}
	(0.067)	(0.067)	(0.067)	(0.067)	(0.067)	(0.067)	(0.067)	(0.067)
INPDT	-0.014	-0.022		-0.025	0.007	0.007		-0.034
	(0.032)	(0.030)		(0.063)	(0.036)	(0.035)		(0.052)
INPCS	-0.017		-0.023		-0.001		0.001	
	(0.029)		(0.028)		(0.033)		(0.032)	
NEWMKT				0.004				0.060
				(0.060)				(0.053)
N	3150	3150	3150	3150	2609	2609	2609	2609
R^2	0.016	0.016	0.016	0.016	0.009	0.009	0.009	0.010

Note. Robust standard error in parenthesis. Columns (1)-(4) are for CIS3 regression, while columns (5)-(8) are for CIS4 regression. Sector dummies included. ^{a} $p < 0.01$, ^{b} $p < 0.05$, ^{c} $p < 0.10$

This is the case of coefficients of $(R)WAGE$, $(R)PROD$, $\Delta RULC$, and $INPDT$ which are qualitatively similar to the previous ones. In particular, product innovation appears to be an important determinant of export performance in both surveys across the different econometric specifications, with the exception of the result obtainde in the growth rate equation. In the case of selection, there is also evidence that introducing a product which is new also for the reference market increase the probability of exporting.

The innovation process variable exhibits a much weaker pattern, in agreement with other results obtained using survey data (Becker and Egger, 2007; Caldera, 2010). It is significant in the selection equation and in the export market shares equation performed on CIS4 survey, while it is statistically not different from zero in all other regressions. Moreover, in two cases (column 3 of table 7 and column 7 of table 8) the variable is significant only when the product innovation dummy is not taken into account. This suggests that process innovation is important to the extent that it paves the way to the introduction of new products.

7 Conclusions

The paper contributes to the analysis of the the determinants of international competitiveness offering both the macro and the micro evidence about the relevance of cost and technological competition. Results of the empirical exercise in the first part show that technological capabilities are indeed relevant factors in explaining trade patterns between countries. Labour costs, on the contrary, have an ambiguous effect on export market shares: thet have a negative sign in just two sectors, while in most cases they are either positive or not significant.

The analysis at the micro level provides the first large scale study on export behaviour of firms that accounts also for the role of innovation. The micro evidence has been decomposed in two different processes: the selection of firms into export markets and the dynamics of market shares with respect to a subset of OECD country. In both cases, technology has been found to have a relevant role. How much a firm invests and if a firm patents appears to be correlated both to the probability of being an exporter and to the capacity to acquire and sustain market shares. On the other hand, the evidence about costs is mixed. Simple wage expenditure shows a positive correlation with the probability of being an exporter, while relative unit labour costs, a more appropriate measure of cost competitiveness, seems to be relevant only in some sectors.

We conclude with a set of results about the role of product and process innovation using CIS data, as it is usually done in the literature addressing the role of innovation in firms export behaviour. Results from CIS survey confirm the previous findings. In particular, they show that product innovation is a more relevant dimension than process innovation in determining firms export success.

These results suggest two things. At the macro level, technological absolute advantages do matter, as predicted by the intepretations of trade flows in Posner (1961) and Dosi et al. (1990). At the micro level, the evidence speaks in favor of models of trade based on "quality sorting" more than "efficiency sorting", along the conclusions suggested by the evidence at the product level in Manova and Zhang (2012).

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