“Innovative capacity and export performance: Exploring heterogeneity along the export intensity distribution”

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Abstract

This paper sheds additional light on the relationship between firm level innovative capacity and export intensity. By drawing from the recent literature on exporters' heterogeneity, we apply quantile regression techniques to a sample of Italian firms in order to verify whether the effect of innovative capacity – measured by R&D expenditures – varies along the conditional distribution of the export intensity. We control both for censoring and for potential endogeneity of the innovation activities by using firms’ distance to sector specific technological frontier as instrument. We find that R&D expenditures positively affect export intensity and that such effect has a bell shaped pattern along its conditional distribution: firms characterized by export intensity of about 35% can take highest advantage from investing in R&D activity. Overall results prove to be robust to several specification checks and suggest not only that firms innovative capacity helps to explain heterogeneity in export intensity performance but also that its positive effect differs across the export to sales ratio distribution.

Keywords: Exports, R&D, quantile regression, endogeneity, distance to the frontier.
JEL classification codes: F14, O32, D22, C31, C36

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1. Introduction

During the last two decades a host of empirical works have analyzed the relationship between firms characteristics and their exporting activity. The different approaches followed by the empirical literature reflect the evolution of theoretical models which have gradually improved the explanation of the complex interactions between firms heterogeneity and participation to international markets.

The role of firms innovative activity in facilitating the exporting activity is one of the issues which have been analyzed. Earlier models focused on the role of innovation in favoring the exporting activity through new or cheaper products whereas more recent contributions take into account possible feedback effects running from international markets participation to firms innovative performance. On the basis of such literature it is now widely recognized that endogeneity issues need to be accounted for when analyzing the export-innovation relationship (Melitz and Redding 2013).

On the one hand, investments in innovation might allow firms to improve their productivity so that they can afford high costs associated to exporting, moreover they might enable firms to achieve greater ability to meet international markets demand thus making exporting more profitable; on the other hand, the exporting experience might stimulate innovative activity through learning effects and better access to best practice technologies.

The applied literature has analyzed the link between innovation and exporting on the basis of different empirical approaches and have provided robust evidence in favor of the self selection hypothesis, whereby most innovative firms display higher probability to start exporting or to perform better on international markets whereas the evidence in favor of the learning by exporting hypothesis is weaker (Wagner (2012a)). It is worth noting that – despite the alleged two ways relationship between innovation and exporting activities – the endogeneity issue has not always been appropriately tackled. The aim of this paper is to shed additional light on the effects of firms' innovative capacity on their export intensity, by taking into account endogeneity issues and other firms characteristics which might favor the exporting activity. Moreover, the main novelty of this study is that it investigates if the relationship between innovation and export varies along the conditional distribution of the export intensity. Although this research question has already been addressed by Wagner (2006) on sample of German firms, the author does not take into account endogeneity issues. We instead address both issues and we apply the recently developed conditional quantile instrumental variable estimator (CQIV) suggested by Chernozhukov et al. (2011) to a sample of Italian firms[1].

All estimated models provide evidence in favor of a positive impact of R&D expenditures on export intensity and suggest that such effect has a bell shaped pattern along the export intensity conditional distribution, reaching its maximum impact around the central part of the distribution and being higher at lower quantiles. Such results imply that firms characterized by export intensity of about 35% can take highest advantages, in term on further expansion of their sales in international markets, from investing in R&D activity.

This paper contributes to the literature which highlights the heterogeneity across exporters. Unlike the vast majority of the applied literature at the micro level, which focuses on heterogeneity in firms' observed characteristics, it highlights another dimension of heterogeneity across exporters, namely the one in the effect of some covariates. If some differentials are observed, we believe that

1[1]Applied literature on export has used quantile regressions for a different purpose, a few authors having evaluated the impact of the exporting activity along the productivity distribution (Serti and Tomasi (2009), Arnold and Hussinger (2010), Bellone et al (2010), Cassiman and Golovko (2007), Haller (2012), Powell and Wagner (2011) among others).

such information might be useful for the design of policy interventions aimed at favoring exporting activity and productivity-enhancing policies at the micro level.

The rest of the paper unfolds as follows: the next section synthesizes the theoretical background and the evolution of the empirical literature which has analyzed the relationship between innovation and export. Section three describes the sample and Section four illustrates our empirical strategy. In section five we discuss empirical results and section six concludes.

2. Theoretical framework and empirical literature.

Macroeconomic theory has analyzed the relationship between innovation and exporting within the framework of trade theory and growth theory. Trade models focus on firm's capacity to develop product and process innovations as one of the main factors explaining internationalization choices and exporting performance. Neo-endowment trade models (e.g. Davis, 1995) explain trade on the basis of specialization and competitive advantage associated to factor endowments, which include knowledge accumulation and innovative capacity together with labor and capital. Trade and foreign direct investment (FDI) are associated to different stages of the product life-cycle in models based on product life cycle theory (Vernon (1966) and Krugman (1979) among others) which predict that new innovative products are more likely to be produced and exported by developed countries, but will be produced (through FDI or imitation) and exported by less developed countries as products mature[2].

Within the framework of growth theory, endogenous growth models (e.g. Romer (1990) and Grossman and Helpman (1991)) suggest that the exporting activity might spur innovation by means of different transmission channels: stronger competition induced by the enlargement of relevant markets which requires productivity improvements, the need to satisfy international technical standards, technological transfer from external markets (learning-by-exporting), better exploitation of scale economies which allow firms to cover the large fixed costs related to R&D and innovative activities.

Not surprisingly, these insights have been incorporated by the recent trade literature that moved away from analyzing industry level determinants of export to highlight the heterogeneity of exporters within industries[3]. Some theoretical models have tried to explain the link between firms' decision to export and their productivity after assuming that productivity is a random, exogenous draw from a casual distribution (Bernard et. al. (2003) and Melitz (2003) among others), while other authors have sought to endogenize firm-level productivity, by allowing firms to invest in productivity enhancing activity, like R&D. In such a theoretical framework measured firm productivity is often the outcome of a number of endogenous decisions which are taken jointly with trade participation.

Yeaple (2005) focuses on a general equilibrium trade model with homogeneous firms. Among other results, his model shows that, in the presence of fixed costs associated with both technology adoption and exporting, only those firms adopting a more advanced technology are able to start exporting. Similarly, Bustos (2011) suggests a model of trade with heterogeneous firms where the technology choice is jointly modeled with production and export decisions and shows that trade liberalization can stimulate the adoption of upgrade technology: "this modeling framework implies

2 Similarly, technology-gap trade models (e.g. Posner (1961) predict that a country which introduces a new product will export abroad as long as other countries start producing the same product by imitation: when the imitation lag is over new innovations need to be generated in order to support the exporting activity.

3 Melitz and Redding (2013) provide an exhaustive overview of "heterogeneous firms and trade" literature.

that (a) the most productive firms will choose to both innovate and export, (b) firms of lower productivity only export, (c) firms of still lower productivity choose to do neither, and (d) the least productive firms exit" (Melitz and Redding (2013)). Dynamic models of trade and innovation predicting that exporters will choose a higher innovation intensity with respect to non-exporters have been recently suggested. For example Aw et al. (2011) develop and estimate a dynamic, structural model of exporting and R&D that allows the self-selection of more productive firms into both exporting activity and R&D investments and recognizes a direct effect of R&D and exporting on future productivity. In particular, authors suggest that the joint evolution of productivity and export decisions observed in a panel of Taiwanese firms can be explained by endogenous productivity changes induce by R&D efforts.

At the empirical level, innovative activity has been has been included among those variables (others being productivity, size, age, and the like) that explain the heterogeneity observed, at the micro level, in firms' participation in international markets. The international evidence reveals a positive relationship between firms innovative capacity and exporting activity. Most studies employ R&D[4] as a proxy for firm innovative capacity and find that it is an important determinant of both exporting probability and export intensity (Gourlay and Seaton (2004), Harris and Li (2009) and Wagner (2006) among others). Such result is not confirmed by other authors which however identify positive effects of other innovation input indicators, like the share of workers with technical and scientific backgrounds or the presence of joint R&D projects with external partners (e.g. Hanley (2004) and Lefebvre et al. (1998)). Furthermore, innovation output indicators, as product and/or process innovations or patents, are found to positively affect export intensity and/or the probability to become exporters (Caldera (2010), Lopez-Rodrìguez and Garcìa-Rodrìguez (2005), Ganotakis and Love (2011) and Lachenmaier and Wößmann (2006) among others).

Studies applied on Italian firm level data confirm the positive impact of input and output innovation indicators on exporting activity (e.g Basile (2001), Benfratello and Razzolini (2008), Castellani (2002), D'Angelo (2012), Morone et al. (2011), Nassimbeni (2001), Frazzoni et al. (2011), Forlani (2010), Sterlacchini (2001))[5]. In particular, among the most recent studies, D'Angelo (2012) shows that export intensity is positively affected by the share of R&D employees, the collaboration with universities for the R&D activity, the introduction of product and process innovations and the turnover from innovative activity[6]. Frazzoni et al. (2011) analyze the role of lending relationship and innovative capacity as main determinants of both exporting probability and export intensity on a sample of manufacturing firms. By applying Full Information Maximum Likelihood (FIML-IV) Probit and Tobit models, authors find that the introduction of product innovations exert a positive impact on exporting activity, while the introduction of process innovations seems to not have any explanatory power. Morone et al (2011) investigate the effect of alternative forms of innovation on the decision whether to export or not using data from the Indagine Tagliacarne 2004. By estimating the average treatment effect (ATE), where the type of innovation undertaken by firms (technological innovations, non-technological innovations or both)[7] is considered as treatment, authors find that firms engaging non-technical innovations are more likely to look for new markets, or to start exporting in the future, with respect to firms adopting technical innovations: indeed, switching from non-export to export status requires deep changes in management of firm involving new business

4 R&D is generally measured by R&D expenditures or R&D employees.

5 For an exhaustive survey on the Italian empirical literature see Bottasso and Piccardo (2013).

6 The author estimate Tobit models on a sample of small and medium firms operating in high tech industries.

7 Technological innovations include product and process innovations, whereas non-technological innovations include organizational and marketing innovations.

practices as well as new marketing strategies; moreover, firms performing both types of innovation exhibit a higher probability to enter foreign markets.
A related branch of the empirical literature investigates the impact of exporting activity on innovative capacity, thereby testing the so-called "learning-by-exporting hypothesis" which predicts that that firms improve their performance by exporting. In particular, at the international level, some studies identify a positive effect of firms exporting activity on the introduction of product innovations (e.g. Damijan et al. (2010), Lileeva and Treer (2010) and Van Beveren and Vandenbussche (2010)), while others show that firms increase their R&D activity and upgrade their technologies as a result of exporting activity (e.g. Aw. et al. (2011), Bustos (2011), Criscuolo et al. (2010), Van Beveren and Vandenbussche (2010), Verhoogen (2008) and Wagner (2012b)). Using Italian firm level data, Bratti and Felice (2011) test whether export activity improves firms innovativeness on a sample of about 1.500 firms. Authors estimate the probability of introducing product innovations and find that firms internationalization seems to boost the introduction of new product, even controlling for other observable factors that may influence firm's innovativeness[8]. Similar results are obtained by applying both control function approach and instrumental variables techniques which account for endogeneity issues stemming from the possibility that firms innovativeness might in turn affect the exporting activity[9].
Wrapping up, the nowadays large literature has highlighted how firms innovative capacity is closely related with firms' penetration in foreign market. A dimension which still remains almost unexplored is whether the causal impact of innovative activity on export intensity differs for different quantiles of the export intensity distribution. The only article analyzing this issue is Wagner (2006) who applies quantile regression to a panel of German firms and finds that this effect is larger for higher quantiles. However, the author does not tackle the endogeneity of innovative activity and restricts its sample to exporting firms, thereby disregarding censoring issues. A similar analysis on Italian data but explicitly taking into account endogeneity and censoring issues is the aim of this paper..

3. Data

The empirical analysis is based on a dataset of Italian manufacturing firms obtained by merging the VI, VII, VIII and IX waves of the "*Indagine sulle imprese manifatturiere italiane*" (Survey on Italian Manufacturing Firms) run every three years by the Unicredit-Capitalia Observatory of Medium and Small firms. The sample is stratified according to size class, geographical area and industry in order to significantly represent the population of Italian manufacturing firms[10].
These waves cover the periods 1992-1994, 1995-1997, 1998-2000 and 2001-2003 respectively, and provide qualitative and quantitative information concerning several firms characteristics such as ownership structures, workforce composition, internationalization and innovation activities, among others . Not all waves report the same set of variables and not all variables have annual frequency, some of them referring to the last year of each wave and others covering the three-years time span.

8 Moreover a positive correlation is found between innovativeness and the share of graduated workers, FDI, group membership, some technological inputs, mergers and acquisitions. Conversely, a negative correlation is found between introducing innovative products and unit labor costs and physical capital intensity.
9 Chosen instruments include a sector-province specific measure of firms average distance from potential export markets, a proxy for exports market potential and the lagged unit labor cost.
10 The sample is composed by a random sample of manufacturing firms with 10-500 employees and all firms with more than 500 employees.

Basic data have been integrated with balance sheet information derived from the AIDA repository, a database elaborated by Bureau Van Dijk.

Unfortunately, the panel is strongly unbalanced, since only a very small fraction of firms is observed in all waves and a major change in the set of included firms occurred between the VII and VIII wave. Therefore, we decided to apply cross sectional techniques on a sample of 1,165 firms obtained after pooling the four waves. Given the aforementioned break in the set of firms and given the use of lagged variables, we decided to keep in the sample firms observed in both the VI and VII waves and those observed in both the VIII and IX. Therefore, current variables are observed in years 1997 or 2003, while three years lagged variables are observed in years 1994 or 2000 or over the periods 1992-94 or 1998-00[11].

Table 1 shows the distribution of the sample in terms of 2-digit industry ATECO classification together with firms export status at time *t*: On average, 77% of firms are engaged in exporting activity and the share of exporting firms is higher than 50% in all industries. In particular, clothing, rubber and plastics, furniture, non-electric machinery, electric machinery and electronic material, medical apparatus and instruments are those sectors where the fraction of exporting firms is above than 80%.

Table 1. Number of observations

Ateco 91 2-digit classification	Number of firms	Share of exporting firms
15 – Food products and Beverages	91	58%
17 – Textiles	128	79%
18 – Clothing	27	81%
19 – Leather	37	76%
20 – Wood	38	63%
21 – Paper products	43	67%
22 – Printing and publishing	35	54%
24 – Chemicals	55	71%
25 – Rubber and plastics	86	88%
26 – Non-metal minerals	74	51%
27 – Metals	44	75%
28 – Metal products	118	72%
29 – Non-electric machinery	205	94%
30 – Office equip. and computers	6	67%
31 – Electric machinery	37	97%
32 – Electronic material	21	86%
33 – Medical app. and instruments	18	89%
34 – Vehicles	34	74%
35 – Other transportation	10	80%
36 – Furniture	58	84%
Total	1165	77%

11 This choice is also dictated by the lack of information on one of our main variable of interest (the share of export on total sales) in year 2000.

Table 2 shows some descriptive statistics for the whole sample, for sub-samples of exporting and non exporting firms and for different ranges of the distribution of the export intensity.
The export intensity (*expint*), defined as the ratio of firm's export sales on total sales, is on average about 40% for exporters and displays a high level of dispersion around the mean; moreover, standard deviation computed at different ranges of the distribution suggest that such dispersion increases with the export intensity For almost half of exporting firms (about 40%) sales deriving from the exporting activity are below the 30% of total sales, while remaining firms are uniformly distributed across higher values of the export intensity. Therefore, the export intensity distribution appear not to be normally distributed and is characterized by a higher concentration of observation in the left tail; this shape of the export intensity distribution is confirmed by both graphical methods and statistical tests[12]. Descriptive statistics on the share of firms involved in foreign direct investment (*FDI henceforth*) is quite small (2.5%), thereby suggesting that firms included in the sample mainly expand their activities abroad by exporting.
The average size of firms in the sample (*size*), as measured by the number of employees, is about 142; however, size distribution is very asymmetric, with half of firms classified as small (52%) and just a lower fraction (14%) defined as large[13]. Exporting firms are, on average, significantly larger (172.69) than non exporting ones (41.53) and size is positively correlated with export intensity, so that larger firms are those exhibiting higher shares of sales deriving from the exporting activity.
Area dummies (*North, Centre, South*) show that most firms (75%) are located in the North of Italy, while 19% are located in the Centre[14]: rather comfortingly, our sample approximately reflects the distribution of manufacturing activities over the country. When considering exporting firms, firms in the North appear to be more export oriented than firms in the rest of the country. In terms of foreign ownership, 6% of exporting firms has a foreign majority shareholder (*foreign*) against 2% of non exporting ones.
Data on labour productivity, measured as the ratio of valued added on total number of employees (*lp*), suggest that exporters are more productive than non-exporters and that such differential grows along the export intensity distribution: this relationship is commonly observed in most of studies analyzing firms international activity. Firms innovative capacity is measured by the expenditure in R&D activity (*R&D*): more than half of exporting firms (52%) performed R&D activity, against only about 20% of non exporting firms; furthermore average expenditure in R&D activity is much higher for exporting than for non-exporting firms and significantly increases along the export intensity distribution[15].

12The values of both the Skewness (0.61) and Kurtosis (2.09) measures confirm that the export intensity distribution is not normal and it is skewed to the right, so that there are more observations on the left of the distribution. Other statistical tests (Skewness and Kurtosis test, Shapiro-Wilk and Shapiro-Francia tests for normality) support such evidence.

13We define firms as small when *size≤50* employees, as medium when *50<size≤250* and large when *size>250.* Just 19 firms have more than 1,000 employees.

14*North* is a dummy variable equal to one for firm located in the following Italian regions: Emilia-Romagna, Friuli-Venezia Giulia, Liguria, Lombardy, Piedmont, Trentino-Alto Adige, Valle D'Aosta and Veneto. *Centre* is a dummy variable equal to one for firms located in the following Italian regions: Abruzzo, The Marches, Tuscany, Lazio and Umbria. *South* is a dummy variable equal to one for firms located in the remaining regions.

15As for the R&D expenditures over total sales ratio, exporting firms show an R&D intensity of about 0.87% while non exporting firms invest a lower percentage of about 0.28%. Moreover, the R&D intensity increases along the export intensity distribution ranging from 0.33 to 1.18% with values around 0.65% at the median.

Table 2: Descriptive statistics for different ranges of export intensity

	Exporting firms	Non-exporting firms	Whole sample	0q-30q $exp_i \leq 5\%$	30q-50q $exp_i \leq 22\%$	50q-70q $exp_i \leq 50\%$	70q-100q $exp_i \geq 50\%$
Expin	39.97	0.00	30.71	0.99	14.16	37.74	72.23
	(28.07)	(0.00)	(29.83)	(1.73)	(4.78)	(8.49)	(13.52)
Size	172.69	41.53	142.29	61.04	137.31	175.47	219.67
	(393.69)	(58.43)	(350.56)	(195.88)	(503.21)	(243.69)	(438.16)
Lp	46.48	43.50	45.79	43.31	43.76	46.62	49.45
	(28.99)	(29.45)	(29.11)	(28.60)	(26.66)	(24.86)	(33.88)
R&D	310.24	16.41	242.14	31.59	138.63	327.30	497.77
	(1441.53)	(67.15)	(1269.81)	(178.33)	(616.13)	(1794.25)	(1690.65)
FDI	0.03	0.01	0.02	0.01	0.01	0.04	0.03
	(0.17)	(0.06)	(0.16)	(0.09)	(0.08)	(0.20)	(0.17)
Forei	0.06	0.02	0.05	0.02	0.05	0.08	0.06
gn	(0.23)	(0.14)	(0.21)	(0.12)	(0.23)	(0.28)	(0.23)
North	0.79	0.61	0.75	0.64	0.74	0.82	0.84
	(0.41)	(0.49)	(0.43)	(0.48)	(0.44)	(0.39)	(0.37)
Centr	0.16	0.29	0.19	0.27	0.17	0.15	0.14
e	(0.37)	(0.45)	(0.39)	(0.44)	(0.38)	(0.36)	(0.35)
South	0.05	0.10	0.06	0.09	0.09	0.03	0.02
	(0.21)	(0.29)	(0.23)	(0.29)	(0.28)	(0.18)	(0.14)

Notes: standard deviations in parenthesis.

4. Empirical strategy.

The aim of this work is to investigate whether innovative activities and other export intensity determinants differently affect export intensity at various point of its distribution by applying quantile regressions techniques.

As previously mentioned, such approach has only been adopted by Wagner (2006) on a sample of German exporting firms. The author estimates a model where export intensity depends on size, its square, the branch plant status of the establishment, a dummy variable which identify whether a firm operates in a crafts sector, the workforce composition, three dummies for different classes of R&D intensity and a binary indicator for patents registration. However, standard quantile regression techniques adopted by Wagner (2006) do not account neither for the censored nature of our dependent variable nor for the possible endogeneity of explicative variables.

In order to assess the relationship between firms innovative capacity and export intensity (firm's export sales on total sales), together with the effects of other firms' characteristics on their export performance, we consider the following empirical model:

$$Expint_i = \beta_0 + \beta_1 \boldsymbol{Innov}_i + \beta_2 \boldsymbol{X}_i + u_i \qquad (1)$$

where subscript *i* denotes firms.

Firms' innovative capacity is measured by the logarithmic transformation of firms R&D expenditure which captures the existence of a system of incentives towards intentional innovative activities and can be considered as a proxy for "the allocation of resources to research and other information generating activities in response to perceived profit opportunities" (Grossman and Helpman (1991))[16].

As for the other control variables, X_i is a vector of firms characteristics which have been usually found to affect export intensity in previous empirical literature; among them we include firm size, ownership structure, labour productivity and a binary variable indicating if the firm has established, through either brownfield or greenfield, a foreign subsidiary in the previous three years period. The vector of covariates also includes a set of industry dummies, which allow us to account for the omission of sector specific time invariant characteristics which might bias our parameter estimates[17] and three area dummies variables indicating if firms operate in the North, Centrrer or South of Italy so that we control for time invariant locational effects. Indeed, being located in an area closer to foreign markets, characterized by higher quality economic infrastructures, lower corrupted environment, higher human capital, etc. might favor exporting performance and failing to account for such characteristics might bias parameters estimates.

Size is expected to have a positive effect on export intensity: given the existence of relevant sunk costs necessary to enter into foreign markets, larger firms might be able to take advantage of economies of scale in production, might show higher capacity of taking risks and obtain credit at lower costs (Wagner (1995)). Such prediction stems from several theoretical models suggested by different trade theory models (see Melitz and Redding (2013)). In order to account for the possibility that relationship between size and export intensity is nonlinear we also include the square of the size variable: Wakelin (1998) suggests that an inverted U-shape relationship may be associated to the existence of very large firms with monopolistic power, which may show less motivation to export.

Export intensity is expected to be positively affected by foreign ownership: firms belonging to foreign owners might be more able to compete on international markets as they might have a larger international network (Sjöholm (2003)) which allows them to develop a better international marketing network and to reduce transaction costs associated with international trade (Ramstetter (1999)).

Another factor which might reasonably affect export performance is firm involvement in foreign direct investments (FDI) activity. From a theoretical point of view, some authors suggest that export activity and FDI are strategic substitutes; for example Helpman et al. (2004) show that the most productive firms choose to perform FDI, while those characterized by lower levels of productivity choose to export. However, it might be the case that FDI and exporting activity might act as strategic complements since FDI might improve the knowledge of foreign markets and the marketing networks.

Productivity, as measured by labor productivity, is included in our specification as predicted by recent theoretical models on trade which predict the existence of a relationship between the exporting activity and firms productivity: higher productivity favor the entry into international markets and may improve firms exporting performance.

The empirical strategy consists in estimating a parsimonious specification of equation (1) which includes the R&D variable alongside with size (and its square), industry and geographical dummies as regressors. This basic model is subsequently extended in order to alternatively account for the possible role of FDI activity, ownership structure and productivity. In particular, we do not include

16 We refer to Section (2) for a discussion on the relationship between firm innovative capacity and export intensity, both form a theoretical and an empirical perspective.

17 We include in the model 20 dummy variables for 2-digit ATECO manufacturing sectors.

productivity in our basic specification since the model includes the R&D variable which is considered as one of the major driver of productivity so that their explanatory power might overlap.
Our discussion concerning the specification of the empirical model suggests that some explanatory variables might be endogenous to the model given the likely existence of reverse causality : export intensity might affect control variables so that they are simultaneously determined. By assuming that the impact of our control variables on the export intensity needs time to take place, we include (three years) lagged of explanatory variables in order to weaken the reverse causality link[18]. However, given that the main focus of this study is to analyze the impact of R&D expenditure on firms exporting performance, we further tackle the endogeneity issue concerning the R&D variable by applying instrumental variables estimation techniques. In particular, we assume that firms distance (lagged at t-3) from industry specific technological frontier might work as instrument for the R&D indicator. We derive instrument relevance from the recent literature (Aghion et al. (2004, 2005)) which argue that firms closer to the frontier have higher incentives to perform R&D activities in order to improve their innovation performance and expand their market shares .As for instrument validity, we posit that firms' distance from industry specific frontier affects export intensity through firms' innovative capacity. This hypothesis cannot be tested in our context and rests on results obtained by the international empirical literature which does not find consluive evidence supporting the learning by exporting hypothesis (Wagner (2012)).
Indeed, Aghion et al. (2004, 2005) suggest that the impact of (foreign) competition on firms' incentives to innovate is related to their distance from the technological frontier: competition should stimulate innovation activity for firms close to the technological frontier. In Aghion (2004) firms that are closer to the frontier have a greater incentive to innovate in order to preserve their market share, while firms that are far from the frontier have lower expected benefits from innovation since they can hardly face tough competition. On the other side, Aghion et al. (2005) suggest that firms closer to the frontier are spurred to innovate because competition reduces their pre-innovation profits (rents obtained if the firms do not innovate); on the contrary competition discourages firms that are far from the frontier from innovating because it negatively affects their post-innovation rents.
In order to build firm level distance from industry specific frontier we estimate firm level TFP[19] and define industry frontiers on the basis of the highest TFP level observed in each sector classified with the 2-digit industry ATECO classification. Moreover, we perform some robustness analysis and we build a different measure of firms technological distance, after defining industry specific frontier by means of the observed share of "white collars" on total employment at t-3. In particular, we assume that the presence of a high share of white collars might be related to the production of high value added activities which brings firms closer to the industry frontier.
Another issue which we need to control is the censored nature of our dependent variable: indeed export intensity is only observable for the sample of exporting firms which might not be randomly selected. In order to account of both endogeneity of R&D and sample selection bias issues we apply the estimator recently proposed by Chernozhukov et al. (2011) labelled as CQIV estimator[20]. This estimator uses a control function approach by estimating a first stage for the endogenous regressor

18 Export intensity is observed either in 1997 or 2003, while lagged explanatory variables are observed either in 1994 or in 2000 (or over the periods 1992-94 and 1998-00).
19 We decided to estimate the TFP at industry level as a residual of the production function using the semi-parametric approach proposed by Levinsohn and Petrin (2003).
20 Such estimator allows for the inclusion of just one continuous endogenous explanatory variable in the model. This limitation explains why we limit ourself to the effect of innovation inputs (R&D) and not of innovation output (product and process innovations) for which we only have binary indicators in our dataset.

and a second one in which the residual estimated in the first stage is inserted as additional regressor. In the second stage, a probability of censoring is estimated on all observations and standard quantile estimators for uncensored data are iteratively applied on the subset of observations for which the probabilty of censoring is sufficiently low (for technical details see Chernozhukov et al. (2011)).

The robustness of our results has been analyzed by estimating different specifications of equation (1) with various estimation techniques. In particular, we apply censored quantile regression (CQR), instrumental variable quantile regression (QIV) and simple quantile regression techniques (QR). The CQR approach treats the censoring nature of the data but does not account for endogeneity issues whereas the QIV approach only controls for endogeneity. Moreover, in order to verify whether the quantile approach does give a more exhaustive picture of the relationship between firms export intensity and their innovation potential, we estimate our models by means of standard methodologies like Instrumental Variables TOBIT, TOBIT, IV and OLS which provide counterpart estimates of the parameters evaluated at the conditional mean of the export intensity distribution.

5. Empirical results

Table 3 reports the estimates of the most parsimonious specification of equation (1) obtained by applying different econometric techniques. In particular, looking at the quantile regressions applications, since 23% of observed firms do not export, we decided to discuss results only for quantiles above 0.30; in particular, estimates are performed at seven quantiles, namely 0.30, 0.40, 0.50, 0.60, 0.70, 0.80 and 0.90.

Before discussing punctual estimates we note that first step results confirm the relevance of the chosen instrument since estimated coefficients for the distance variable (reported in Table 3) are found to be always negative and statistically significant, thus suggesting that firms closer to the industry frontier have more incentive to invest in R&D in order to improve their innovative performance..

Overall results show that R&D expenditures positively affect export intensity; however, the magnitude of the effect displays a significant variability associated to different estimation techniques.

Tobit IV estimates suggest that an increase of 10% in R&D expenditures induces an increase in export intensity of about 0.2 percentage points, while such effect ranges between about 0.01 and 0.35 percentage points when considering CQIV estimates. In particular R&D estimated coefficients show a bell shaped pattern with the highest impact observed at the 0.70 quantile and higher values observed in the right tail of the export intensity distribution if compared with values obtained in the left tail.

Therefore, CQIV regressions suggest that firms characterized by export intensity higher than about 35% can obtain higher advantages from investing in R&D activity in term on expansion on international markets, while such effect is lower, but still significant, for firms whose exports sales is lower. The same pattern of the R&D coefficient is observed when applying the QIV estimator, even if marginal effects are found to be slightly lower and ranging between 0.05 and 0.32; similarly, the impact of R&D on the export intensity evaluated at the conditional mean results to be lower when we apply IV techniques which ignore the censored nature of the dependent variable (0.15 vs 0.2).

The existence of a bell shaped relationship between firms innovative capacity and exporting activity is less evident when we observe estimates results obtained from CQR and QR approaches. In both cases the pattern of estimated coefficients for R&D appears to be flatter and shifted to the left of the

export intensity distribution as they reach their maximum value around the median; furthermore, marginal effects are found to be lower with respect to CQIV and QIV values since they range between 0.03 and 0.06. Likewise parameters estimates of the R&D variable obtained with Tobit and OLS methods are lower with respect to those from Instrumental Variables approaches (TobitIV and IV). Hence, estimates obtained when both endogeneity issues and the censored nature of the dependent variable are neglected provide the lower bound of parameters values.
Consistently with previous international empirical literature our findings suggest that investments in R&D activity has a positive effect on firms export intensity: R&D expenditures might generate higher probability of introducing product/process innovations and might increase firms absorptive capacity which allows firms to improve their export performance. Furthermore, estimates obtained by applying quantile regressions techniques provide a more clear picture of such effect which results to vary at different point of the export intensity distribution.
Overall findings on the effects of R&D on export intensity are broadly consistent with those obtained by Wagner (2006) on a panel of German firms by applying standard quantile regression techniquesalthough he finds that the effect disappears for extreme values of the R&D intensity distribution[21].
Moreover, our results are in line with those obtained on Italian data by Basile (2001), Nassimbeni (2001), Frazzoni et al. (2011) and D'Angelo (2012) among others, as well as with the international empirical evidence provided, for example, by Lopez-Rodrìguez and Garcìa-Rodrìguez (2005) and Salomon and Shaver (2005), which highlight firms advantages in terms of export intensity derived from their innovation activity.[22]
Turning to discuss estimates results concerning different control variables included in the basic specification of equation 1, we note that the effect of firms size (evaluated at t-3) is not stable along the export intensity distribution and exhibits a significant variability associated to different estimation techniques. In particular, Tobit IV estimates suggest the existence of an inverted U-shaped relationship between size and exporting activity. However, coefficients from the CQIV regressions follow an bell shaped pattern up to the median while an U-shaped relationship between size and export intensity is observed in the right tail of the distribution.[23] Given that firms size in our sample increases along the export intensity distribution, these findings are broadly consistent with those obtained by Sterlacchini (2001), who finds an inverted U-shaped relationship for small firms, an U-relationship for large firms and none impact of size on export intensity for medium firms. A similar pattern of the size coefficients is observed when applying the QIV estimator; while IV estimates do not show any impact of size on export intensity at the conditional mean of the export intensity distribution. A bell shaped relationship between firms size and exporting activity which persists along the export intensity distribution is shown by CQR and QR estimates as well as by Tobit and OLS regressions.
Overall results on the shape of the relationship between size and export intensity reflect those obtained by previous empirical studies which provide mixed evidence: for example Castellani (2002) and Nassimbeni (2001) identify an inverted U-shape relationship between the two variables, while Sterlacchini (2001) suggests that such shape is not constant across firms size distribution.[24]

21 We cannot perform a comparison with Wagner's (2006) results in terms of punctual estimates since his sample of firms is very different as far as size, export intensity, R&D intensity are concerned.

22 See Section 2.

23 These results are supported by F-tests on joint significance of the size parameters.

24 Some authors find a positive impact of size on export intensity on Italian data but do not investigate if such relation might be non linear (e.g.. Basile (2001, Becchetti et al. (2010), and D'Angelo (2012).

Finally, our results differ from those suggested by Wagner (2006), who finds a linear relation between size and export intensity only at the 0.25 quantile of the export intensity distribution.
Looking at the impact of firms geographical location, quantile regressions techniques suggest that for firms characterized by export intensity values lower than 22% (median values), being located in the South of Italy exerts a positive impact on export intensity if compared with firms located in the Centre, while this effect is not confirmed for firms exhibiting higher export intensity as well as at the conditional mean of the export intensity distribution (about 31%). On the other hand, no effect is found for firms operating in the North and characterized by low export intensity (lower than median values), while empirical evidence is mixed for firms on the right tail of the export intensity distribution, since only estimation approaches which do not account for endogeneity of the R&D variable show a positive "north" effect on export intensity.
Most of results discussed so far are broadly confirmed by further empirical analysis where we estimate different extensions of the basic specification. When we include a dummy variable indicating if firms performed FDI at t-3 we find that such variable has a positive and decreasing effect on the exporting activity only in the left tail of the export intensity distribution, while such effect is not confirmed above the median. Our results are consistent with those obtained by previous applied works which identify a positive impact of FDI on exporting activity and suggest a complementary relationship between exports and FDI (e.g. Lipsey and Weiss (1981) and Clausing (2000)).
We alternatively estimate our basic specification after augmenting it with a dummy variable which identifies firms having a foreign majority shareholder. Again the positive impact of having a foreign majority shareholder is identified only in the left tail of the export intensity distribution. Some studies conducted on international data identify a positive relationship between foreign ownership and exporting activity; for example, Cole et al. (2010) analyze a sample of Taiwanese manufacturing firms and suggest that that foreign ownership increases the probability of exporting; Filatotchev et al. (2008) show that foreign ownership affects export intensity in transition economies. Such results might be explained by considering that firms with lower export intensity might have greater benefits in term of exporting performance from better knowledge of foreign markets' related to their ownership structure or to their FDI activity.
A further extension of our empirical model has been obtained after including a firm partial productivity measure evaluated at t-3 and constructed as the ratio between added value and total employment. Estimates suggest that labor productivity does not affect the export intensity for firms belonging to our sample, probably because of the presence of the size variables and of the innovation proxy (R&D) which is considered as one of the major productivity driver.
Further robustness analysis has been conducted by estimating our basic specification and assuming an alternative instrument. In particular, we adopted a measure of skillness of firms employees, as measured by the share of "white collars" on total employment, for defining sector specific frontiers as well as firms' specific distance. Such firm characteristic might be associated to greater innovative effort associated to the production of higher value added goods. Empirical estimates broadly confirm our main results[25].

25 All robustness analysis has been performed by estimating each augmented specification with all estimation techniques applied to our main specification.

6. Concluding remarks

In this study we analyze firms export intensity determinants with a particular attention on the role of innovative capacity as one of the most important source of better export performance. In order to carry out our analysis, we apply different econometric techniques on a cross-sectional dataset of Italian manufacturing firms obtained by merging the VI, VII, VIII and IX waves of the "Survey of Italian manufacturing firms " and by recovering balance sheet data from AIDA dataset.

In order to better analyze the relationship between firms' innovative capacity and export intensity we study if such relationship varies along the export intensity distribution by applying quantiles regression techniques; in particular we deal with the censoring nature of the export intensity variable and with the endogeneity of the innovation variable by applying the CQIV estimator recently proposed by Chernozhukov et al. (2011).

Empirical results obtained by applying different estimation techniques suggest that R&D expenditures positively affect export intensity; moreover, when the endogenous nature of the R&D variable is properly treated, estimates suggest that such effect has a bell shaped pattern along the export intensity conditional distribution, with firms whose export intensity ranges between values of about 40% and 50% exhibiting higher returns from investing in R&D activity[26], while returns are found to be lower but still significant in the tails of the export intensity distribution.

Overall results suggest that firms innovative capacity helps to explain heterogeneity in export intensity performance among Italian firms and might provide useful insight for the design of policy instruments aimed at favoring export and productivity improvements. Finally, empirical results on the impact of included control variables on export intensity are in line with those obtained by the previous empirical literature conducted on both Italian and international data.

26These firms exhibit an average R&D intensity of about 0.83%.

Table 3 Empirical estimates

CQIV	30	40	50	60	70	80	90	TOBITIV
$ln(R\&D_{t-3})$	0.97***	1.38***	1.98***	3.22***	3.49***	3.03***	2.73*	2.02**
	(0.30)	(0.43)	(0.62)	(0.57)	(0.86)	(0.88)	(1.61)	(0.96)
$size_{t-3}$	26.75***	25.14***	11.03	-17.54*	-27.32	-32.31*	-18.23	6.53
	(5.38)	(7.84)	(11.20)	(10.45)	(17.01)	(17.02)	(29.17)	(17.60)
$size^2_{t-3}$	-4.47***	-4.37***	-2.13	2.29	3.83	6.45*	2.15	-1.71
	(0.88)	(1.29)	(1.87)	(1.73)	(3.91)	(3.30)	(4.90)	(3.07)
North	-2.36	-2.28	-3.36	-5.66	-5.43	-0.01	9.43	1.15
	(2.31)	(3.21)	(4.69)	(4.28)	(6.60)	(7.11)	(14.27)	(7.20)
Centre	-19.81***	-17.55***	-10.01**	-10.09**	-10.47*	0.05	14.40	-4.34
	(2.33)	(3.15)	(4.38)	(4.00)	(6.14)	(6.60)	(13.08)	(6.56)
CF residual	-0.44	-0.82*	-1.41**	-2.73***	-3.09***	-2.66***	-2.61	-
	(5.96)	(1.15)	(0.62)	(0.57)	(0.87)	(0.88)	(1.61)	
_cons	-3.04	0.16	32.17*	20.65**	30.56*	22.48	78.85	63.06
	(5.96)	(9.59)	(18.98)	(8.21)	(17.43)	(16.46)	(48.21)	(22.46)
$distance_{t-3}$	-9.7***	-9.7***	-9.7***	-9.7***	-9.7***	-9.7***	-9.7***	-9.7***
	(3.28)	(3.28)	(3.28)	(3.28)	(3.28)	(3.28)	(3.28)	(3.24)
CQR								**TOBIT**
$ln(R\&D_{t-3})$	0.52***	0.54***	0.60***	0.51***	0.36***	0.38***	0.13	0.45***
	(0.04)	(0.03)	(0.06)	(0.06)	(0.09)	(0.12)	(0.14)	(0.07)
$size_{t-3}$	36.16***	39.97**	34.44***	30.49***	28.67***	15.57	23.37***	33.37***
	(3.03)	(2.19)	(4.63)	(4.12)	(8.81)	(10.54)	(7.43)	(5.44)
$size^2_{t-3}$	-6.98***	-6.76***	-6.01***	-5.53***	-6.84**	-1.74	-4.66***	-6.17***
	(0.56)	(0.36)	(0.76)	(0.69)	(3.27)	(2.89)	(1.46)	(1.18)
North	-1.00	0.88	4.75	8.61**	11.93**	14.48*	27.61***	9.16**
	(2.81)	(1.89)	(4.26)	(3.79)	(5.70)	(7.68)	(10.58)	(4.48)
Centre	-19.49***	-15.75***	-4.91	0.66	1.51	8.97	30.47***	1.05
	(3.41)	(2.26)	(4.66)	(4.12)	(6.14)	(8.13)	(11.03)	(4.81)
_cons	-4.64	-12.44**	-7.33	-16.35	37.02***	60.12***	32.22**	28.20***
	(6.05)	(5.68)	(11.37)	(13.53)	(13.23)	(17.19)	(13.69)	(6.17)
QIV								**IV**
$ln(R\&D_{t-3})$	0.48***	0.74***	1.68***	2.65***	3.16***	1.87*	2.39	1.46**
	(0.17)	(0.25)	(0.48)	(0.62)	(0.86)	(0.97)	(1.57)	(0.74)
$size_{t-3}$	41.35***	33.06***	16.36*	-5.98	-21.49	-8.04	-21.18	8.00
	(3.13)	(4.55)	(8.81)	(11.36)	(15.64)	(17.86)	(28.58)	(13.63)
$size^2_{t-3}$	-8.07***	-5.45***	-3.01**	0.48	2.74	0.25	3.18	-1.93
	(0.53)	(0.75)	(1.46)	(1.89)	(2.61)	(2.98)	(4.81)	(2.38)
North	-0.03	-0.30	-3.07	-5.12	-5.49	4.25	1.78	1.18
	(1.27)	(1.83)	(3.53)	(4.58)	(6.28)	(7.18)	(12.32)	(5.47)
Centre	-3.93***	-2.65	-3.35	-6.83	-10.41*	2.46	4.25	-2.47
	(1.13)	(1.64)	(3.19)	(4.17)	(5.74)	(6.51)	(11.13)	(4.95)
CF residual	-0.17	-0.31	-1.14**	-2.20***	-2.82***	-1.52	-2.31	-
	(0.17)	(0.25)	(0.48)	(0.62)	(0.86)	(0.97)	(1.56)	
_cons	10.20**	17.21**	41.22***	66.98***	85.06***	52.39*	80.07*	56.29**
	(4.81)	(7.03)	(13.70)	(17.82)	(24.62)	(28.34)	(46.33)	(17.33)
$distance_{t-3}$	-9.7***	-9.7***	-9.7***	-9.7***	-9.7***	-9.7***	-9.7***	-9.7***
	(3.28)	(3.28)	(3.28)	(3.28)	(3.28)	(3.28)	(3.28)	(3.28)
QR								**OLS**
$ln(R\&D_{t-3})$	0.31***	0.42***	0.51***	0.47***	0.37***	0.35***	0.15	0.33***
	(0.01)	(0.02)	(0.05)	(0.04)	(0.08)	(0.11)	(0.14)	(0.06)
$size_{t-3}$	44.50***	39.57***	37.18***	33.24***	25.64***	23.43***	14.44*	27.35***
	(1.10)	(1.44)	(3.49)	(3.17)	(5.82)	(7.49)	(7.87)	(4.16)
$size^2_{t-3}$	-8.67***	-6.53***	-6.41***	-5.91***	-5.03***	-4.82***	-2.57*	-5.15***
	(0.21)	(0.23)	(0.58)	(0.53)	(0.99)	(1.28)	(1.53)	(0.70)
North	0.69	1.02	2.82	6.70**	12.03**	12.91**	12.53	6.92**
	(0.84)	(1.11)	(2.78)	(2.67)	(4.97)	(6.51)	(8.59)	(2.81)
Centre	-3.32***	-2.16*	-0.55	0.23	1.50	8.42	14.69	1.35
	(0.90)	(1.19)	(2.99)	(2.88)	(5.37)	(6.99)	(9.11)	(3.22)
_cons	17.48***	35.75***	32.88***	39.35***	38.69***	59.55***	66.35***	6.03
	(2.10)	(2.79)	(6.89)	(6.70)	(12.56)	(16.70)	(22.32)	(10.37)

*Note: standard errors in parentheses; * p < 0.10, ** p < 0.05, *** p < 0.01. No. Observation 1165; CQIV: Censored Quantile Instrumental Variable,*

CQR: Censored Quantile Regression; QIV: Quantile Instrumental Variable; QR: Quantile Regression; CF residual: Control Function residual from first stage.
Estimates performed with Stata 12 Software.

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