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TO THE THRESHOLD AND BEYOND: SIZE, PRODUCTIVITY AND (SCALE) BARRIERS TO EXPORT

Stefano Costa*, Federico Sallusti*, Claudio Vicarelli*, Davide Zurlo*

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Abstract

Making use of a firm-level dataset for the universe of Italian exporting firms collected by ISTAT, we identify the minimum combinations of size and productivity that Italian manufacturing firms need to achieve (in their own industry) in order to access international markets. These “export thresholds” are estimated by applying for the first time in economics the ROC (Receiver Operating Characteristics) methodology, so far widely used in other disciplines (e.g. medicine, machine learning, natural sciences).

The results of the analysis allow us to provide, for each industry: (1) a mapping of the upper and lower-side of the distribution of firms with respect to the export threshold, stressing the size-productivity combination choices of exporting and non-exporting units; (2) the relative weight of productivity and size in determining the export threshold in a given industry; 3) the best lever of policy to be used in order to increase firms’ intensive margin (the share of exported turnover) as well as the extensive margin for the Italian economy (the share of exporting firms).

The methodology proposed in this paper can also open the field to further important developments. In particular, our empirical model could be augmented to point out other determinants of the thresholds than size and productivity, especially those related to the industry structure or regulation. Such “exogenous” dimensions of the export thresholds would help better detect effective policy interventions to reduce barriers to trade

JEL code: F14, L60, L11

Keywords ROC analysis, export threshold, intensive and extensive margin of exports

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1. Introduction

In the last decade, the recovery of international trade after the sharp fall in 2009 largely benefited those Countries most ready to exploit opportunities provided by foreign demand, in a framework where domestic demand was sluggish or decreasing and export activity stood out as a key factor for firm survival.

This was all the more relevant for Italy. Especially during the “second dip” of the crisis (2011-2014), Italian firms’ ability to operate in foreign markets was crucial to the evolution of the business cycle (see, among others, Accetturo et al., 2013; ISTAT, 2017). Italy, in fact, is characterized by a high number of exporting firms (more than 177 thousands in 2014), with a significant weight in economic terms (they account for about half of Italian total value added). However, their share on total number of firms is still small (less than 6%). In manufacturing, which accounts for some 85% of Italian export, in 2014 exporting firms were about 86 thousands, representing more than 80% of the sector's value added. Moreover, their share of exported turnover was particularly low (5.1% in median), so that even exporting firms largely depend on domestic demand (Istat, 2017).

These peculiar characteristics of the Italian manufacturing system have fueled the debate about the identification of the most appropriate policy measures to support and increase firms’ internationalization: is it more effective to aim at boosting the export-to-turnover ratio (i.e. feeding the intensive margin) or at enlarging the number of exporters (i.e. increasing extensive margin)? To answer such questions, we need to know something more about what are the necessary and sufficient conditions to undertake the export activity in Italy.

In this vein, the purpose of this work is threefold: a) providing for each business sector an (estimated) “export threshold”, that quantifies the combination of firm’s size and productivity (namely the widely known main determinants of the probability of export) corresponding to the transition between the non-exporter to exporter status; b) providing a “map” of the positioning of firms with respect to these threshold values, which also allows to depict the distribution of the exporting firms according their size-productivity combination values and intensive margins; c) providing, based on such results, a guidance for evidence-based policies aimed at fostering the internationalization of Italian firms.

For the purposes of this paper, we rely on the literature focusing on firm heterogeneity, which refers both to firms’ characteristics (e.g., size, location, business sector, exporting status) and performance (e.g., revenues, profitability, productivity).

Firms ability to trade is strictly linked to firm’s productivity and size. On the theoretical ground, differences in firms’ productivity are at the heart of several models (see Melitz and Ottaviano, 2008; Chaney, 2008; Bernard *et al.*, 2011) developed since the seminal work of Melitz (2003), according to which only more productive firms can cover the trade costs (sunk or entry costs) required to profitably operate in international markets (see Redding, 2010 for a survey on this literature). There are two different kinds of trade costs: variable trade costs and fixed trade costs. A fall in the variable cost induces an endogenous shift in the productivity cut-off for exporting. A reduction in the fixed export costs has the same qualitative effect on the cut-off. This implies that following reductions of both types of trade costs will lead to new firms, which would not have exported under higher cost conditions, to enter foreign markets.

In Melitz (2003), exporting from country j to a foreign market i involves a fixed cost for market entry and variable iceberg trading costs. With CES preferences, it is the presence of fixed cost that ensures that only the most productive firms export, because only the capability of reaching high levels of productivity allows

firms to generate enough variable profits to cover the fixed cost. Otherwise, in the presence of only variable trade costs, all firms would export, since CES preferences imply that the marginal utility of consuming any given variety approaches infinity as consumption of that variety approaches zero. A fall in variable costs induces an adjustment of the value of exports by firms which are already exporting (intensive margin) and a rise in the number of exporters, while a fixed cost reduction only gives rise to the latter adjustment. In contrast, Melitz and Ottaviano (2008) assume quadratic preferences, which give rise to variable mark-ups and thus to competition effects arising from trade cost reductions. Under this assumption, it follows that intensive margin can also be affected by a reduction in fixed entry costs.

On the empirical ground, in their influential works Bernard and Jensen (1995) showed that firm heterogeneity is systematically related to trade participation. Within an industry, some firms export while many others do not and, even among exporters, the fraction of shipments exported is often small. Exporters are larger, more productive, and pay higher wages than other firms within the same industry.

Besides productivity, trade participation is also strictly linked to firm size. Most studies have found exporters to be larger in size than non-exporters (Wagner, 2007). This raises important questions about the sources of productivity gains related to exporting and more specifically, whether such sources are related to firm size. Internal sources of productivity growth include managerial talent, quality of factor inputs, information technology, R&D, learning by doing, and innovation (Syverson, 2011). Small and large firms could differ in terms of access to these sources of productivity growth (Leung *et al.*, 2008). External factors such as regulations and access to financing could also be responsible for productivity differentials between small and large firms (Tybout, 2000).

Causal relationship among productivity, size and export activity has been largely analyzed. Several empirical works found evidence of self-selection hypothesis: firms able to export are more productive because foreign markets entry costs represent a barrier that less productive firms are not able to overcome. This hypothesis implies that a firm should reach a “minimum level” of productivity before starting to export. However, the learning-by-exporting hypothesis points out the role of international competition as a key element to improve firm productivity: knowledge flows from international buyers and competitors help improve the post-entry performance of exporters. Empirical evidence of self-selection is clear and wide while evidence regarding the learning-by-exporting hypothesis is somewhat more mixed (see Wagner, 2007 and Singh, 2010 for a survey). These two hypotheses are alternative but not mutually exclusive.

To sum up, productivity and size have been identified as the main drivers of firm’s ability to export. However, to the best of our knowledge, so far there are no attempts to calculate the “minimum level” of the combination of these determinants, i.e. the threshold between the firm ability to export and not to export. We fill this gap making use of a unique firm-level dataset which collects information about the main structural features of Italian firms, their export performance, and the structure of their involvement in international trade. These thresholds are calculated applying for the first time in economics a technique widely used in medicine: the ROC curve.

The rest of the paper is organized as follows. Section 2 presents a description of the dataset and methodology. Section 3 discusses the estimation results and some important policy implications raised by our approach. Section 4 summarizes and concludes.

2. Data and methodological strategy: the use of the ROC analysis in the “export threshold” identification

2.1 Data

The reference statistical source is the firm-level dataset “Frame-Sbs”. Developed by ISTAT in the last years, it relies on administrative data source to provide information on the structure (number of employees, business sector, location, age) and main Profit and Loss account variables (value of production, turnover, value added, labour cost) of all the about 4.4 million of Italian firms (Luzi and Monducci, 2014).

To our purposes, this database is firstly integrated with other firm-level information drawn from custom trade statistics (COE), which is a census-type statistics (based on administrative data) reporting imports, exports and trade balance values. For each firm operating in Italy and time period, it tracks the value of goods traded with both EU (intra-EU trade) and non-EU operators (extra-EU trade) by destination market.

Finally, the firm-level estimates of Total factor productivity (Tfp) are added to this integrated dataset.¹

However, to our aims some further restrictions are needed. In particular, bearing in mind the peculiar structure of the Italian business system, characterised by an overwhelming presence of very small firms (in 2014 the enterprises with just one person employed accounted for over 50% of total firms and 12% of total employment), we choose to focus on firms with “economic relevance” for the analysis of export strategies. To do so, we imposed some restrictions for each productive units, considering only firms that: 1) operate in manufacturing industries (excluding Tobacco, Refined petroleum products, Maintenance and repair, Other manufacturing); 2) have positive value added; 3) have at least 1 employee; 4) have positive consumption of fixed capital. This choice, moreover, is also consistent with the requirements necessary for the estimates of Tfp (availability of full information for every firm).

Table 1: Italy: Industry classification and firms characteristics, 2014

Industry	Nace code included	Number of firms	Share of firms	share of value added	Share of employees	Share of exports
Food and beverage	10,11	37439	17.8	16.2	16.0	8.2
Textile	13	8705	4.1	4.1	4.2	2.9
Wearing apparel	14	12673	6.0	5.6	6.0	4.1
Leather	15	8931	4.3	4.2	4.7	4.8
Wood	16	16620	7.9	7.4	5.4	0.5
Paper and print	17,18	12777	6.1	6.1	5.4	2.4
Chemicals and pharmaceuticals	20,21	3491	1.7	2.0	2.5	8.4
Rubber and plastic	22	7635	3.6	4.0	4.7	5.4
Non metallic minerals	23	12107	5.8	5.6	5.5	2.9
Metals	24,25	47580	22.6	23.4	22.0	14.7
Electronics	26,27	9315	4.4	4.8	5.3	8.8
Machinery	28	18251	8.7	9.9	11.4	21.7
Automotive	29,30	2880	1.4	1.5	2.0	12.7
Furniture	31	11705	5.6	5.4	5.1	2.6

Source: Authors’ calculation on Istat data.

¹ The estimation of TFP involves the use of some measure of capital at individual level, which is not included in Frame-Sbs. In order to overcome this lack of information, consumption of fixed capital (used as a proxy for capital endowment) is taken, for incorporated companies, from balance sheets provided by Italian Chamber of Commerce. Estimates of TFP are obtained following the Woolridge (2009) methodology as applied in Di Mauro and Ronchi (2015). In this case, a panel dataset is built (starting from Frame-Sbs and balance sheet) taking into account the period 2010-2014.

Referring to 2014, we finally obtain an operative database of 210.109 observations. With refer to manufacturing industry, it includes about 50% of firms, but accounts for 80% of employees, 82% of value added, and 87% of exports. Industry composition and main information about strata of analysis are reported in Table 1.

As far as industry composition is concerned, our dataset closely reflects the specialization model of the Italian economy with respect to its participation in international trade: machinery, automotive, metals and food and beverage account for over half of the total manufacturing export.

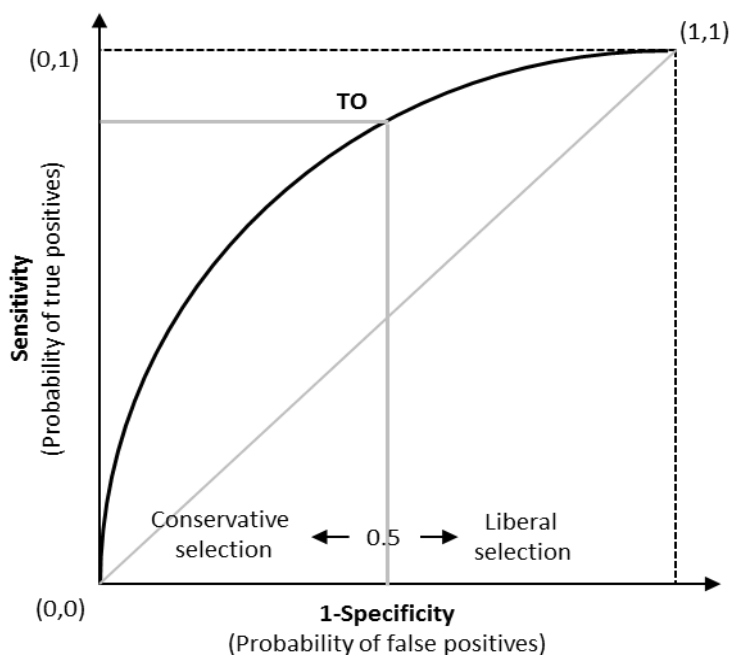
2.2 Methods

The definition of the “export threshold” is mainly based on an application of the Receiving Operating Characteristics analysis (hereinafter ROC, see Fawcett, 2005), which permits to define a cut-off point over a dependent variable in a logit model so as to efficiently cluster observations with respect to the dependent binomial variable.

This application of the ROC analysis is widely used in medicine (Kumar and Indrayan, 2011), machine learning (Majnik and Bosnic, 2013) and natural sciences (Warnock and Peck, 2010). To the best of our knowledge, this is the first attempt to apply it in economic analysis.

Taking a logit model, the ROC curve (in Figure 1) represents the position of each observation in the space of “sensitivity” and “reciprocal of specificity”. Sensitivity is the probability of individuating true positives, while the reciprocal of specificity is the probability of individuating false positives.

Figure 1 – The ROC curve



For each industry ROC analysis allows us to identify the “threshold firm”, namely the unit with the value of the composite indicator –the size-productivity combination – which discriminates between non exporting

firms (i.e. units with values of composite indicator lower than the threshold) and exporting firms (whose values of composite indicator are higher than the threshold). This combination is the industry “export threshold”. At the same time, the firm-level composite indicator will also provide a measure of the distance of each firm from the threshold.

The whole procedure to define the “export threshold” is composed by three stages.

In the first one, a logit model is estimated where the condition of exporter is the dependent variable:

$$\text{Prob}(\text{Export} = 1 | S, \pi, A, G, I) = \Lambda(\alpha_1 S + \alpha_2 \pi + \alpha_3 A + \alpha_4 G + \alpha_5 I) \quad [1]$$

where Λ is the cumulative distribution function of the logistic distribution, α_j are estimated parameters, S is the size of firms (proxied by the number of persons employed), π is the estimated individual Total Factor Productivity², A is the age (in terms of number of years of activity), G is a set of dummy variables indicating the location of firms³ and I is a set of dummy variables related to NACE 3 digit level of economic activity.

In the second phase, the estimated coefficients of productivity and size in the linear component of the logit model of equation [1] are used to obtain the composite indicator Z for each firm. In particular, estimated parameters for covariates are used as weights, while size and productivity are taken at individual level⁴. Dummy variables for location and industries are taken at firm level too, while age is included as industry-by-location average:

$$Z = \hat{\alpha}_1 S + \hat{\alpha}_2 \pi + \hat{\alpha}_3 \bar{A} + \hat{\alpha}_4 G + \hat{\alpha}_5 I \quad [2]$$

Finally, in the third stage, in order to carry out the ROC analysis and identify the size-productivity combination that discriminates between exporters and non exporters, the composite indicator is used as explicative variable in another logit model still having the condition of exporter as dependent variable. The “export threshold” is defined by using Youden’s (1950) J statistics.

In our case, the value of specificity is set equal to 0.5, thus giving the same weight to errors connected with the detection of false positives (i.e. identifying a firm as an exporter when it does not actually export) or false negatives (i.e. naming a firm as a non exporter when it actually exports). This choice is meant to preserve the “neutrality” of the procedure with respect to the outcome of the model. In fact, setting a value lower than 0.5 would reflect a more “conservative” orientation, as it makes positive classifications only in presence of a strong evidence. Conversely, setting a value higher than 0.5 would reflect a more “liberal” orientation, as it makes positive classification also in presence of a weaker evidence (Fawcett, 2005).

Once the threshold observation is selected, the relative value of the composite indicator represents the “export threshold” $Z_i = \hat{Z}$, that is the “minimal” size-productivity combination to access international markets.

This analysis provides a relevant set of information about the positioning of firms of an industry with respect to the access to international markets. Indeed, the value of composite indicator for each productive unit can be compared with the threshold value \hat{Z} , and it can be interpreted as the positive (or negative) gap

² See note 1 for details.

³ We refer to five geographical areas: North-West, North-East, Centre, South, Islands.

⁴ For the indicator Z other functional forms have been tested, including different combinations of our control variables. In all cases, the explicative power of the indicator (in terms of area under the ROC curve, precision and accuracy) worsens. Results are available on request.

of the firm with respect to the threshold depending on the firm’s own combination of size and productivity. At the same time, it is also possible to determine the amount of productivity and/or size a firm has to recover in order to reach the export threshold, thus opening the room to fine policy analysis.

Given the results of the ROC analysis at the third stage, there are four possible outcomes: 1) if the procedure classify a firm as an exporter and this latter is a real exporter, we have a true positive (TP) case; 2) if the firm is classified as a non-exporter but it actually exports, it is counted as a false positive (FP); 3) if the firm is non-exporter and it is classified as non-exporter, then it is counted as a true negative (TN); 4) if a non-exporter is erroneously classified as exporter, it is counted as false negative (FN).

In table 3 a set of performance metrics are reported. The “area under the ROC” is a measure of the overall performance of the composite indicator in classifying exporters, while the other metrics represent the ability of the estimated export threshold to correctly classify the units as exporters or non-exporters. In this context, the “precision” measures the share of true positives (i.e. real exporters) among all the firms the model classify as exporters:

$$Precision = \frac{TP}{TP+FP} \quad [3]$$

In turn, “accuracy” shows the share of the correct classifications (true positive and true negative) with respect to all sampled observations:

$$Accuracy = \frac{TP+TN}{Total\ observations} \quad [4]$$

Finally, the share of false positives and false negatives with respect to the whole set of observations are the “accuracy” 100’s complement.

Overall, all the metrics reported in Table 3 point out a great ability of the model to capture the actual presence of foreign activity for Italian firms.

Table 3 – Fitting tests of the ROC estimates

Industry	Area under ROC curve	Precision	Accuracy	False positives	False negatives	Share of total export for true positives
Food and beverage	0.88	85.0	82.3	14.6	3.2	98.8
Textile	0.81	88.7	76.9	9.8	13.3	97.5
Wearing apparel	0.72	77.0	67.2	20.1	12.7	97.9
Leather	0.67	86.2	69.3	11.1	19.7	94.6
Wood	0.74	82.0	77.2	16.9	5.8	96.7
Paper and print	0.80	88.3	77.7	10.3	12.0	99.2
Chemicals and pharmaceu	0.75	92.8	71.5	5.5	22.9	99.2
Rubber and plastic	0.79	93.1	70.7	5.2	24.1	98.0
Non metallic minerals	0.78	83.3	74.9	15.0	10.1	98.2
Metals	0.82	78.5	73.4	20.1	6.5	99.1
Electronics	0.74	83.1	67.2	13.7	19.1	98.3
Machinery	0.77	91.3	67.2	6.4	26.4	97.5
Automotive	0.75	86.9	71.1	10.7	18.1	99.0
Furniture	0.78	86.7	75.9	11.6	12.5	98.2

Source: Authors’ calculation on Istat data.

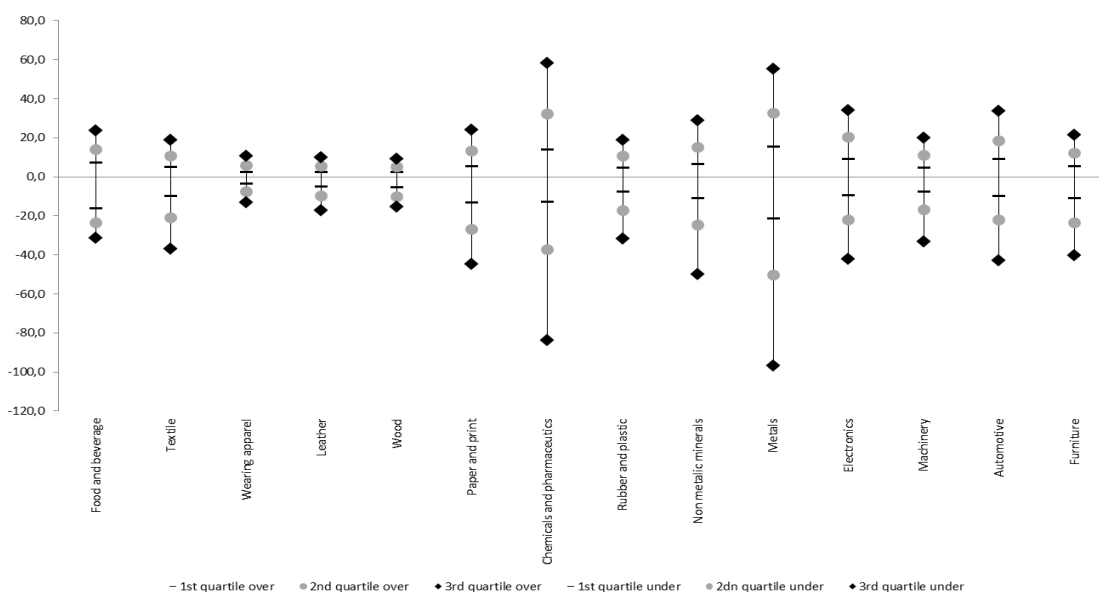
More specifically, the “area under the ROC curve” shows that our composite indicator has high ability to correctly classify firms with respect to their export status, ranging from 0.67 in Leather to 0.88 in Food and beverage. Moreover, the precision ranges from 77.0% in Wearing Apparel to 93.1% in Rubber and Plastic. Finally, the share of total export covered by the true positive classification ranges between 94.6% and 99.0%, meaning that real exporters that the model is not able to identify (i.e. false negatives) are truly marginal exporters.

3. Results: A “map” of the firms over and below the export threshold

The procedure illustrated in previous paragraph allows to obtain a “map” of the distribution of Italian manufacturing firms across the export threshold in each industry, thus providing some useful indications on the linkages between size, productivity and access to export both from a positive and normative point of view. As far as the positive analysis is concerned, for example, the possibility to pinpoint every single firm’s combination of size and productivity on the basis of its distance from the threshold helps clarify the “requirements” of the participation in international trade, (e.g. pointing out in what industries the capacity to successfully sell abroad implies a “jump” in productivity, in size, some form of compensation between size and productivity and so on). At the same time, this has also important consequences for a normative analysis, as it means that we are able to identify what aspect of Italian firms performance needs to be stimulated (again: size, productivity, a combination of these two factors) in order to foster the competitiveness of the Italian business system in international markets. What is more, our framework also offers a measure of the extent to which, for each industry, the incidence of exporting firms would be increased if the export threshold could be somehow reduced by some type of policy intervention.

On such bases, the “map” of the industries’ position across the thresholds is reported in Figure 2.

Figure 2. Firms distribution above and below the export threshold (quartiles of distance, in terms of differences between firm’s values of Z_i and \hat{Z})



Source: Authors’ calculation on Istat data.

Our estimates show that in 13 sectors out of 14 (with the exception of Food and beverages) the values of the composite indicator Z related to the “below-threshold” units are more dispersed than the ones for “above-threshold” firms. In other terms, the firms that crossed the export threshold tend to be more similar to each other, in terms of the combination of size and productivity, with respect to the “below-threshold” (i.e. non exporting) ones. This happens to a larger extent in industries where the international competition, for Italian firms, is particularly strong, such as Textiles, non metallic minerals and Furniture.

This picture of exporting and non-exporting firms also helps point out other significant heterogeneities between industries. On the one hand, comparing the distance between the quartiles of the Z indicator of firms above and below the thresholds makes it possible to evaluate the differences in the size-productivity profiles between exporting and non-exporting firms. In this vein, for example, in some relevant industries of the Italian specialization model – e.g. Wearing apparel and Leather – the firms laying below the export threshold appear quite similar to the exporting ones. On the contrary, in industries characterized by high entry barriers and intense inter-firm relationships (value chains) such as Chemical and pharmaceuticals and Metals (but also Food and beverage), the combinations of size and productivity of exporting firms are very different (with higher values of Z indicator) from the ones of units below the threshold. In such industries, moreover, also the distances between the exporting and non exporting firms that are closer to the thresholds (i.e. first quartiles of the two distributions) are larger, suggesting that the “threshold step”, in such cases, may be quite high.⁵

More in general, our classification of Italian firms above and below the export thresholds confirms the main empirical evidence on exporting and non-exporting firms. As reported in Table 2, on average exporting firms are larger and more productive than non-exporting ones, and account for a much higher share of value added. However, we also can see that among the below-threshold firms, in every industry the units farthest from the threshold (4th quartile) are characterized by very poor levels of TFP, incidentally revealing conditions of severe inefficiency for one quarter of Italian domestic firms. As far as the above-threshold units are concerned, it is worth noticing that the firms most distant from the threshold account by far for the lion’s share of total export (85% for whole manufacturing, with percentages ranging from 77% in Electronics to over 93% in Automotive, and Paper and print). Such a substantial gap between exporters laying in 4th quartile from the threshold and all other exporting firms also emerges with regard to firms’ size: in every industry the average size of 4th quartile above the threshold is a multiple of that of 3rd quartile (ranging from 2.6 in Leather to 4.4 in Machinery and 11 in Automotive).

⁵It has to be borne in mind that, at this stage of the analysis, the possible closeness of domestic firms to the threshold, in itself, does not imply that the access to international markets is within easy reach. In principle, actually, thresholds cannot be properly compared with each other, because they strictly depend on the size-productivity conditions prevailing in their own sectors. Moreover, a number of other factors, other than a firm’s size-productivity combination, might affect the capacity to venture into exporting: the level of the international demand for its goods, entry barriers, domestic relations of sub-contracting and so on. In other terms, also the business structural and demand characteristics are to be taken into account in order to adequately detect where a possible policy incentive to firm’s growth in terms of size and/or productivity would be more effective in increasing Italian extensive margin of export.

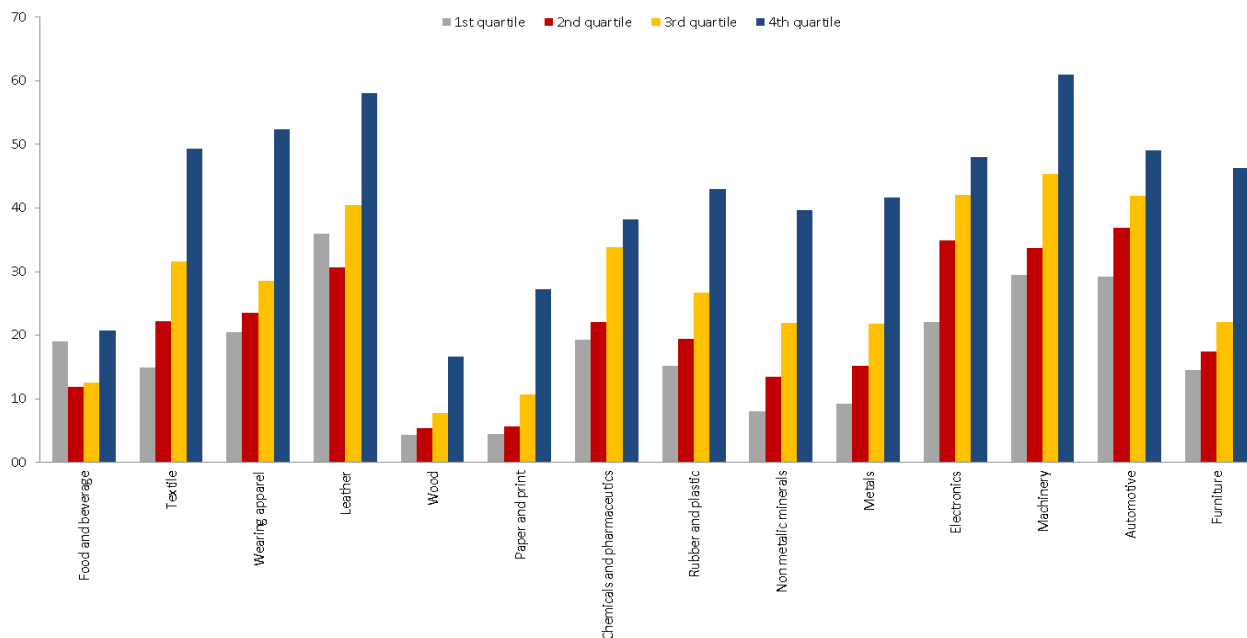
Table 2 – Characteristics of firms above and below the export threshold, by industry and distance from the thresholds (quartiles of the values of Z composite indicator) – 2014

Food and beverage					
Above threshold					
Quartiles	Persons employed (mean)	TFP (mean)	Share of value added (%)	Share of persons employed (%)	Share of export (%)
q1	8.1	0.4	4.6	6.0	3.8
q2	9.5	0.7	6.3	7.1	3.9
q3	15.9	1.1	12.9	11.8	9.9
q4	57.1	1.6	63.1	42.4	82.4
Total	22.6	1.0	87.0	67.3	100.0
Below threshold					
q1	8.1	0.5	7.5	14.3	-
q2	4.9	0.3	3.1	8.6	-
q3	3.3	0.1	1.6	5.8	-
q4	2.2	-0.4	0.7	4.0	-
Total	4.6	0.1	13.0	32.7	-
Leather					
Above threshold					
Quartiles	Persons employed (mean)	TFP (mean)	Share of value added (%)	Share of persons employed (%)	Share of export (%)
q1	14.9	0.5	5.6	8.4	3.8
q2	18.6	0.6	8.1	10.5	4.5
q3	22.2	0.8	12.1	12.6	10.1
q4	57.9	1.3	57.3	32.8	81.6
Total	28.4	0.8	83.0	64.4	100.0
Below threshold					
q1	11.0	0.3	8.8	14.8	-
q2	7.1	0.1	4.7	9.6	-
q3	4.7	-0.1	2.4	6.3	-
q4	3.7	-0.7	1.0	5.0	-
Total	6.6	-0.1	17.0	35.6	-
Chemicals and pharmaceuticals					
Above threshold					
Quartiles	Persons employed (mean)	TFP (mean)	Share of value added (%)	Share of persons employed (%)	Share of export (%)
q1	13.0	1.1	2.7	4.1	1.5
q2	21.9	1.2	5.3	6.9	3.7
q3	49.3	1.5	14.1	15.5	14.6
q4	213.3	1.7	75.0	67.1	80.1
Total	74.3	1.4	97.1	93.6	100.0
Below threshold					
q1	9.1	0.9	1.5	2.8	-
q2	6.4	0.7	0.8	1.9	-
q3	3.9	0.4	0.4	1.2	-
q4	2.1	-0.2	0.1	0.6	-
Total	5.4	0.4	2.9	6.4	-
Metals					
Above threshold					
Quartiles	Persons employed (mean)	TFP (mean)	Share of value added (%)	Share of persons employed (%)	Share of export (%)
q1	12.0	0.1	9.4	10.0	1.8
q2	12.5	0.1	10.2	10.4	3.5
q3	15.6	0.2	13.6	13.0	7.5
q4	52.9	0.4	52.0	44.0	87.3
Total	23.2	0.2	85.3	77.3	100.0
Below threshold					
q1	8.6	0.2	8.8	11.2	-
q2	4.7	0.0	3.7	6.2	-
q3	2.6	-0.2	1.6	3.4	-
q4	1.4	-0.5	0.6	1.8	-
Total	4.4	-0.1	14.7	22.7	-
Automotive					
Above threshold					
Quartiles	Persons employed (mean)	TFP (mean)	Share of value added (%)	Share of persons employed (%)	Share of export (%)
q1	18.0	0.3	2.6	2.9	0.9
q2	24.9	0.4	3.5	4.0	2.3
q3	45.8	0.5	8.6	7.3	4.5
q4	504.9	0.8	80.7	80.8	92.3
Total	148.3	0.5	95.4	95.0	100.0
Below threshold					
q1	10.5	0.1	1.7	1.9	-
q2	7.9	0.0	1.1	1.4	-
q3	6.2	-0.2	0.8	1.1	-
q4	3.6	-0.7	1.0	0.6	-
Total	7.1	-0.2	4.6	5.0	-
Textile					
Above threshold					
Quartiles	Persons employed (mean)	TFP (mean)	Share of value added (%)	Share of persons employed (%)	Share of export (%)
q1	12.1	0.4	6.1	7.5	2.1
q2	15.5	0.5	8.8	9.6	4.5
q3	20.1	0.7	12.7	12.4	11.0
q4	68.9	0.8	56.6	42.5	82.5
Total	29.2	0.6	84.2	72.0	100.0
Below threshold					
q1	8.6	0.2	8.6	11.8	-
q2	5.4	0.0	4.1	7.4	-
q3	3.7	-0.2	2.1	5.1	-
q4	2.7	-0.7	0.9	3.7	-
Total	5.1	-0.2	15.8	28.0	-
Wood					
Above threshold					
Quartiles	Persons employed (mean)	TFP (mean)	Share of value added (%)	Share of persons employed (%)	Share of export (%)
q1	5.8	0.4	5.9	7.1	1.8
q2	7.6	0.5	8.6	9.4	3.5
q3	10.9	0.7	14.0	13.4	9.0
q4	29.5	1.0	52.4	36.5	85.7
Total	13.4	0.6	81.0	66.4	100.0
Below threshold					
q1	3.9	0.2	9.4	13.1	-
q2	2.6	0.0	5.0	8.5	-
q3	1.9	-0.2	3.0	6.5	-
q4	1.7	-0.7	1.7	5.5	-
Total	2.5	-0.2	19.0	33.6	-
Rubber and plastic					
Above threshold					
Quartiles	Persons employed (mean)	TFP (mean)	Share of value added (%)	Share of persons employed (%)	Share of export (%)
q1	13.6	0.6	4.9	6.1	1.9
q2	18.9	0.7	7.8	8.4	4.2
q3	33.3	0.8	14.8	14.9	10.8
q4	123.5	1.0	63.2	55.1	83.0
Total	47.3	0.8	90.6	84.5	100.0
Below threshold					
q1	9.6	0.5	4.9	7.0	-
q2	5.9	0.3	2.7	4.3	-
q3	3.6	0.1	1.3	2.6	-
q4	2.0	-0.4	0.5	1.5	-
Total	5.3	0.1	9.4	15.5	-
Electronics					
Above threshold					
Quartiles	Persons employed (mean)	TFP (mean)	Share of value added (%)	Share of persons employed (%)	Share of export (%)
q1	13.5	0.3	5.4	6.2	2.2
q2	18.1	0.4	7.7	8.3	5.7
q3	29.9	0.5	13.7	13.7	15.1
q4	130.0	0.7	65.2	59.8	77.0
Total	47.9	0.5	92.0	88.1	100.0
Below threshold					
q1	9.9	0.2	4.0	5.2	-
q2	6.7	0.1	2.4	3.6	-
q3	4.1	0.0	1.2	2.2	-
q4	1.9	-0.4	0.4	1.0	-
Total	5.6	0.0	8.0	11.9	-
Furniture					
Above threshold					
Quartiles	Persons employed (mean)	TFP (mean)	Share of value added (%)	Share of persons employed (%)	Share of export (%)
q1	7.9	0.4	4.9	6.3	1.4
q2	10.9	0.5	7.4	8.8	2.7
q3	16.4	0.7	12.7	13.2	6.5
q4	63.6	0.9	63.6	50.9	89.3
Total	24.7	0.6	88.6	79.2	100.0
Below threshold					
q1	5.5	0.3	5.9	9.2	-
q2	3.3	0.1	3.1	5.6	-
q3	2.1	-0.1	1.6	3.5	-
q4	1.5	-0.6	0.7	2.5	-
Total	3.1	-0.1	11.4	20.8	-
Wearing apparel					
Above threshold					
Quartiles	Persons employed (mean)	TFP (mean)	Share of value added (%)	Share of persons employed (%)	Share of export (%)
q1	8.4	0.3	4.9	7.6	1.6
q2	11.2	0.4	7.3	10.1	2.9
q3	14.5	0.6	11.7	13.1	6.4
q4	50.6	0.9	66.2	45.8	89.0
Total	21.2	0.6	90.0	76.7	100.0
Below threshold					
q1	6.6	0.2	4.6	8.6	-
q2	5.0	0.0	2.9	6.4	-
q3	3.7	-0.2	1.7	4.8	-
q4	2.7	-0.8	0.7	3.5	-
Total	4.5	-0.2	10.0	23.3	-
Paper and print					
Above threshold					
Quartiles	Persons employed (mean)	TFP (mean)	Share of value added (%)	Share of persons employed (%)	Share of export (%)
q1	10.8	0.4	5.3	6.8	0.8
q2	13.8	0.5	7.4	8.7	1.6
q3	19.3	0.6	11.6	12.2	5.1
q4	76.0	0.8	63.2	47.9	92.5
Total	30.0	0.6	87.4	75.6	100.0
Below threshold					
q1	6.8	0.3	7.3	11.4	-
q2	3.8	0.1	3.1	6.3	-
q3	2.3	-0.2	1.5	3.9	-
q4	1.6	-0.7	0.7	2.7	-
Total	3.6	-0.1	12.6	24.4	-
Non metallic minerals					
Above threshold					
Quartiles	Persons employed (mean)	TFP (mean)	Share of value added (%)	Share of persons employed (%)	Share of export (%)
q1	9.4	0.5	4.8	6.8	1.6
q2	12.6	0.6	7.7	9.1	3.9
q3	16.5	0.7	11.9	11.9	9.0
q4	64.8	0.9	60.6	46.9	85.5
Total	25.8	0.7	85.0	74.6	100.0
Below threshold					
q1	6.1	0.3	5.7	8.2	-
q2	4.9	0.1	4.1	6.5	-
q3	4.8	0.0	3.6	6.4	-
q4	3.2	-0.4	1.7	4.3	-
Total	4.7	0.0	15.0	25.4	-
Machinery					
Above threshold					
Quartiles	Persons employed (mean)	TFP (mean)	Share of value added (%)	Share of persons employed (%)	Share of export (%)
q1	13.3	0.5	4.4	5.7	2.1
q2	18.2	0.6	6.7	7.8	3.7
q3	31.3	0.7	12.6	13.4	9.5
q4	139.0	0.9	67.9	59.6	84.8
Total	50.4	0.7	91.7	86.6	100.0
Below threshold					
q1	9.4	0.4	4.3	6.0	-
q2	6.2	0.3	2.4	3.9	-
q3	3.7	0.1	1.2	2.3	-
q4	1.8	-0.3	0.4	1.1	-
Total	5.3	0.1	8.3	13.4	-
Total					
Above threshold					
Quartiles	Persons employed (mean)	TFP (mean)	Share of value added (%)	Share of persons employed (%)	Share of export (%)
q1	10.9	0.4	5.4	6.8	2.0
q2	13.6	0.5	7.4	8.4	3.7
q3	20.4	0.6	12.8	12.7	9.3
q4	83.1	0.9	63.6	51.6	85.0
Total	32.0	0.6	89.2	79.5	100.0
Below threshold					
q1	7.8	0.3	5.8	9.0	-
q2	4.9	0.1	2.9	5.6	-
q3	3.2	-0.1	1.5	3.7	-
q4	2.1	-0.5	0.7	2.3	-
Total	4.5	0.0	10.8	20.5	-

Source: Authors' calculation on Istat data.

The analysis of the export propensity of “above-threshold” firms offers some further insights on this. As Figure 3 shows, accordingly with the stylized fact that Italian business system is characterized by a relatively low intensive margin (see Istat 2017), in almost all industries the export-to-turnover ratio barely reaches 30% for half of firms (2nd quartile); actually, in all industries the most open firms are those more distant from the threshold (4th quartile). Moreover, in 10 sectors out of 14, the largest increase in such “intensive margin” occurs only between the 3rd and 4th quartiles, independently from their distance from the threshold. This is particularly evident in some typical industries of the Italian specialization model (Textiles, Wearing, Leather, Machinery, Wood and Furniture). In other terms, apart from a limited set of export-oriented firms deeply involved in international trade, Italian enterprises generally depend to a very large extent on the domestic demand to survive.

Figure 3. Export propensity of firms above the threshold, by industry (average of export-to-turnover ratio by quartiles of distance from the threshold)

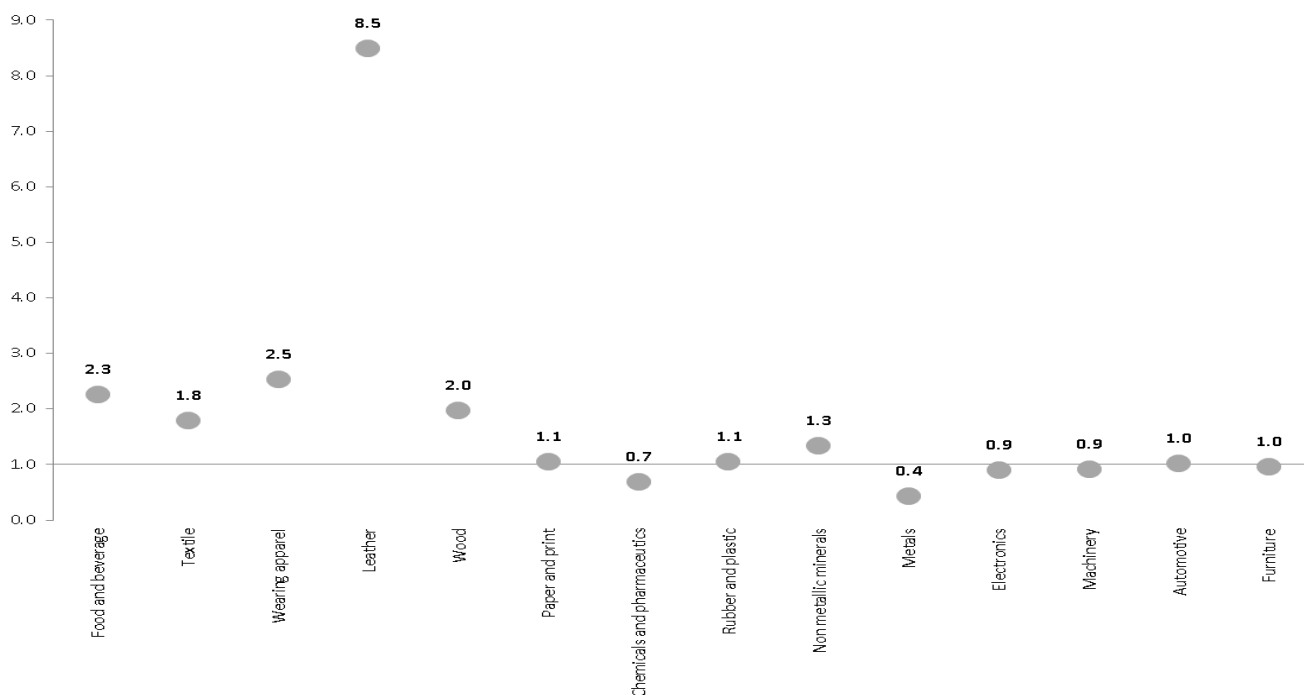


Source: Authors’ calculation on Istat data.

This approach also allows to evaluate the role of size and productivity as possible policy targets aimed at increasing the degree of internationalization of the Italian production system. In fact, a measure aimed at stimulating firms’ productivity or growth may have a very different effect from industry to industry. A measure of the relative importance of these two factors is given by the ratio between the respective estimated coefficients $\hat{\alpha}_1$ and $\hat{\alpha}_2$ in equation [1] and may be read as an “exchange value” between size and productivity in each industry. This is shown in Figure 4: in most sectors, to reach the export threshold an increase of productivity would turn out to be more effective than a dimensional growth. This is especially the case in the sectors more exposed to international competition where the profile of firms above and below the threshold is more homogeneous (Leather, Clothing, and Wood, see Figure 2). On the contrary, a size increase would be more effective in increasing the number of exporters in advanced technology or

capital intensive industries such as Chemistry and pharmaceuticals, Metallurgy and metal Products, Machinery and Electronics.

Figure 4. Relative Importance of productivity and size in determining the "export thresholds" by industries – 2014 (effect of productivity / effect of size)



Source: Authors' calculation on Istat data.

4. Conclusions

In this paper, we determine export thresholds for Italian manufacturing industries by applying for the first time in economics a technique widely used in other disciplines such as medicine and natural sciences: the ROC curve. Export threshold is here defined as the minimum combination of levels of size and productivity corresponding to the transition from the non-exporter to exporter status. We calculate export thresholds making use of a unique firm level dataset collecting information about the structural features of Italian firms, their economic results and export performance.

Basing on our model we classify firms as exporters or non exporters depending on whether their value of size-productivity combination lays above or below the export threshold, also giving a measure of their distance from the threshold itself. Fitting tests reveal a high ability of the model in capturing firms actually exporting (true positive cases) or not-exporting (true negative cases). Moreover, our "estimated exporters" account for almost 100% of the total value of export.

Applying this methodology, we are able to obtain a "map" of how Italian manufacturing firms are distributed across the export threshold in each industry, which may be helpful both from an analytical and normative point of view. The most clear and useful evidence to policymakers is that Italian industrial system is characterized (in 2014) by a relatively low intensive margin: the most remote firms from the threshold (4th quartile) are those with the highest propensity to export, covering much part of export value

for the manufacturing sector as a whole. In other words, it emerges a substantial gap between a quarter of exporters (firms with the highest combination of productivity and size) and the rest of Italian exporters. In particular, a large segment of Italian exporting firms is “marginal” in terms of share of value added and total export, even though they have productivity and size levels sufficient to export; it follows that the capacity of these firms to survive generally depends to a very large extent on the domestic demand.

As far as the Italian extensive margin is concerned (i.e. the share of exporters), the economic relevance (in terms of value added) of firms below the export threshold appears to be marginal. However, especially in the so-called “traditional industries” (Food and beverage, textiles, leather, wood), characterized by a higher labour intensity, non-exporting firms account for a significant share of overall employment (between 28% and 35%). Furthermore, among the “below-threshold” firms the ones closest to the threshold are those with the greatest economic relevance in terms of value added and employment. It follows that in some important industries of the Italian specialization model, a policy aimed at increasing the extensive margin could be focused on this group of firms with beneficial effect both on firms’ performance and total employment. Finally, for each sector our “map” allows to find out which factor (between productivity and size) would be more effective for a firm to overcome the export threshold, so providing some more insights to the debate on the “productivity-vs-size” recovery need for Italian business system to successfully face international competition.

Finally, besides these results, the methodology proposed in this paper can open the field to further developments. In particular, an in-depth study of how the structural peculiarities of each industry interact with the export thresholds could help better qualify the role of size and productivity from a policy-oriented point of view. Indeed, it would allow to assess the effectiveness of an increase in size or productivity as well as its “feasibility” given the conditions prevailing in the industry. This in turn paves the way to the “exogenous” dimensions of export thresholds.

In this vein, our empirical model could be augmented to take into account policy variables related to different kinds of trade costs highlighted by theoretical and empirical literature, both behind the border (such as transport costs, tariff and non-tariff regulatory measures, market access restrictions, trade finance availability) and crossing the border (such as documentation and customs compliance requirements, lengthy administrative procedures and other delays, transport infrastructure and logistics).

In other words, while in this paper we basically highlighted the role of main “endogenous” factors (i.e. factors directly depending on firm strategy and management, like productivity and size) related to the probability of being an exporter, we are currently extending this approach to consider also “exogenous” barriers to trade that could be somehow reduced by some type of policy intervention. In this case, it would be possible to calculate how much a reduction in these trade barriers would increase the number of “new” exporting firms by lowering the export threshold.

In addition, several other topics regarding export thresholds can be explored. Some of the questions that can be addressed are the following: how and to what extent do the thresholds move over time? How and in what direction does the business cycle impact on the thresholds? What is the impact of the recession of 2011-2014 on export capacity and thresholds? How, and to what extent, geographic diversification of exports affects the threshold values?

This approach seems to open interesting prospects for policy makers: there is still a lot of work to be done, but it is worth exploring these possibilities.

References

- Accetturo A., A. Bassanetti, M. Bugamelli, I. Faiella, P. Finaldi Russo, D. Franco, S. Giacomelli and M. Omiccioli (2013), "Il sistema industriale italiano tra globalizzazione e crisi", *Questioni di Economia e Finanza*, Banca d'Italia.
- Bernard A.B., S.J. Redding and P.K. Schott (2011), "Multi-product firms and trade liberalization", *Quarterly Journal of Economics*, 126(3), pp. 1271-1318.
- Bernard A.B. and J.B. Jensen (1995), *Exporters, Jobs and Wages in U.S. Manufacturing: 1976-1987. Brookings Papers on Economic Activity, Microeconomics* 1, 67-119. doi: 10.2307/2534772
- Chaney T. (2008), *Distorted Gravity: The Intensive and Extensive Margins of International Trade*, *American Economic Review*, 98, 1707-1721. doi: 10.1257/aer.98.4.1707
- Di Mauro F. and M. Ronchi (2015), "Assessing European competitiveness: the contribution of CompNet research", *CompNet Report*, European Central Bank, June.
- Fawcett T. (2005), "An introduction to ROC analysis". *Pattern Recognition Letters*, 27, pp. 861-874.
- ISTAT (2017), *Rapporto sulla Competitività dei settori produttivi*, March.
- Krugman P. (1979), *Increasing Returns, Monopolistic Competition and International Trade*, *Journal of International Economics*, (9), pp. 469-79.
- Kumar R. and A. Indrayan (2011), *Receiver operating characteristic (ROC) curve for medical researchers*. *Indian Pediatrics*, April; 48(4), pp. 277-87.
- Leung D., C. Meh and Y. Terajima (2008), "Productivity in Canada: Does Firm Size Matter?", *Bank of Canada Review*, Autumn, pp. 7-16.
- Luzi, O. and R. Monducci (2016). "The new statistical register 'Frame SBS': overview and perspectives". *Rivista di statistica ufficiale*. 1/2016. pp. 5-14.
- Melitz M.J. (2003), *The impact of trade on intraindustry reallocations and aggregate industry productivity*, *Econometrica*, 71, pp. 1695-1725.
- Majnik M. and Z. Bosnić (2013), "ROC analysis of classifiers in machine learning: A survey .Intelligent Data Analysis", vol. 17 (3) pp. 531-558.
- Melitz M.J. and G.I.P. Ottaviano (2008), "Market Size, Trade and Productivity", *Review of Economic Studies*, 75, pp. 295-316.
- Pisu M. (2008), "Export destination and learning by exporting: Evidence from Belgium", *WP Research n.140*, National Bank of Belgium.
- Redding S. (2010), "Theories of Heterogeneous Firms and Trade", *NBER Working paper 16562*, December.
- Singh T. (2010), "Does International Trade Cause Economic Growth? A Survey". *The World Economy* 33 (11), pp. 1517-1564.
- Syverson C. (2011), "What Determines Productivity?", *Journal of Economic Literature*, 49(2), pp. 326-365.
- Tybout J. (2000), "Manufacturing Firms in Developing Countries: How Well Do They Do and Why?" *Journal of Economic Literature*, vol. 38, pp. 11-44.
- Wagner J. (2007), "Exports and Productivity: A Survey of the Evidence from Firm level Data", *World Economy*, vol. 30(1), pp. 60-82.
- Wagner J. (2011), "International trade and Firm Performance: A Survey of Empirical Studies since 2006", *Iza Discussion Paper n.5916*, August.
- Warnock D.G. and C. Peck (2010), "A roadmap for biomarker qualification", *Nature Biotechnology*, vol. 28, pp. 444-445.

Wooldridge J.M. (2009), *Introductory Econometrics: A Modern Approach*, New York, South-Western Cengage Learning

Youden, W.J. (1950). "Index for rating diagnostic tests". *Cancer*. 3: 32–35.