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Do innovative activities matter to small firms in non-R&D-intensive industries? An application to export performances

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Abstract

The paper deals with the role of innovative activities in small, non-R&D-performing firms which belong mainly to 'supplier dominated' industries and, to a lesser extent, to 'specialised suppliers'. After describing the type and extent of non-R&D innovation inputs for a sample of Italian manufacturing firms, their export behaviour and performance are analysed by means of Tobit, Probit and truncate regressions. The results show that the probability of being an exporter is affected positively (as far as an upper threshold) by the size of a firm and negatively by its nature as a sub-contractor; conversely, innovative activities and especially the amount of expenditure on design, engineering and pre-production developments exert a significant and positive impact on the share of exports on sales.

Key words

Innovative activities; non-R&D intensive industries; small firms; export performance.

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1. Introduction

As early as the 1970s the innovation-related literature was stressing that R&D - viewed as 'creative work undertaken on a systematic basis to increase the stock of scientific and technological knowledge and to use this knowledge in new applications' (Stead, 1976, 3) - accounted only for a fraction of total innovation costs. In the article just quoted, Stead pointed out that, along with R&D, at least six other activities were needed to complete an innovation project: new product marketing, patent work, financial and organisational changes, final product and design engineering, tooling and industrial engineering, manufacturing start-up. Moreover, comparing among the results of three studies carried out in the U.S. and Canada, Stead showed that, although R&D costs were relatively more important than had been previously thought, the share of total innovation costs due to R&D ranged from 5 to less than 40 per cent.[1]

Subsequently, similar lines of argument - i.e. that R&D is a crucial input to the innovation process but it is inadvisable to rely exclusively on this indicator - can be found in Pavitt (1982) and other authors who have stressed that innovative activities such as design work and engineering development are frequently neglected, and that R&D statistics can be misleading in the case of smaller firms, which often do not have formal R&D units.

Consider a firm that carries out some of the activities typical of the development phase in order to make a new product. These activities are not necessarily performed 'on a systematic basis', and they do not require the firm to carry out basic or applied research, given that it can buy or even

[1]The figures reported by Stead in his article have been lowered because the R&D item also included either product and design engineering or the construction and testing of prototypes and

'steal' the new item of technological knowledge necessary for making the new product[2] from outside. It is then reasonable to assume that this firm will not have a formal R&D department or laboratory, that it will be of small size, and that its innovative activity will not be considered as R&D in official statistics. Some empirical evidence supports these assumptions; as Kleinknecht (1987), Santarelli and Sterlacchini (1990) and Kleinknecht and Reijnen (1991) have shown, small-scale, informal or non-systematic R&D activities have been substantial both in the Netherlands and Italy but official R&D surveys have failed to capture them.

However, the central issue addressed in this paper is that besides R&D, both formal and informal, there are other innovation inputs (peculiar to each of the different phases described by Stead) which cannot be neglected by the economic analysis of technological change. In this connection, I will focus, along with R&D, on the role of innovative capital goods and the activities of design, engineering and pre-production developments: the latter activities, in particular, are needed for the further modifications of a product after completion of the R&D phase, but, as said, they can be performed also by firms that do not carry out any R&D at all. I shall show that the intensity of these non-R&D activities is particularly high in small firms, especially those belonging to 'supplier dominated' industries (Pavitt, 1984). Consequently, taking account of these non-R&D costs not only yields more comprehensive innovation indicators, but it seems necessary in order to establish strong and systematic relationships between innovation inputs and economic performances (such as productivity growth, profitability and export shares)

pilot-plants.
[2]One may argue that this new product can hardly be 'new for the whole market'; in any event, it can be new for the market relevant to the firm and thus can affect significantly its economic

that hold for different firms (large and small) and industries (more or less R&D intensive).

Thus, it is no coincidence that I shall focus on the Italian case, given that Italy is a country characterised by a strong presence of small firms and non-R&D intensive industries. With respect to these, a large body of empirical evidence has shown that R&D efforts in Italy (either in terms of expenditures or employees) do not exert a significant impact on profit levels or on rates of productivity growth (both labour productivity and TFP). Somewhat better results have been obtained by linking innovative efforts to firms' export performances, but this has occurred only when, besides R&D, other innovation inputs have been considered. Notwithstanding the limited scope of this paper, I believe that this unsatisfactory performance of R&D indicators for the type of industries mentioned above is not confined to Italy.

The paper is organised as follows. Section 2 analyses, for the Italian case, the findings of the Community Innovation Survey (CIS), which was a first attempt to collect, among other information, data on a comprehensive set of innovation inputs. It is shown, in particular, that the non-R&D costs of innovation prevail across Italian manufacturing industries with the exception of the 'science based' ones. Some implications of this phenomenon are discussed. Section 3 describes the features of a field research carried out in Italy and which examined the innovative activities of a sample of 143 manufacturing firms of small size, most of which belonged to 'supplier dominated' industries. The questionnaire administered to these firms was similar to that employed for the CIS; however, by evaluating the role of capital goods as innovation inputs, instead of using exclusively investment

performances.

data, an attempt was made to assess the innovative content of the firms' capital stock. Section 4 presents the main results of the field research. After describing the relationships among innovation inputs and firm characteristics, their impact on export behaviour and performance is analysed by means of Probit, Tobit and truncate regressions. The results show that the probability of being an exporter depends positively (although below an upper threshold) on the size of a firm and negatively on its nature as a sub-contractor; the share of exports on sales is instead positively affected by innovative activities, and especially by the intensity of expenditure on design, engineering and trial production.

2. The CIS in Italy

As mentioned in the introduction, the CIS[3] was the first attempt to provide statistical information about non-R&D costs on innovations (together with the R&D ones) and different innovation outputs; the latter were obtained by measuring the impact of innovative activities in terms of shares of total sales ascribed (by the firms) to improved or new products. An analysis of the main findings of the survey carried out in Italy (cf. Istat, 1995) can be found in Evangelista et al. (1997). Cesaratto and Stirati (1996) have made a first attempt to evaluate the impact of innovation inputs on economic performances (employment and value added per employee) using micro-data, while Mattioli and Sterlacchini (1998) and Sterlacchini (1998) have analysed the relationships among innovation inputs and outputs across manufacturing

[3]For a review of the main features of the CIS, see European Commission (1994) and Archibugi et al. (1994).

industries[4].

Comprehensive sectoral analyses of the CIS in Italy are then developed in the works just cited. Here, it will suffice to show the role of different innovation input indicators for some Italian manufacturing industries representative of the four categories of Pavitt's taxonomy. Table 1 shows that, if total manufacturing is considered, the costs of acquiring innovative capital goods take the lion's share of the total innovation costs of Italian innovating firms,[5] followed by expenditures on R&D and, at a distance, by those on design, engineering and pre-production developments. Across industries, it emerges that innovative capital goods play a dominant role in the 'scale intensive' and 'supplier dominated' industries (with the exception of clothing, which is the only one with a sizeable share of expenditures on marketing activities), while R&D accounts for more than 60% of total innovation costs only in 'science based' industries.

Table 1 around here

Comparison of R&D shares with those due to design, engineering and pre-production developments reveals that the latter are (relatively) higher in 'supplier dominated' and 'specialised supplier' industries. However, there is an important difference between the two groups of industries: in the former, design, engineering and trial production are the largest internal source of

[4]Some results from the CIS in the Netherlands have been analysed by Brower and Kleinknecht (1996 and 1997).

[5]Those (7,426) which declared that they had introduced at least one innovation during the period 1990-92. The number of firms that completed the questionnaire - which was mailed to all the Italian manufacturing enterprises with more than 19 employees - was 22,356 (cf. Istat, 1995).

innovation[6] while among the 'specialised suppliers' there is a marked prevalence of R&D.

Turning to the features of Italian innovating firms, Table 2 shows that those belonging to 'supplier dominated' and 'specialised supplier' industries are, on average, smaller than the others; moreover, in the same industries, the share of innovating firms which perform R&D is lower, particularly in the 'supplier dominated' industries, where more than 50% of innovating firms rely exclusively on other innovation inputs. In general, one notes that within each group of industries the average size of innovating firms which do not carry out R&D is much smaller than that of R&D performing firms. However, a significant presence of small non-R&D performing firms is a distinctive feature of the industries mentioned above (especially the 'supplier dominated' ones), since in 'scale intensive' and 'science based' industries the percentages of innovating firms that carry out R&D are very high (respectively, 82 and 90%).

Table 2 around here

In conclusion, one may say that, given the industrial specialisation of Italian manufacturing, the share of small firms which introduce innovations without undertaking R&D is remarkable (more than 36% in total manufacturing). The presence of these small firms is particularly strong in 'supplier dominated' industries, but it is also substantial in the 'specialised supplier' ones. It should be stressed that, during the 1980s and the early 1990s, the performances of these 'low-tech' industries in terms of labour

[6]The acquisition of innovative capital goods, patents and licences can be considered sources of

productivity growth (Oecd, 1996) and export shares (Ice, 1996) were better than those of other Italian manufacturing industries.

As a consequence, the central question addressed in the next sections is this: are the economic performances of small non-R&D performing firms significantly affected by their efforts in terms of innovative activities other than R&D? With respect to economic performances I will focus on firms' export behaviour, while the indicators of innovative activities will be similar to those considered in the CIS. However, in answering the above question, I did not use the data collected by the Italian survey because it considered only firms with more than 19 employees, and thus neglected the large majority of small enterprises: in effect, according to the Italian Census of Production, more than 90% of total manufacturing firms recorded fewer than 20 employees in 1991. Thus, in order to take the whole range of small firms (included the smallest ones) into account, the following analysis is based on the results of a specific field study, whose features are described in the next section.

3. Characteristics and methodology of the field study

The field study was carried out as part of a research project, funded by the Marche Region of Italy[7], on the technological opportunities and organisational constraints of the firms located in the regional area classified as Objective 2: this term denotes the areas of the European Regions affected by industrial decline (in terms of employees) and to which specific European

innovation external to the firm, while all the remaining innovative activities are internal sources.
[7]The research project - assigned to the Department of Economics of Ancona University on the basis of a call for tenders - was funded as an 'action of technical assistance' in the Single

Structural Funds are devoted. A random sample of 150 firms was built according to the main features (industry, firm size and location) of the population of manufacturing enterprises located in the Objective 2 area[8]. The study was then based on a questionnaire administered to the firms at the end of 1997 by means of direct interviews; satisfactory responses were obtained for 143 firms.

3.1. Characteristics of the sample

Table 3 distinguishes the 143 firms interviewed by industry and size. Six industries were selected according to the industrial specialisation of the Objective 2 area of the Marche Region and their shares in terms of number of firms are consistent with those of the population. This does not apply to the size classes because, in order to attain a sufficient number of observations for each class, firms with more than 49 employees are over-represented. Nevertheless, 63% of the firms in the sample have fewer than 20 employees and only one has more than 200 employees; this situation is typical not only of the Objective 2 area but also of the entire Marche Region as well as the Regions of the North-East and Centre of Italy (such as Veneto, Emilia-Romagna, Umbria and Tuscany).

Programme Document - Objective 2 1994-96 of the Marche Region.

[8]The INPS (Institute of Social Security) data base recorded 1,271 manufacturing firms active at the beginning of 1995 in the Objective 2 area of the Marche Region. A close inspection of the data base revealed that about 300 of them could not be considered manufacturing enterprises in a strict sense (such as, for instance, shops selling home-made pasta or bread, or those selling furniture which they did not produce). As a consequence, the sample represents more than 15% of the total population of firms and 40% of those belonging to the industries that were selected (cf. the next sub-section).

Table 3 around here

Since the 1970s, this high proportion of small manufacturing firms in the above Regions has become a permanent feature of the industrialisation process. Each Region (or even Province) is specialised in different industries but the structure of industrial (local) systems is very similar, being based on the agglomeration, in particular areas, of a high number of small manufacturing firms working along the same production 'filière', in a network characterised by increasing specialisation (of single productive units) and division of labour (among units). The situation is therefore that of the 'industrial districts' thoroughly analysed by Brusco (1982) and Pyke et al. (1990). For the purposes of this study is sufficient to stress that this strong presence of small firms is associated with the phenomenon of industrial division of labour described in a seminal article by Allyn Young (1928): in effect, many firms are specialised in particular phases of the production process and work as sub-contractors for other firms which, often, operate in the downstream stages of the 'filière'. Given the level of productivity that highly specialised firms can achieve, productive decentralisation is a permanent strategy of the 'leading' firms rather than being limited to periods of increasing demand.

The leading or 'independent firms' produce their goods for final users (either consumers or firms) while the sub-contractors are the firms to which other enterprises, belonging to the same industry, decentralise one or more production phases: for example, an enterprise making wash filters for a dish washer producer is an independent firm, while a firm sewing vamps for a shoe producer is a sub-contractor. As we shall see in the next sections, this distinction has important implications also for the analysis of the innovative activity of small firms. Considering our sample, 104 out of the 143 firms (73%) were classified as sub-contractors, since more than 60% of their 1996 sales[9] derived from the productive decentralisation of other firms; following the same criterion, the remaining 39 units were independent firms.

With respect to the selected industries, some specifications are needed. The knitwear industry is treated separately from clothing because it is characterised by a quite different production process and type of machinery employed. The predominant activity in the former industry is weaving (followed - but not always - by cutting), while predominant in the latter are the cutting and sewing of fabrics. The wood & furniture industry does not include the firms which restrict their activities to the assembling of furniture's components; thus, all the firms are more or less involved in wood working. In the footwear industry, too, firms that only assemble shoe parts are omitted[10]; most of the firms of this industry cut and (especially) sew vamps, while a minority of them produce soles[11].

From a technological point of view, all the above mentioned industries can be classified as 'supplier dominated'. For the remaining industries, that of dies can be included in the group of 'specialised suppliers', while it is more difficult to classify the plastic products industry. This is usually included in the 'scale intensive' group, but considering the small size of the firms (see again Table 3) and that most of them do not produce consumer goods but

[9]Since some firms work only partly as sub-contractors or independent units, the threshold of 60% of total sales was chosen to insert them into one of the two groups.
[10]The reason for neglecting the firms that only assemble furniture or shoes is that process innovations are usually more important in the production of their parts.
[11]Considering the (very) different production processes of the two types of firms, the footwear industry is less homogenous than the other five considered in this study. For this reason, the findings on this industry should be treated with caution.

plastic components for other industries (especially those of motor vehicles and domestic appliances), the features of this industry seem more consistent with those of 'specialised suppliers'. Leaving aside classification problems, it is interesting to note that the industries of dies and plastic products complement each other, simply because making ash-trays for cars (or wash filters for dish washers) a specific die is needed. As a consequence, the two industries can be seen as complementary suppliers of plastic components that can be used by a wide range of industries.

3.2. Methodology of the innovation survey

The questionnaire administered to the firms aimed primarily at collecting information on their innovative activities. With respect to economic performances, we were able to obtain comprehensive data only on the firms' export intensities (the shares of exports on sales). In fact, since sales per employee cannot be considered an appropriate measure of productivity, and given the difficulty of obtaining balance sheet data on value added, capital stock and profits,[12] we had to abandon the idea of working with productivity and profitability variables. Obviously, we also collected information on the main characteristics of the firms (which will be described in the next section) that might affect both their innovative activities and export performances.

As far as technological variables are concerned, we initially followed the CIS methodology. The firms that declared that they had introduced at least one innovation during the period 1994-96[13] were asked to break down total

[12]Especially from the firms owned by individuals which, according to Italian law, are not compelled to publish them.
[13]This was the case of 90 out of the 143 firms (63%). The percentages of innovating firms across

innovation costs sustained over the same period into different items (from R&D to the acquisition of innovative capital goods).

The first two columns of Table 4 show, for our sample, the average intensities of innovation inputs by industry; they are computed as shares of innovation costs on the sales cumulated over the period 1994-96. The figures are consistent with the conclusions drawn in Section 2: small firms belonging to 'supplier dominated' industries rely above all on innovative machinery rather than R&D. In fact, R&D expenditures, those on marketing activities and the costs of acquiring patents and licences are not reported in the table because, accounting for 0.03% of total sales, they are negligible. The only major innovation costs are those relative to the acquisition of innovative capital goods (INVSAL), followed at a distance by design, engineering and pre-production development (DEPRSAL). In the entire sample, about 6% and less than 1% of total sales are devoted, respectively, to these innovation inputs. The acquisition of innovative capital goods appears more intense in the knitwear and plastic products industries, while design, engineering and trial production are more substantial in the dies and wood & furniture industries. It should be stressed that the unsatisfactory performance of the clothing industry, both in terms of INVSAL and DEPRSAL, is partly explained by its low share of innovating firms (cf. the previous footnote).

Table 4 around here

As said, the innovation input indicators discussed above are identical to those introduced by the CIS. A shortcoming of this survey - as well as of previous ones on innovation - is that innovative capital goods are measured

industries are the following (in descending order): dies (100%), plastic products (87%), wood &

solely in terms of investment flows during a given period (one year in the CIS, three years in our survey). In my opinion, if the intention is to measure the inputs required to introduce process innovations, it is necessary also to evaluate the technological level of a firm's capital stock. This is particularly the case when the pace of technological change is discontinuous, and then characterised by periods of relative technological stability in which only small improvements are made to production processes; during these periods, it is not necessary for a firm substantially to replace its capital stock through the intense acquisition of new machinery. If this is the case, a firm that invests more than the others in the current period may still have a less advanced capital stock simply because other firms have invested a lot in the past.

In effect, if one looks at the significant process innovations affecting the industries in our sample (such as CAD-CAM for cutting fabrics, programmable spinning machines in knitwear, CAD-CAM and NC in the wood and dies industries) most of them were already available more than 10 years ago[14]. Obviously, it is true that the last generation CAD-CAM, as compared to the previous version, contains some improvements, but these do not amount to a significant process innovation and do not provide late adopters with substantial advantages.

Since a distinction between technologically advanced and backward firms based exclusively on investment data could generate misleading results, in the field study an attempt was made to assess the innovative content of the firms' capital stock as well. For this purpose, we first established – with the help of industry experts (production managers of leading firms not involved

furniture (80%), footwear (69%), knitwear (64%), clothing (43%).

[14]In a study of a sample of supplier dominated firms located in the Marche Region, Santarelli and Sterlacchini (1994) found that the leading firms in the regional industries of clothing and

in our survey) – the main phases into which the typical production processes of the six selected industries could be broken down. Secondly, for each phase, we found a sort of 'technological frontier' (or 'best practice' technology) by identifying the machinery, equipment and logistic devices that were currently available and could guarantee - to the experts' knowledge - the maximum level of automation.

Subsequently, the firms were asked to specify the machinery or equipment used in each of their production phases. This enabled us to assign a score to each firm; the maximum score was obtained by the firms that were on the 'technological frontier' (specific of each industry) for all the production phases in which they were involved; lower scores were ascribed to the firms that used less advanced process technologies in one or more phases.

Finally, in order to compare the technological content of the firms' capital stock, a synthetic indicator was obtained by dividing the (average) score of each firm by the maximum (average) score that could be attained. This indicator is called AUTOM (since it is a proxy for the level of automation of the production process): it is equal to 100 if the firm lies on the 'technological frontier' and decreases to a minimum of 50 the further the firm lies from the frontier. The construction of the AUTOM variable is described in detail in the appendix, with an example for the clothing industry.

The main shortcoming of this procedure is that it involves a certain degree of subjective judgement (if the score for a CAD-CAM is 4, should a group of NC take 3 or 2.5? And a group of electro-mechanical machines 2 or 1.5?). However, as long as the adopted criteria are consistently applied across the different industries, this limitation should not bias the results for a cross-

wood & furniture had adopted these process innovations during the second half of the 1980s.

section of firms.

The last column of Table 4 reports the means of AUTOM for the six industries in the sample. On average, the firms using the best available process technologies are concentrated in the dies and plastic products industries, while the worst performance is recorded by clothing firms. Interestingly, the knitwear industry, which was characterised by the highest share of innovation costs due to the acquisition of innovative capital goods, attains an average value of AUTOM much lower than that recorded by the plastics and dies industries. This provides preliminary support for the argument set out above: in a given period, the firms that invest more than the others in innovative machinery are not necessarily the best in terms of the innovative content of their capital stock.

4. Innovative activities, firms' characteristics and export performances

The innovation inputs described in the previous section can be related to firms' characteristics by taking five variables into account:

1. firm's size (SALES) measured by the amount of sales in 1992; sales were preferred to employees since they guarantee a high variability among firms. In particular, if sub-contractors are compared with independent firms, average firm size does not appear significantly different when the number of employees is considered, but there is a marked difference between the two types of firm in terms of sales (and, thus, sales per employee)[15];

[15] In 1996, both independent firms and sub-contractors record an average size of 24.8 employees. As regards firms' sales, instead, the former group has an average size of 7.2 billion Italian liras and the latter 1.8 billion. These differences depend, among other things, on the fact

2. the affiliation of a firm with an industrial or business group (GROUP), which is identified by means of a dummy variable;
3. the share of exports on sales in 1992 (EXPORT); this variable measures, in a broad sense, the presence of the firm in foreign markets; in the subsequent regression analysis, EXPORT, viewed as an indicator of economic performance, will be used as a dependent variable;
4. the share of sales in 1992 due to the productive decentralisation of other firms (SUBCON); as has been assumed, a value of SUBCON greater than 60% indicates that the firm can be classified as a sub-contractor;
5. the share of sales in 1992 ascribed to customised products (CUSTOM); this variable measures the degree of product differentiation, which is maximum in the presence of products designed to fulfil the specific needs of each client.

Table 5 around here

Table 5 shows, for the 143 firms in the sample, the correlation matrix between innovation inputs and the above mentioned firm characteristics. The innovative content of capital stock (AUTOM) is particularly associated with the firm size (SALES) and, to a lesser extent, with the share of expenditures on design, engineering and pre-production developments (DEPRSAL), the share of exports (EXPORT), and the share of innovation costs due to

that independent firms often decentralise a substantial portion of their production activities to sub-contractors so that their turnover is much greater than their value added. This phenomenon supports the decision not to use sales per employee as a measure of productivity. If one does so, the differences in terms of productivity levels will be explained substantially by the nature of the firm, that is, whether the firm is a sub-contractor or not.

innovative capital goods (INVSAL).

It should be stressed that the correlation between AUTOM and INVSAL is not particularly high, and that the latter variable is only correlated with innovation inputs, while both AUTOM and DEPRSAL are also associated with some firm characteristics; DEPRSAL, in effect, is significantly correlated with EXPORT and decreases as long as the share of sales due to sub-contracting (SUBCON) rises. These results provide a further justification for the distinction between the innovative content of investment and that of capital stock.

In general, it emerges that the firms which work mainly as sub-contractors are smaller, export less than the others, spend less on internal innovative activities and realise lower shares of customised products (CUSTOM). However, one notes with interest that SUBCON is not significantly correlated with AUTOM and INVSAL; this means that being a sub-contractor does not imply, *per se*, being a backward firm either in terms of capital stock or investment activity. Instead, the bigger firms are not sub-contractors, show a higher propensity to be affiliated with an industrial group, export more, and own a 'better' capital stock than their smaller counterparts. Finally, CUSTOM is positively correlated, although with a low significance level, only with expenditures on design, engineering and trial production; in fact, the average level of CUSTOM is particularly high - as was expected - in the dies industry, which also recorded the highest value of DEPRSAL (cf. Table 4).

To summarise, table 5 suggests that the patterns of innovative activity can be different also within a sample of small firms mainly belonging to 'supplier dominated' industries. In particular, the size of firms in terms of sales and their nature as sub-contractors significantly affect both the extent and the type of innovative activities and their export performances.

The next step was to consider the share of exports on sales as an indicator of economic performance, and to identify its main determinants by means of a regression analysis. The dependent variable ranges from 0 (when a firm does not export at all) to 100, and in our sample 113 out of the 143 firms were non exporters. In this case, OLS estimates are not appropriate since they can predict values of the dependent variable outside its possible range. As a consequence, recent empirical studies concerned with export performance at firm level used censored Tobit estimates (see Kumar and Siddharthan, 1994; Wagner, 1995; Lefebvre et al., 1998). Alternatively (following Wakelin, 1997), the single censored Tobit model (which considers both the probability of being an exporter and the level of export) can be tested against a two-stage model in which the probability of being an exporter is treated separately from the choice of how much to export: the first stage is based on a Probit model which takes account of all the sample observations, while in the second stage a truncate model is applied by considering only the values of the dependent variable greater than zero (that is, only the exporting firms). By using a χ^2 likelihood ratio test it is possible to identify the best model specification;[16] obviously, the choice of the two-stage model rather than a single censored Tobit implies that the explanatory variables affecting the probability of being an exporter are significantly different from those influencing the share of exports on sales.

[16] This procedure for censored data was introduced by Cragg (1971) and Lin and Schmidt (1984). The likelihood ratio test is computed as $\lambda = 2(\ln L\text{probit} + \ln L\text{truncation} - \ln L\text{tobit})$ where lnL stands for log-likelihood. If λ is greater than the critical value of the χ^2 distribution for the relevant degrees of freedom, the unrestricted model specification based on the combination of Probit and truncate regressions is more suitable than the restricted Tobit model.

The variables used as determinants of export behaviour (decision or probability to export) and performance (share of exports) were those already described when commenting on Table 5. However, also a dummy variable for innovating firms (INNOVA, which is equal to 1 if the firm introduced at least one innovation during the period 1994-96 and zero otherwise) was employed and, to consider fixed effects, industry dummies were included in all the regressions. With respect to firm size, along with the variable SALES,[17] also its quadratic term was inserted, in order to allow for the presence of a non-linear relationship with export performance. Finally, the variable CUSTOM (share of sales due to customised products) was not included in the regressions because, as said, it showed a high correlation coefficient with the dummy for the dies industry.

Most of the explanatory variables employed in this study are similar to those used in the recent empirical literature focussing on the relationship between innovative activities and export performance. However, the innovation variable used by Kumar and Siddharthan (1994) was the ratio of R&D expenditures to firm sales, while, along with R&D intensity, Lefebvre et al. (1998) employed other R&D related variables; Wakelin (1997) instead used the number of significant innovations (introduced and used) taken from the SPRU data base. These studies have shown that innovative activities exert, in general, a significant and positive impact on a firm's export performance after controlling for the size of firms. In this connection, a quite general result is that export performance rises with firm size until an upper threshold and then decreases (cf. Bonaccorsi, 1992; Wagner, 1995). Economies of scale (i.e. the advantages of working at a minimum efficient

[17] In all the regressions carried out, firm's size measured by the number of employees was never

size) and the amount of fixed costs needed to attain a given sales force are the main factors explaining the positive impact of firm's size on export behaviour. At the same time, however, the presence of an 'inverted U' relationship suggests that the export performance of small and, above all, medium sized firms can be similar to (or even better than) that of their largest counterparts.

Compared to the above mentioned papers, the distinctive features of the present study are its use of particular sample composed of small firms with fewer than 200 employees, the application of innovation indicators specific to small non-R&D performing firms, and the use, along with firm's size, of a variable which identifies the nature of the firm, that is, whether it is a sub-contractor or an independent unit.

Table 6 around here

Table 6 shows the regression results (for the sake of brevity the coefficients of industry dummies are not reported). Considering the whole sample (143 observations), the likelihood ratio test suggested that the single censored Tobit model should be preferred to the two-stage model; as a consequence, in the first column of Table 6 only the results of the Tobit estimates are reported. Recalling that the dependent variable is the share of exports on sales in 1996, it emerges that both the coefficients of SALES are significant, but the negative sign of the squared term indicates that the size-export share relationship is inverted U-shaped. However, the most significant (negative) determinant of export performance is the variable SUBCON,

significant as a determinant of export performance.

which denotes the share of sales due to sub-contracting: the higher the sales depending on the productive decentralisation of other firms, the lower is a firm's export performance. Since most of the sub-contractors included in our sample worked exclusively for other firms located in the same Region or in Italy, this result is not surprising. The affiliation of the firm with an industrial group (GROUP) is instead not statistically significant.[18] With respect to innovation indicators, both the dummy variable for being an innovating firm (INNOVA) and the intensity of expenditures on design, engineering and pre-production developments (DEPRSAL) exert a positive and significant impact (even though the significance level is lower than 0.05) on export performance.

Interesting results emerge when only the sub-sample of innovating firms (90 observations) is taken into account. In this case, the likelihood ratio test does not clearly indicate the best model specification; at a significance level of 0.05 the combination of the Probit and truncate model should be rejected, but at the level of 0.1 it should be preferred to the single Tobit model. As a consequence, the findings of both specifications are presented in Table 6. The results arising from the Tobit estimates are identical to those that emerged when the whole sample was considered. On the contrary, the two-stage model specification suggests that the variables affecting the probability of exporting differ from those that explain the share of exports on sales. In effect, the Probit estimates for all innovating firms indicate that the probability to export (the dependent variable being a dummy equal to one if the firm exported in 1996 and zero otherwise) depends positively, up to an upper threshold, on firm's size and negatively on the share of sales due to sub-contracting. The

[18] This result will apply to all the subsequent regressions.

truncate model for the sub-sample of exporting firms (27 observations) confirms the negative impact of SUBCON, but also suggests that export shares rise as both DEPRSAL and the innovative content of a firm's capital stock (AUTOM) increase.[19] Thus, in the case of innovating firms, the extent of innovative activities does not perform well in predicting whether a firm will export or not, but it is particularly effective in explaining why a firm exports relatively more than others; the opposite is the case with firm's size, while the nature of a firm as sub-contractor depresses both its export behaviour and performance.

Given the crucial role played by the SUBCON variable in the previous analyses, a third regression was carried out which considered only the sub-sample of independent firms (39 observations), that is, the firms in which the share of sales due to sub-contracting was lower than 40%. For obvious reasons, the variable SUBCON was omitted in this regression. In this case too, both the model specifications are presented in Table 6, since the likelihood ratio test suggested acceptance of the Tobit model at a significance level of 0.01, but its rejection at the level of 0.05. Starting from the Tobit estimates, the export performance of independent firms is still characterised by an inverted U-shaped relationship with firm's size; nonetheless, the coefficient of the intensity of expenditures on design, engineering and pre-production developments is positive and particularly significant, and also the innovation dummy exerts a positive impact (although less significant) on export performance. Moving to the two-stage model, the probability of being

[19] Looking at the coefficients of the two innovation indicators, note that the impact of DEPRSAL on export performance is much greater than that of AUTOM; a 1 point increase in the percentage of sales devoted to design, engineering and trial production should raise the percentage of exports on sales by 16.5 points, while a similar increase in the technological level of capital stock should determine an increase of 1.6 points in the share of exports on sales.

an exporter is influenced, in the usual fashion, by firm's size, and it is positively affected, even though with a low significance level, by all three indicators of innovative activities: DEPRSAL, AUTOM and INVSAL (the share of innovation costs due to innovative capital goods on sales). By contrast, the share of exports on sales is not influenced by firm size, but depends, positively and significantly, on DEPRSAL and the innovation dummy. Given the low number of observations, the results yielded by this last group of regressions, and especially those of the truncate model, should be treated with caution. In any event, it is possible to state that when the analysis is restricted to independent firms (i.e. those characterised by a higher probability to export) the intensity of all innovation inputs and, in particular, an increasing share of expenditures on design engineering and pre-production developments is associated with better export performances.

5. Concluding remarks

This paper has shown that the innovative efforts of small firms belonging to non-R&D intensive industries do matter, even though they focus on activities different from R&D. First, it has been shown that, in Italy, the intensity of innovation costs due to the acquisition of innovative capital goods and the activities of design, engineering and trial production are substantial, especially in 'supplier dominated' industries but also in small firms classified as 'specialised suppliers'. Second, the results for a sample of small firms belonging to the above mentioned industries show that also the innovative content of a firm's capital stock is correlated to the intensity of innovation inputs different from R&D. Lastly, although for these small firms the probability of being an exporter depends on their size and nature (namely, whether they are sub-contractors or not), their export performance is positively affected by non-R&D innovation inputs, and particularly by the share of sales devoted to design, engineering and pre-production development.

Thus, for small enterprises, reaching a minimum efficient size and attaining the status of 'independent firm' seem inescapable conditions for entering foreign markets. Thereafter, however, a firm's export performance depends significantly on its innovative efforts, and especially on those related to the activities closest to the phase of product commercialisation. To increase and keep their export shares, even firms that do not perform R&D must, above all, constantly improve their products by devoting financial and human resources to design, engineering and trial production and, secondly, mantain an adequate level of productivity by working with the most efficient capital stock. The product and process innovations needed for the survival and growth of these small firms do not necessarily require R&D efforts, since, on the one hand, product innovations in 'specialised supplier' and especially 'supplier dominated' firms are mainly of incremental nature and, on the other, process innovations depend essentially on the supply of (and the interaction with) capital good industries.

As a consequence, increased attention should be paid to non-R&D innovation inputs by both economists and, above all, the policy makers who, at different levels (European, national and regional), design and implement innovation policies, in particular those targeted on small firms. While the diffusion of innovative capital goods among small firms has benefited from

substantial support both in Italy and in other European Countries (cf. Santarelli and Sterlacchini, 1994), less attention has been devoted to the innovative activities internal to firms that differ from R&D. It must be added that, given the crucial role played by qualified technicians and engineers in design, engineering and pre-production development, the desirable policy interventions in this field are closely linked to those designed to enhance the human capital of small firms.

Appendix: The construction of the AUTOM variable

To assess the innovative content of a firm's capital stock, the main criterion used was the distinction, for each production phase, between machines and logistical devices based on micro-electronics and those which relied on electro-mechanical technologies. As is well-known, the advantage for the firm of the former process technologies is that it can attain a high level of flexibility without a loss of efficiency (as happens with the latter).

For the clothing industry, five phases of the typical production process were identified, and for each phase a score was ascribed to the machinery employed which ranged from 2 to 4 according to its complexity and potential for automation. The scores were assigned as follows:

Production phases	Machinery	Score
Spreading and cutting of fabrics	CAD-CAM system	4
	Manual system (with photocells and electrical cutters)	2
Sewing	Integrated (NC) system of electronic sewing machines	4
	More than 50% of electronic sewing machines	3.5
	Less than 50% of electronic sewing machines	3
	Only electro-mechanical sewing machines	2
Embroidery	CAD-CAM system	4
	Sewing and embroidering electro-mechanical machines	2
Ironing	NC ironing machines	4
	Electro-mechanical ironing machines	2
Labelling	Programmable labelling machines	4
	Electro-mechanical labelling machines	2

Suppose that a firm is 'vertically integrated' (i.e. carries out all production phases internally) and employs less than 50% of electronic machines in the sewing phase (thus obtaining a score of 3), while in the remaining phases it uses electro-mechanical technologies or manual systems (i.e. those obtaining the lowest score of 2). The variable AUTOM – that is, the position of this firm with respect to the 'technological frontier' – will be equal to 55. In effect:

1) 2+3+2+2+2=11 (total score);
2) 11/5=2.2 (average score: i.e. per phase);
3) 2.2/4=0.55 (average score of the firm on the maximum average score
4) 0.55*100=55 (AUTOM)

If a firm carries out only 3 of the 5 production phases, its total score will be divided by 3 and then related to the maximum (average) score, which is always equal to 4. By considering the average score of each firm and thus neglecting the number of phases in which the firm is directly involved, the variable AUTOM does not over-evaluate the technological performances of vertically integrated firms as opposed to sub-contractors, which are often specialised in one or two production phases (in the case of clothing, for instance, the sewing phase is almost always undertaken by sub-contractors)

For all the industries considered in this study, the scores ranged from 2 to 4, and the variable AUTOM from to 50 to 100. Note that in some industries, along with machinery, also the devices used in shop-floor logistics were taken into account. For instance, in the wood & furniture industry the presence of automatic handling of semi-finished panels - as opposed to manual handling - allowed assignation of a higher score. The same applies to the plastics industry for the automatic loading of presses and the extraction and handling of plastic products.

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Table 1
Average percentage distribution of innovation costs of Italian innovating firms by item (total innovation costs =100) - 1992.

	R&D	Design, engineering and pre-production development	Innovative capital goods	Other (c)
Supplier dominated:				
Clothing	16.50	36.20	27.10	20.20
Leather & footwear	15.50	17.00	63.40	4.10
Wood products (a)	9.70	10.20	78.10	2.00
Specialised supplier:				
Machine tools	47.60	27.60	22.20	2.60
Industrial machinery	38.90	31.10	24.80	5.20
Instruments	54.00	21.30	21.30	3.40
Scale intensive:				
Basic industrial chemicals	47.30	6.40	45.00	1.30
Domestic appliances	27.20	14.70	54.10	4.00
Motor vehicles	37.80	4.00	58.10	0.10
Science based:				
Pharmaceuticals	66.70	8.70	18.00	6.60
Office machinery & computers	64.80	21.70	12.40	1.10
Radio, TV & communication eqpt.	66.10	18.20	13.70	2.00
Total manufacturing	35.06	15.02	47.10	2.82

(a) = excluding furniture.
(c) = Acquisition of patents and licences and marketing activities (with the exclusion of expenditure on the market launch of new products).
Source: Italian survey on innovation (Istat, 1995)

Table 2
Characteristics of Italian innovating firms*

	Average size of total innovating firms (employees)	Average size of innovating firms that do not carry out R&D	Percentage of innovating firms that do not carry out R&D
Supplier dominated	69.4	51.8	50.5
Specialised supplier	107.3	49.6	30.5
Scale intensive	348.7	90.8	18.4
Science based	546.9	122.7	10.0
Total manufacturing	171.3	64.8	36.3

* For the composition of the four groups of industries see table 1.
Source: own computation from the Eurostat data base on the CIS.

Table 3

Firms interviewed by size and industry

Size (employees):	1-9	10-19	20-49	50-99	100 and more	TOTAL
Industries:						
Clothing	9	22	17	7	2	57
Knitwear	14	6	5	0	0	25
Wood & furniture	7	6	3	3	1	20
Footwear	8	4	3	1	0	16
Plastic products	6	4	4	1	0	15
Dies	3	1	3	1	2	10
TOTAL	47	43	35	13	5	143

Table 4

Means and standard deviations (in brackets) of innovation input indicators by industry*

	INVSAL	DEPRSAL	AUTOM
Clothing	1.7	0.1	61.3
	(3.5)	(0.4)	(15.7)
Knitwear	13.8	0.6	64.1
	(20.0)	(1.6)	(14.9)
Wood & furniture	5.5	1.1	64.4
	(8.4)	(2.1)	(15.7)
Footwear	4.0	0.7	64.8
	(5.0)	(2.5)	(22.0)
Plastic products	10.5	0.6	72.7
	(13.9)	(1.1)	(14.5)
Dies	7.2	2.8	75.5
	(4.3)	(1.8)	(10.0)
TOTAL	5.9	0.6	64.8
	(11.2)	(1.6)	(16.3)

* INVSAL and DEPRSAL are expressed as percentages of innovation costs (due, respectively, to the acquisition of innovative machinery and the activities of design, engineering and trial production) on firm sales. AUTOM is a qualitative variable whose value, for each firm, ranges from 50 (maximum distance from the 'technological frontier' of the industry) to 100 (the firm lies on the 'technological frontier').

Table 5
Correlation coefficients among innovation inputs and firms' characteristics

	AUTOM	INVSAL	DEPRSAL	SALES	EXPORT	SUBCON	GROUP	CUSTOM
AUTOM	1.00							
INVSAL	0.24**	1.00						
DEPRSAL	0.25**	0.26**	1.00					
SALES	0.33**	-0.08	0.06	1.00				
EXPORT	0.25**	0.02	0.30**	0.36**	1.00			
SUBCON	-0.11	0.14	-0.24**	-0.44**	-0.39**	1.00		
GROUP	0.21*	0.06	0.11	0.42**	0.11	-0.17*	1.00	
CUSTOM	0.06	0.07	0.21*	0.11	0.12	-0.26**	0.04	1.00

* Significance level = 0.05 ** Significance level = 0.01

Table 6
Determinants of export performance (t statistics in brackets)[a]

Sample:	All firms	Innovating firms	Innovating firms		Independent firms	Independent firms	
Observations:	143	90	90	27	39	39	19
Estimation method:	Tobit	Tobit	Probit	Truncate	Tobit	Probit	Truncate
Dependent variable:	Share of exports	Share of exports	Probability to export	Share of exports	Share of exports	Probability to export	Share of exports
Constant	-49.3 (-1.60)	-16.3 (-0.53)	0.43 (0.42)	-71.6 (-1.14)	-63.1** (-1.99)	-8.05** (-2.06)	-50.0 (-1.50)
SALES	5.69** (2.70)	5.97** (2.67)	0.27** (2.93)	0.03 (0.01)	6.07** (3.60)	0.61** (2.59)	2.40 (0.75)
$SALES^2$	-0.14** (-2.31)	-0.14** (-2.29)	-0.01** (-2.71)	-0.03 (-0.16)	-0.13** (-2.89)	-0.01** (-2.43)	-0.06 (-0.67)
SUBCON	-0.58** (-3.41)	-0.54** (-2.77)	-0.01** (-2.37)	-1.00** (-2.13)	omitted	omitted	omitted
GROUP	-13.3 (-0.96)	-12.3 (-0.86)	-0.50 (-0.96)	-34.8 (-1.44)	-11.8 (-0.89)	-1.43 (-0.97)	-7.48 (-0.42)
INNOVA	32.8* (1.83)	n.a.	n.a.	n.a.	38.3* (1.92)	0.68 (0.32)	43.9** (2.40)
INVSAL	0.56 (1.01)	0.50 (0.86)	0.02 (0.97)	3.06 (1.31)	1.40 (1.21)	0.19* (1.71)	0.62 (0.29)
DEPRSAL	5.20* (1.85)	5.29* (1.83)	0.11 (1.30)	16.5** (2.09)	12.0** (4.19)	1.85* (1.59)	11.3** (3.17)
AUTOM	0.19 (0.54)	0.13 (0.36)	-0.02 (-0.59)	1.59** (1.98)	0.16 (0.40)	0.06* (1.69)	0.67 (1.31)
Loglikelihood	-176.2	-158.0	-36.6	-111.2	-92.6	-10.1	-71.7
σ	37.6** (7.09)	38.2** (6.71)	n.a.	29.2** (4.18)	21.7** (5.91)	n.a.	15.4** (4.85)

a = in all the estimates industry dummies were included.

* Significance level = 0.10 ** Significance level = 0.05 n.a. = non applicable

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