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Abstract

Past research showed that exporters perform better than non-exporters in several domains, micro-level empirical evidence on the innovation-enhancing effect of export is, however, very scant. In this paper, we analyze the relationship between a firm's export status and its product innovation activity by using a rich firm-level survey on Italian manufacturing. First, we find that the positive effect of exporting on product innovativeness is robust to controlling for many sources of firm's observable heterogeneity and to allowing export activity to be endogenous. Second, we report evidence that the effect of exporting on product innovation is likely to be demand-driven, that is to originate from the interaction between domestic firms and foreign customers.

Keywords. Export, Firms, Italy, Manufacturing, Product Innovation
JEL Codes. F1 L2 O3

1 Introduction

Despite the importance of both the globalization and the innovation processes and the increasing emphasis on their positive impact on competitiveness and economic growth, the interactions between the two phenomena are far from being clear, especially when the analysis is conducted at the firm level rather than at the national or the industry level.

From some of the earliest contributions in the economic thought to a number of more recent ones belonging to the endogenous growth literature, the introduction of new or better products has been always recognized as the ultimate force driving a country's process of economic development.[1] Recent empirical evidence also shows that, at the firm level, product innovation has a positive effect on sales, employment (Hall et al., 2008) and - in some cases - on productivity (Crépon et al., 1998). At the same time, a recent and quite active strand of literature, the New-New Trade Theory (NNTT), has emphasized the role of firm internationalization in enhancing industry-level and country-level productivity.

There are many ways through which export activities may promote the introduction of new or better products (*learning by exporting*), as widely emphasized by the New Growth Theory and the New Trade Theory and as suggested by the micro literature on the sources of innovation at the firm level.

Exporting may induce a flow of information and knowledge that develops through commercial interaction, that is through interactions with for-

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[1]New or better products may positively affect aggregate growth because they are used as more efficient intermediate or capital goods in other production processes and industries, enhancing productivity and reducing costs. New or better products are created to satisfy new or more sophisticated needs, overcoming demand saturation; particular emphasis has been given to the welfare enhancing effect of the latter channel as new products are less likely to have an adverse effect on employment than new processes.

eign agents such as buyers, suppliers, intermediaries, and competitors. On the one hand, exporters may need technical assistance from foreign firms and through this channel access directly the knowledge of foreign suppliers, technicians or other researchers. On the other hand, foreign consumers may have different tastes and exporting activities may convey information on their specific needs. Alternatively, if the buyer is a foreign firm using different and more advanced technologies, it may require high quality/advanced technology goods to be used in its production process. Moreover, according to the basic Schumpeterian hypothesis, the increase in the size of the market and the associated increase in the monopolistic rent for successful innovators will provide incentives to increase the firm's R&D expenditure. Moreover, according to the recent extensions of the Schumpeterian model (see Aghion and Howitt, 1998; Aghion et al., 2005), the increase in the product market competitive pressure might force firms to innovate in order to survive. Finally, it is worth mentioning another activity that closely relates to innovation, that is to say imitation, by which firms are (often) engaged in copying the designs and processes already developed by competitors (Vernon, 1966; Segerstrom, 1991; Grossman and Helpman, 1991).[2] In this case exporters may imitate foreign competitors.

Despite the fact that many of these channels develop at the firm level, most of the existing empirical research assesses the effect of trade on innovation at the industry or country level,[3] and research on the effect of exporting on product innovation at the firm level is very scant.[4]

The goal of this paper is twofold. First, we aim at better investigating the relationship between export activities and a firm's propensity to introduce new or better products, in order to understand whether there is a positive effect of export activity on product innovation (*learning by exporting*). The second goal is to make an attempt at determining the potential causes (*pathways*) of this effect.

Assessing the existence and magnitude of *learning by exporting* and the pathways through which it develops is important for policy recommendations. For instance, if better and more innovative firms self-select into the international markets and there is no *learning by exporting*, then trade policies are not useful to increase the innovation propensity of *all* existing firms in a country. Trade openness would in this case have an impact on the average performance of a sector or a country through the survival of the 'fittest' firms. On the contrary, if a positive effect of export on innovation is at work, reducing barriers to trade will also improve the innovation performance of all existing firms which decide to export, raising their likelihood to survive

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[2] Due to the nature of firm-level survey data, is not always possible to make a clear distinction between innovation and imitation at the empirical level unless patent applications or accreditation are used as dependent variables.

[3] Keller (2004), Breschi et al. (2005).

[4] See the next section for a short and not exhaustive review.

the international competition.

We study the effect of exporting on product innovation using a rich firm-level survey on Italian manufacturing firms, the Survey of (Italian) Manufacturing Firms (*Indagine sulle Imprese Manifatturiere*, SIMF hereafter), which provides a wealth of information both on the inputs and the outputs of innovative processes and internationalization activities of firms.[5] We first check for the robustness of the positive relationship between export and product innovation by using OLS on the (rich) data we have. Secondly, we implement an instrumental variables (IVs) strategy that enables us to take into account the potential endogeneity of export activities with respect to the introduction of product innovations at the firm-level and to address, therefore, the potential firm *self-selection* issue which has been recently emphasized by the New New Trade Theory literature. Thirdly, we make an attempt to explore the possible sources and pathways of the positive effect of exporting on product innovation, by distinguishing between demand-side and supply-side sources of innovation.

Our empirical analysis shows two interesting results. The first result is that the positive association between export activity and a firm's product innovativeness survives the inclusion of many observable characteristics that might produce a spurious correlation between the two. The positive association remains when using IVs, which leads us to qualify it as a genuine effect of exporting on innovation. As for the pathways, we find that: 1) exporting is less strongly associated with process innovation than with product innovation; 2) the number of a firm's 'export markets' positively affects its product innovations while it has a much lower effect on its process innovations, which becomes nil when both the firm's export status and the number of export markets are controlled for. Given these last pieces of evidence, our second result is that the *learning by exporting* effect we find is much more likely to be generated by the demand side than by the supply side of export markets; in other words, learning by exporting likely happens through interactions between domestic firms and foreign customers and cross-country consumer heterogeneity could therefore play an important role in explaining the higher product innovativeness of exporters.

The structure of the paper is as follows. Section 2 includes a brief survey of the literature on the links between exporting and product innovation. Section 3 describes the empirical strategy and section 4 describes the data used. Sections 5-7 report our main results and section 8 concludes.

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[5]For some related literature using the same data set see, among others, Basile (2001), Parisi et al. (2006) and Benfratello and Razzolini (2007).

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2   Firm-level empirical evidence on export and innovation

In this paper we focus on the most common internationalization mode (exporting) and on a direct measure of product innovation, that is a firm's likelihood of introducing a new or an improved product. We think that considering product innovation is interesting for several reasons. First, because it is a measure of the output of innovation activities instead of the inputs, such as R&D investment, and in that way it is an indicator of successful innovation, not necessarily entailing an increase in either marginal or fixed costs of production. Second, because as a measure of output it overcomes some of the problems related to the interpretation of productivity measures.[6] Last but not least, many surveys show that although few firms do R&D investments many firms introduce product innovations. Hence, using an indicator of product innovation can be particularly important when studying innovation in countries' which structurally underinvest in research and where small and medium sized firms are prevalent, such as Italy.

Then, our analysis should be seen as complementing other studies focusing on different measures of innovation such as R&D or productivity.

The positive relationship between firms' innovation and export activities may be due to a two-way causal link or to a *self-selection* mechanism. In short, innovation may spur export, export may induce innovation or a third unobservable firm's characteristic (e.g., a firm's productivity) may make some firms self-select into both activities.

The positive effect of innovation on export activities has been widely investigated at the theoretical level by both the New Growth Theory and the New Trade Theory literatures; at the empirical level, several contributions at the macro, industry and, more recently, firm level reach consensus on the positive effect of innovation, and in particular R&D investment, on export activity.[7]

The *self-selection* mechanism has been recently stressed by the theoretical contributions of the NNTT literature pointing out how firms that are more efficient (or more innovative) enter foreign markets because they are productive (and perhaps innovative) enough to bear the sunk costs of entry (Melitz, 2003; Melitz and Ottaviano, 2008; Hallak and Sivadasan, 2007; Crinò and Epifani, 2008). More recently, some of these contributions have argued that both the innovation performance and the export activity may represent a consequence of previous firms decisions on R&D investment Costantini and Melitz (2008) or that export activities may induce ex-post

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[6]For instance, estimates of productivity using sales, which are common in the economic literature, often cannot distinguish between price (market power) and quantity (productivity) effects, since data are not available.

[7]Among the others, see Basile (2001), Lachenmaier and Woessmann (2006) and Cassiman and Martinez-Ros (2007).

investment in R&D in order to improve the quality of products to be sold in higher income countries (Verhoogen, 2008; Antoniades, 2008).

This literature has spurred a lively strand of empirical research that focuses on the relationship between internationalization and firm performance using firm-level data (Wagner, 2007; Greenaway and Kneller, 2007). A wide consensus has been reached by the empirical research that more productive/innovative firms self-select into international markets (among others Clerides et al., 1998; Bernard and Jensen, 2004), but many contributions using rigorous empirical strategies have been able to also identify positive causal effects of export activity on firm's productivity (see, for instance, Castellani, 2002; Greenaway and Kneller, 2007; Serti and Tomasi, 2007; Crespi et al., 2008; Razzolini and Vannoni, 2008).

As for the analysis using measures of innovation different from productivity, a recent contribution by Liu and Buck (2007) considers the effect of three main channels of international spillovers (R&D activities of foreign MNEs, export sales and expenditure on imported technology) on product innovation. The analysis is carried out by using a panel of sub-sector level data for Chinese high-tech industries, and new products are defined as either novel or improved products. The authors show a positive and significant effect of all the interactions between a measure of absorptive capacity and the three internationalization modes on product innovation; only export remains positive and significant taken by itself. It is worth noting that while domestic R&D looses significance when the other variables are introduced, firm size remains one of the most relevant determinant of innovation in all specifications. A second contribution by Salomon and Shaver (2005), using firm-level data, finds evidence of *learning by exporting* considering product innovation for Spanish manufacturing firms from 1990 to 1997. Information on product innovation is drawn from a survey where firms self-report the number of new or better products and the number of patent applications. The authors find a positive causal effect of both the status of exporter and export volumes on innovation performance, conditional on the firm's size, R&D expenditure and advertising intensity. In particular, the increase in product innovation takes place soon after exporting. In contrast to the previously mentioned contributions, firm size is never significant, while R&D expenditure and previous innovation have, respectively, a positive and a negative impact on innovation. Two other contributions provide evidence of the existence of a positive association between export and innovation without aiming at identifying causal effects Castellani and Zanfei (2007) and Gorodnichenko et al. (2008) [8] also considering other channels of technological transfer.

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[8]The focus of this paper is on the relationship between the higher competition induced by globalization and innovation, in particular by testing the main predictions derived by the recent contribution of Aghion et al. (2005). It is worth noting that while instrumenting the competition proxies, with regards to the trade variables the authors fail to identify a causal relationship between innovation and internationalization modes. In one of the

From the above mentioned contributions it emerges that export is an important channel of innovation, even when controlling for R&D expenditure and independently of a firm's absorptive capacity. The channels through which export positively impact on innovation, emphasized by these contributions, are the information exchange with foreign markets, through personal contacts with buyers and export intermediaries; the pressure of foreign competition is also found to have a positive impact, while the other traditional channels of international spillovers (information exchange with MNEs firms and knowledge embodied in imported technology) seem to be relevant especially when absorptive capacity is considered. Moreover, the role of R&D expenditure is generally confirmed to be positive and relevant in explaining innovation, while the evidence on firm size is more mixed.

3   The econometric strategy

The focus of this section will be on the 'causal effect' of exporting on the probability of introducing product innovations at firm level, for firms that do export, that is the *average treatment effect on the treated* (ATT). The main problem that must be addressed to estimate this parameter is that of potential endogeneity of export activity with respect to the output of innovation activities, that is a problem of firm's *self-selection* into both export activity and product innovation. For instance, highly productive firms might be more competitive in foreign markets, and therefore sell their goods abroad, but at the same time they might also produce more innovations at parity of inputs in the innovation process, that is they may be more productive also in the innovation process. If this latent productivity is either unobservable or omitted from the econometric model, this might generate an endogeneity problem. In the following discussion we will mostly analyze under which assumptions the parameter of interest can be estimated.

In what follows we will refer to: INN, a dichotomic variable that takes on value one if a firm introduced product innovations and zero otherwise, as our *outcome* of interest; EXP, a dichotomic variable that takes on value one if a firm exported and zero otherwise, as our *treatment* variable; X as a vector of *controls* (or control variables), that is variables that might affect both innovation and export; Z as the *instruments*, variables affecting the export activity only.

We start the discussion using as a benchmark a simple single equation linear model in which the likelihood of introducing product innovations INN depends on a firm's export status EXP, a vector of controls including both time-varying and time-invarying observable characteristics X and some unobservable characteristics that enter the error term u, that is:

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specifications the authors use panel data to assess whether internationalization affects innovation, but in this specification they omit all the control variables.

$$INN = a_0 + a_1\mathsf{EXP} + a_2\mathsf{X} + u \tag{1}$$

where at this stage we have neglected the timing of the outcome, the treatment and the control variables and dropped the firm subscript. We will refer to this model as the linear probability model (LPM, hereafter).[9] For the sake of simplicity, at the moment we are assuming homogeneous export effects on innovation, that is 'homogeneous export premia'. We also assume that $E(u|\mathsf{X}) = 0$, that is controls are uncorrelated with the error term (i.e., they are exogenous), and that there are not general equilibrium effects, that is the outcome for a firm does not depend on the treatment status of other firms.[10]

Model (1) can be estimated using ordinary least squares (OLS). The condition under which OLS provide consistent estimates is $E(u|\mathsf{X}, \mathsf{EXP}) = 0$, that is export status is exogenous with respect to product innovation conditional on the observables.[11] In case this assumption holds (and export premia are homogeneous), then the OLS estimate of a_1 also gives the *average treatment effect* (ATE), that is the average effect on innovation that would be produced by exporting for all firms, both exporters and non-exporters.

Depending on the richness of the data available, this assumption might appear more or less strong, as a number of potential determinants of both innovation and export might have been omitted from the model, enter the error term u and generate a correlation between EXP and u. In such a situation OLS would no longer be appropriate and the estimation of causal effects requires a different strategy.

Before continuing the discussion, let us assume that export activity EXP is in turn the outcome of a firm's decision which will depend also in this case on observable (X and Z) and unobservable characteristics (ϵ), that is:

$$\mathsf{EXP} = b_0 + b_1\mathsf{X} + b_2\mathsf{Z} + \epsilon \tag{2}$$

where Z are variables affecting only EXP but not INN, the so-called 'excluded instruments'. In case $E(u|\mathsf{EXP}, \mathsf{X}) \neq 0$, a consistent estimate of the ATT could be obtained using instrumental variables (IVs), while OLS gives inconsistent estimates.[12] In order for the IVs strategy to work a number

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[9]As known, the LPM has advantages and disadvantages with respect to binary response models, such as probit or logit models. The main advantage is that the LPM does not require assuming a specific distributional form for the error terms (e.g., normality in case of the probit model), while the main disadvantage is that the predicted values are not constrained to be in the unit interval.

[10]The so-called stable unit treatment value assumption (Angrist et al., 1996).

[11]Here, we refer to *statistical exogeneity*. This does not exclude that export activity could be a choice variable for the firm (*economic endogenity*), but implies that in this case all exogenous variables determining export activity and also affecting product innovation have been included in the regression.

[12]IVs are a popular way of assessing causality in cross-section data. For some recent related applications see Lachenmaier and Woessmann (2006) and Parisi et al. (2006).

of further assumptions are needed (see Angrist et al., 1996): 1) the orthogonality condition, that is $E(u|\mathsf{Z},\mathsf{X}) = 0$; 2) the exclusion restriction assumption, that is conditional on the X the instrument has only an indirect effect on the outcome, through the treatment $E(\mathsf{INN}|\mathsf{Z},\mathsf{EXP},\mathsf{X}) = E(\mathsf{INN}|\mathsf{EXP},\mathsf{X})$; 3) the nonzero average causal effect of Z on EXP, that is $E(\mathsf{INN}|\mathsf{Z} = z_0) - E(\mathsf{INN}|\mathsf{Z} = z_1) \neq 0$; 4) the monotonicity assumption, i.e. if $z_1 > z_0 \Rightarrow E(\mathsf{INN}|\mathsf{Z} = z_1) > E(\mathsf{INN}|\mathsf{Z} = z_0)$. Under all these assumptions the IVs estimator allows to recover the ATT.

Up to now we have assumed homogeneous 'export premia'. In reality, the innovation returns to exporting might differ across firms, both according to observable and unobservable characteristics. Here we limit our discussion to the the second case as the first one does not pose particular econometric problems (since it is sufficient to correct the specification by including appropriate interaction terms). In case of heterogeneous returns equation (1) can be rewritten as:

$$\mathsf{INN} = a_0 + (a_1 + a_i)\mathsf{EXP} + a_2\mathsf{X} + v_i \qquad (3)$$

where we have introduced the firm's subscript i. In this case the coefficient on EXP becomes random. In such a situation we may have two possible cases: 1) firms do not self-select into export activity according to their heterogeneous returns (i.e. $E(a_i|\mathsf{Z},\mathsf{X},\mathsf{EXP} = 1) = E(a_i|\mathsf{X},\mathsf{EXP} = 1)$); 2) firms do self select into export activities according to their heterogeneous returns (i.e. $E(a_i|\mathsf{Z},\mathsf{X},\mathsf{EXP} = 1) \neq E(a_i|\mathsf{X},\mathsf{EXP} = 1)$). In the first case and in the presence of correlation between the error terms in the innovation and export processes, IVs allow to recover the ATT. In the second case, only if this is the sole source of self-selection (i.e., $E(v_i|\mathsf{Z},\mathsf{X}) = E(v_i|\mathsf{X}) = 0$), OLS allow to recover the ATT. By contrast, IVs enables to recover the so-called *local average treatment effect* (LATE) on the treated. The LATE is the effect on the firms whose treatment status (being an exporter) is changed because of the different values taken by the instruments that define 'assignment' (see Angrist et al., 1996), who are usually referred to as *compliers*. This is often considered problematic in case a single instrument or very specific instruments, which are likely to affect only particular individuals or firms, are used, since using IVs would imply to estimate the effect of the treatment on very specific subpopulation.

As to the timing of both the outcome and the treatment variable, we will consider the effect of exporting in 2000 on the likelihood of introducing product innovations in the period 2001-2003.[13] Considering lagged export status makes it predetermined with respect to the outcome variable, avoids potential problems of reverse causality, and, in our opinion, allows enough time for the potential *learning by exporting* effect to manifest itself (cf. Sa-

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[13]In principle one could also consider the effect of lagged export intensity, however this piece of information is missing in the 8th wave of SIMF.

lomon and Shaver, 2005). As to the control variables, they will generally refer to 2000 or to the whole period 1998-2000 whenever annual information is not available, and they will be, therefore, always predetermined with respect to the dependent variable that refers to 2001-2003.

4   Data

In the empirical analysis we use data from the 8th (1998-2000) and 9th (2001-2003) waves of SIMF hereafter managed by the UniCredit banking group (formerly by Mediocredito Centrale and by Capitalia).

The survey collects information on a sample of manufacturing firms with 11-500 employees and on all firms with more than 500 employees. The SIMF has been repeated over time at three-year intervals and in each wave a part of the sample is fixed while the other part is completely renewed every time (see Capitalia, 2002, p. 39). This helps to analyze both variations over time for the firms observed in different waves (panel section) and the structural changes of the Italian economy, for the part of the sample varying in each wave. Like in many other surveys used in the empirical literature,[14] also in the case of SIMF the survey is biased against micro-firms and cannot be considered as representative of the whole Italian Manufacturing sector, but only of the firms with the sampled sizes.

The data set gathers a wealth of information on: balance sheet data integrated with information on the structure of the workforce and governance aspects; information on innovation, distinguishing whether product, process or organizational innovations were introduced; information on investments and R&D expenditures; information on the firms' international activities (export, off-shoring and FDI flows by area); information on financial structure and strategies. In order to implement the empirical strategy outlined in Section 3 we need to select all firms appearing in both the 8th and 9th waves of the survey, which refer to 1998-2000 and 2001-2003, respectively. This can create sample selection issues as some firms in the panel section might drop out from the sample for different reasons, such as non-response, cessation of activity, drop of firm size under 11 employees or change of sector (cf. Nese and O'Higgins, 2007).

Here, we limit ourselves to comparing the values of some key variables for our analysis in the single 8th and 9th waves and the 8th-9th wave panel. Table 1 compares means and standard deviations for these variables. The 1998-2003 panel appears to be fairly representative of the 1998-2000 cross-section under several dimensions, although the firms in the panel are slightly larger and more R&D intensive, both factors which might positively affect product innovation.

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[14]See for instance Bernard and Jensen (2004), Becker and Egger (2007).

Table 2 reports some panel descriptive statistics splitting the sample between exporters and non-exporters. It is immediate to note that exporters are much more likely to introduce product innovations and that exporters on average also differ with respect to non-exporters in a number of observable characteristics that could affect product innovation. Indeed, exporters are considerably larger (their average size is about three-times that of non-exporters) and strongly differ in terms of formal R&D activities.

5 OLS results

The dependent variable in our empirical analysis is a dichotomous indicator (INN) representing the answer to the following question in the 9th wave of SIMF: "*Did you introduce product innovations in 2001-2003?*". A 'product innovation' is defined as the introduction of a completely new product or of an important improvement of an old product at the firm-level. The dependent variable INN takes on value one in case of positive answer and zero otherwise. Our main independent variable of interest is exporting in 2000 available in the 8th wave of SIMF's survey, given by the answer to the question "*Did you export in 2000?*", which is represented by a dummy variable EXP that takes on value one in case of positive answer and zero otherwise.

We already said that lagging export status is useful to address potential problems of reverse causality, that is firms that are likely to export are those who innovate in the same period, and to take into account the potential lag with which a *learning by exporting* effect on innovation is likely to emerge.

In this section, we neglect the potential endogeneity of export status (with respect to product innovation) and make use of OLS estimation. Our purpose here is simply to investigate whether the positive correlation between a firm's export status and its product innovativeness survives to the inclusion of several observable characteristics that may be the source of this correlation.

The OLS results are shown in Table 3, which reports specifications progressively adding covariates.

In Model (1), which only includes export status, the estimated coefficient of exporting on the likelihood of introducing product innovations is 0.26, highly statistically significant.

Some characteristics that may be associated with both a firm's export status and product innovation are the industry (two-digit ATECO sector[15]) in which a firm operates and its geographical location, which are then included in the regression. Model (2) shows a reduction in the effect of export statu, which falls to 0.21. Exclusion Wald tests show that industry is a much better predictor of firm's product innovativeness than its geographical

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[15]ATECO stands for *Classificazione delle attività economiche*, that is an Italian classification of economic activities (i.e. industries) similar to NACE European classification.

location: the corresponding p-values for the F-tests turn out to be 0.48 for administrative regions (NUTS 2) fixed effects and 0.00 for industry fixed effects. Despite this evidence, we keep firm's geographical location in the specifications that follow, in order to avoid omitting potentially important local unobservable variables.

Model (3) controls for some observable dimensions of firm's heterogeneity which are likely to be related to both innovation and export activities, such as a firm's year of constitution (firm's age), a dummy for group membership, dummies for spin-offs and mergers or acquisitions, firm's size (number of employees), capital intensity and unit labor costs. Group membership and the dummy for mergers and acquisitions are positively and significantly (at the 10% and 5% statistical level, respectively) associated with firm's product innovation, while unit labor costs are strongly negatively associated with firm's innovativeness. The coefficient on export status falls to 0.18.

Model (4) introduces a set of technological inputs, which are likely to be strongly associated with product innovativeness: R&D intensity on employment (number of R&D workers over a firm's total employment), the percentage of R&D spent on product innovations, a dummy for ICT investments and real investment in fixed capital, which could embody new technologies. All these new controls, except the last one, turn out to be significantly and positively associated with firm's innovation. The coefficient on export status experiences a noticeable drop, falling to 0.15, suggesting that part of the correlation between export status and product innovation might be accounted for by technological variables, and that firms that export also invest more in new technologies (ICT) or exert a higher formal innovative effort through R&D. Models (3) and (4) show that controlling for firm's observed heterogeneity, which is likely to affect both product innovation and export, reduces the innovative effect of export.

Model (5) includes controls for other forms of potential international spillovers, in addition to those running through trade, such as acquisition of patents from abroad, a dummy for foreign ownership, a dummy for being located in a province bordering a foreign country and flows of FDIs. The last covariate only turns out to be positively associated with product innovation, but the coefficient on export is only slightly affected (0.14). This result is not unexpected as in our data just a few firms perform FDI flows (1.9% in our estimation sample) while many firms export (68.3% in our estimation esample), and the correlation between the two activities is not large.[16]

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[16]We also tried to include a dummy variable for making some production abroad, which is only available in the 9th wave of SIMF, and did not find different results. Given that we only have imperfect proxies of FDIs, and especially of delocalization of production, for 1998-2000 we checked the robustness of our results by splitting the sample in two, between firms with no more than 25 employees, which are very unlikely to perform FDIs, and firms with more the 25 employees, and the effect of export status turned out to be very similar in the two subsamples.

Model (6) includes further controls for managerial quality or decentralization, proxied by the return on investment index (ROI) and by the ratio of entrepreneurs, managers and cadres over total number of employees, respectively. Both variables are not significant and do not affect the coefficient on export status.

Model (7) introduces two proxies of firm's absorptive capacity: average labor costs and the percentage of graduates over total firm's labor force. The latter turns out to be significantly (at the 10% statistical level) and positively associated with firm's product innovativeness. The coefficient on export is not affected.

Model (8) controls for some proxies of the presence of firm's financial constraints, proxied by the numer of bank branches over the population as a proxy of *operational distance* and a proxy of *functional distance* at province level (i.e. the average distance between a bank's head quarter and local branches at province level).[17] Both variables turn out to be statistically insignificant, and the coefficient on export does not change.[18]

Model (9) includes a dummy for participation in an R&D consortium. The variable is not statistically significant and the coefficient on export status is unaffected.[19]

Model (10) includes lagged innovation status as an additional control variable.[20] This might be important in order to capture the potential dynamic structure of the product innovation process. Indeed, it might be the case that firms who innovated in the past are both more likely to have exported in the past and to innovate in the future. For this reason, the coefficient on export (in 2000) status might be picking up the effect of *past innovation* (during 1998-2000). However, our results show that even after controlling for past product innovation, which turns out to be strongly correlated with current innovation, the coefficient on export is only marginally affected, falling by 0.008, and remains highly statistically significant. These

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[17]See Alessandrini et al. (2008) for the effect of both measures of distance on firms' financing constraints. We thank Pietro Alessandrini, Andrea Presbitero and Alberto Zazzaro who kindly provided data on banking.

[18]This finding is qualitatively consistent with Benfratello et al. (2008) that using the SIMF panel but controlling for a narrower set of covariates find a weak and not robust effect of the banking system's development on firm's product innovation, while finding a stronger effect on process innovation.

[19]In order to check the sensitivity of our estimates to changing the econometric model, we also estimated Model (9) using a probit specification. The marginal effect of export status is 0.159, significant at the 1% statistical level. Moreover, since the wave 9 of SIMF also provides the percentage of sales coming from innovative products in 2003, we also used this variable as a dependent variable. The coefficient on export is significant at the 1% level and suggests a 2.71 points advantage in the percentage of innovative sales for exporters. We prefer to report in the paper the analyses using the dichotomic innovation indicator since we consider it less prone to measurement error.

[20]This variable, like export status, may be endogenous, but here we neglect this potential problem by using OLS.

estimates suggest, overall, that past export status is as important as past product innovation on the probability of current product innovation.[21]

Hence, from this first section of the empirical analysis we can be quite confident that the positive association between a firm's export status and its product innovativeness is a robust one, and survives to the inclusion of several firm's *observable* characteristics which might generate it. Firms that exported in 2000 are about 14 percent points more likely to introduce product innovations in 2001-2003 than those that did not export. However, nothing ensures that we might have omitted some *unobservable* variables which simultaneously affect a firm's export and innovation activities, and that the coefficient on export status may be simply picking up their effect. For this reason, in the next section we make an attempt to address this problem of potential *endogeneity* of export status using an instrumental variables (IVs) strategy.

6 IVs results

Using IVs requires finding an *instrument*, that is an exogenous source of variation in export status that is uncorrelated with the unobservables affecting product innovation.

From gravity models we borrow the idea that a firm's export status should be strongly negatively correlated with the distance between its geographical location and potential destination countries for its products, as transportation costs generally increase with distance. In particular, we have information on the province in which a firm is located. Potential destination countries for a firm's products were identified by considering for each two-digit ATECO sector the first 25 countries in terms of export value to which Italy exports.[22] Then individual countries' weights were determined by dividing the export value to a specific country by the total value of exports to all 25 countries by sector.[23] This implies that both destination

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[21]We also estimated a specification adding lagged process innovation as a covariate. One possible criticism to our results is, indeed, that past adoption of process innovations induced by firm's internationalization might affect future product innovations. In this specification the coefficient on export is 0.13, significant at the 1% statistical level, while past process innovation turns out to be statistically insignificant. As some recent literature is stressing the role of import on process and product innovation (Liu and Buck, 2007; Gorodnichenko et al., 2008; Esteve-Perez and Rodriguez, 2009), but unfortunately we do nott have data on it, we built a proxy for import which is a dummy that takes on value one if a firm bought transport or insurance services from abroad in 2001-2003 and zero otherwise(the information is not available for 1998-2000) and included it in Model (9) as a further covariate. The coefficient on export remains 0.14, statistically significant at the 1% level, while the coefficient on the proxy for import is 0.10, significant at the 5% level.

[22]We do not use a finer disaggregation of ATECO mainly for two reasons: 1) coding errors increase when considering finer disaggregations; 2) exports are generally not available for all sectors/countries pairs when considering finer disaggregations.

[23]Data on export were taken from the OECD's STAN Bilateral Trade Database. Export

countries and country weights are different across sectors. This procedure enables us to compute a *sector-specific measure of distance*, that is a measure of distance that varies across sectors that we call 'export distance', EXPDISTANCE. Formally, EXPDISTANCE was computed as follows:

$$\text{EXPDISTANCE}_{pi} = \sum_{j=1}^{25} d_{pj} \cdot w_{ij} \tag{4}$$

where d_{pj} is the distance between province p and country j and $w_{ij} = \frac{\text{EXPORT}_{ij}}{\sum_{j=1}^{25} \text{EXPORT}_{ij}}$ is the weight of country j on the total exports of sector i (on the first 25 destination countries for sector i). Distances d_{pj} were computed using latitude and longitude of Italian provinces and foreign countries' capitals.[24]

Two firms in the same province have different 'export distances' if they are in different sectors while two firms in the same sector and in different provinces have different measures of 'export distance', due to their different geographical locations. In order for the instrument to be valid, it is necessary that EXPDISTANCE is not capturing mainly sector or geographical unobservables with also directly affect product innovation. As for the second possibility, our previous OLS result of the insignificance of administrative regions on product innovation makes us rather confident that it should not be the case. However, we control in both stages of IVs for both sector fixed effects and region fixed effects, and for the firm being located in a foreign-border province. The dummy for foreign-border province should capture the fact that firms located in these provinces might be more likely both to be influenced by knowledge spillovers from foreign firms and to export to neighboring countries. In any case, in the computation of 'export distance' are only considered the main *destination countries of Italian exports by sector*, which are weighed by the fraction of exports. In this sense, our variable is much more specific that a simple interaction between province and sector fixed effects, and should be highly correlated with export status, capturing the combined effect of transportation costs and sector comparative advantages on export status, while being loosely correlated or uncorrelated with *foreign knowledge spillovers taking place independently of export*. Indeed, although this is far from being a formal test, when included in the most complete LPM specification estimated with OLS of the product innovation equation EXPDISTANCE is not statistically significant at the 10% level.

The first part of the Table 4 reports the first stage of IVs, and the second part of the table the second stage. In Model (1), which also in-

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weights refer to 1997 so as they are predetermined with respect to the period under study (1998-2003).

[24]These second set of coordinates was taken from the website http://www.cepii.fr/anglaisgraph/bdd/distances.htm. Distances were computed using the STATA module `sphdist` created by Bill Rising.

cludes all covariates of model (9) in Table 3,[25] the only instrument used is
EXPDISTANCE whose effect on firm's export status is negative and strongly
significant.[26] The F-test for the instruments (11.47) and the Kleibergen-
Paap rk Wald F-statistic (see Kleibergen and Paap, 2006),[27] which is 12.43,
suggest that IVs estimates should not suffer from a severe weak instrument
problem, although the partial R^2 is quite low.

From the second stage, the coefficient on export status is much higher
than the one estimated with OLS and is not very precisely estimated, be-
ing only significant at the 10% level. Despite statistics do not show clear
evidence of weak identification, the large difference between OLS and IVs
estimates may still be related to a potential problem of weak instruments
but also to the fact that in case of heterogeneous effects of export on prod-
uct innovation, IVs are likely to estimate a Local Average Treatment Effect
(LATE), that is the effect of export status on the subpopulation of firms
whose export status is changed by the instrument EXPDISTANCE. The
latter are likely to be the ones for which export is more sensitive to trans-
portation costs or sector comparative advantages, for instance firms with
less market power and doing less formal research efforts, which may also
be those who have more to gain from exporting in terms of increasing in-
novativeness. The endogeneity test does not reject the null hypothesis of
exogenous export status at the 10% level (although only marginally).

The first model that we estimated, being exactly identified, does not
allow us to test the validity of our exclusion restrictions, that is to run an
overidentification test. For this reason Model (2) of Table 6 reports the
first and the second stage of an overidentified model using as instruments
EXPDISTANCE and unit labor costs in 1998.[28] The F-test for the excluded
instruments falls with respect to the exactly identified model (7.64), and in
this case the instruments appear to be weak (the Kleibergen-Paap rk Wald

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[25]We exclude lagged product innovation as it we do not have enough instruments to
estimate a dynamic model. However, we already noted in the previous section that the
coefficient on export status is very robust to including past innovation status.

[26]As one possible criticism with using local variables (e.g. distances to potential export
markets) as instruments is that they might be capturing other local province-level unob-
servables affecting both export and innovation, we also estimated the same specification
using province (NUTS 3) fixed effects instead of region fixed effects. The coefficient on
EXPDISTANCE remains highly statistically significant (p-value=0.004) and of a very sim-
ilar magnitude (-0.017) suggesting that firm's geographical location per se should not be
the main driver of our results. The full set of results that are not reported in the paper is
available upon request from the authors.

[27]Baum et al. (2007) suggests using this statistic in the presence of clustered standard
errors, and to use either the Staiger and Stock (1997) rule of thumb that F-statistic should
be at least 10, or Stock and Yogo (2005) critical values. Critical values for 10% and 15%
maximal IV size are 16.38 and 8.96, respectively.

[28]For 1998 unit labor costs the identifying assumption is that they affected export in
2000, but conditional on unit labor costs in 2000 they do not affect product innovation
during 2001-2003.

F-statistic is 8.35 while the Stock and Yogo, 2005, critical values for a 10% and 15% maximal IV size are 19.93 and 11.59, respectively). The coefficient on export status falls by about 10 percent points. The Hansen J-statistic supports the validity of the exclusion restrictions, while the endogeneity test does not reject the null of exogeneity of export status.

Model (3) in Table 4 reports the results of a third (overidentified) model using as an instrument also ISO 9000 certification (in 1998-2000). Strictly speaking, certification to an ISO 9000 standard does not ensure the quality of final products and services, it only certifies that formalized business processes are being applied. ISO 9000 certification is sometimes used by firms as a marketing tool. Hence, we posit that ISO 9000 certification may directly affect a firm's chances to export its products, without having any direct effect on firm's innovativeness conditional on the control variables we already included, such as technological inputs, capital intensity and others.[29] In this model both the F-test for the excluded instruments and the partial R^2 improve with respect to Model (2), and do not show evidence of a weak instrument problem (the Kleibergen-Paap rk Wald F-statistic is 9.41 while the Stock and Yogo, 2005, critical value for a 10% maximal IV relative bias is 9.08). The coefficient on export status is this time more precisely estimated: it is significant at the 5% statistical level and falls to 0.41. Also in this case, the instruments appear to be valid and the endogeneity test does not reject the exogeneity of export.[30]

In summary, the results in this section show that: 1) IVs estimates are larger that OLS estimates; 2) as the overall relevance of the instruments increases, the precision of IVs estimates increases as well and they get closer to the OLS' ones; 3) IVs results are qualitatively consistent with the OLS results: export status positively affects product innovation; 4) the hypothesis of exogeneity of export status with respect to product innovation, conditional on the observables included in the model, is generally not rejected by our data (i.e., OLS give consistent estimates).

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[29]The ISO 9000 certification dummy is not statistically significant (p-value=0.57) when it is included in specification (9) in Table 3 of the product innovation equation.

[30]We also estimated this specification using a sequential probit model, in which a probit for product innovation with an endogenous dummy (export status) and the endogenous dummy are jointly modelled. In order to make the estimation converge we had to replace the region fixed effects in the product innovation equation, which were jointly insignificant, with four macro-area dummies (North-East, North-Weast, Centre, South and Islands). The coefficient on export status turned out to be significant at the 10% level, and the null hypothesis of zero correlation between the errors of the two equations (i.e. exogeneity) was not rejected (p-value=0.47). We prefer the LPM-IVs specification as it does not rely on the joint normality assumption.

7   Where does the 'export status' effect come from?

We have shown that export status positively affects the likelihood that a firm introduces product innovations, we might wonder, however, through which pathways this effect takes place.

The literature investigating the sources of innovation at the firm level distinguishes between *technology push* and *demand pull* factors. According to the first explanation are the activities and capabilities of the firm that drive innovation (e.g., R&D investment, acquisition of new capital/intermediate goods incorporating technical progress, acquisition of patents, technical cooperation, reverse engineering, knowledge spillovers from other researchers), while the second maintains that innovation is mainly spurred by the external requirements of the market. The literature on the demand sources of innovation looks in turn at the demand side in two different ways: a) demand as size of the market or 'incentive effect', in the tradition of the seminal contribution of Schmookler (1966) and more recently Jovanovic and Rob (1987) and Sutton (1998); b) demand as information or 'uncertainty effect', in the tradition of Myers and Marquis (1969) and other seminal contributions showing qualitatively that firms perceive demand as the most important source of ideas. This last stream of literature stresses the interaction with buyers as a source of information which increases the innovative effort of the firm, and it underlines either the role of 'sophisticated' consumers who can provide feedbacks to producers or the role of taste heterogeneity (Malerba et al., 2007; Adner and Levinthal, 2001).

In theory, both *technology push* and *demand pull* factors might explain the higher innovativeness of exporters. It must be noted that since in our empirical specifications we are controlling for many covariates that are likely to mediate the effect of export on innovation in terms of higher 'formal' innovative efforts, such as investments in R&D, acquisition of foreign patents, acquisition of new capital goods to produce different products, market scale effects, the coefficient on export status is likely to capture other effects, which may take the form of pure knowledge spillovers or informal higher innovative efforts, which may originate either from the supply or the demand side.

Although Italy is a laggard country in terms of R&D and production of new technology, it is nonetheless a developed country and access to state of the art production processes enabling the production of new or modified products is likely to be easily available to domestic firms irrespective of involvement in foreign trade and of contacts with foreign suppliers of intermediate goods or foreign competitors.[31] By contrast, we believe that an important source of product innovation for exporters in developed countries

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[31]Like Italian firms will try to export their products abroad, foreign producers will try to sell these technologies to Italian firms.

could be the presence of taste heterogeneity across countries: exporters have to modify or improve their products to meet the needs of foreign customers.[32] The findings in Crespi et al. (2008), which investigates learning-by-exporting using a panel of UK firms, seem to confirm this speculation. Indeed, in both levels and differences, past exporting is significantly associated with more learning from customers relative to other sources, such as suppliers, competitors and trade associations, while exporting is not associated with statistically significantly more learning from other sources.

In what follows, we seek for evidence that demand-side factors, and in particular cross-country heterogeneity in tastes, may represent an important pathway through which a firm's export status affects product innovation.

One first speculation that we put forward is that if the effect of export on innovation were mainly supply-driven, that is coming from the voluntary or involuntary exchange of information with suppliers and other firms, we would expect an effect on process innovation at least as large as the one found on product innovation. For this reason, in Table 5 we report the results of the specification of Model (9) using process innovation in 2001-2003 as a dependent variable. The estimates in column (1) show that export status also positively affects the likelihood of introducing process innovations, although the effect is just half the size of the one found for product innovations and much less statistically significant.

One second speculation that we advance is that as technological changes, e.g. new and more efficient production methods, are likely to spread much more quickly across countries than consumer tastes,[33] the *number of different areas to which a firm exports* should have a higher association with the likelihood of introducing product innovations than with the one of introducing process innovations. Columns (2) and (3) of Table 5 show the effect of the number of export (geographic) areas (NMARKETS) on product and process innovation, respectively.[34] NMARKETS has a much stronger association with product innovations than with process innovations: adding one new geographic area to a firm's export markets is associated to a 4.4 percent points increase in the likelihood of introducing product innovations and to a 1.7 percent points increase in the probability of introducing process innovations. In columns (4) and (5) we allow export status and NMARKETS to have different effects on product and process innovativeness. Results show that, once we control for the number of export markets, exporting per se does not have a statistically significant effect on innovativeness (intercept-effect), while the number of export markets has a significant effect, over and

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[32]See for instance, Scarpa et al. (2005) and Sawyer et al. (2007).

[33]Some sources of taste heterogeneity, such as those related to cultural, ethnic, historical or geographical characteristics for instance, cannot be easily removed in the short term.

[34]The 8th wave of SIMF reports the following export areas: EU15, Eastern Europe, other European countries, Africa, US and Canada, Central and South America, Asia, China, Oceania, and other countries.

above export status, only on product innovation (slope-effect). This also suggests that when the number of export markets was omitted, in Table 3, and we included export status only in the econometric models, we were estimating an average effect of exporting that was based on the average number of export markets for firms that did export in our sample (about 2.8).

We interpret this evidence as consistent with the fact that heterogeneity of consumer tastes across countries may represent an important pathway through which firms who do export are pushed to introduce product innovations, that is to modify or improve their products.

8 Concluding remarks

In this paper we have used data on Italian manufacturing firms to investigate the effect of a firm's export status on its likelihood of introducing product innovations.

We have shown that a statistically significant correlation between exporting and introducing product innovations (which is consistent with *learning by exporting*) remains even after controlling for many observable firm characteristics that may produce it. This result is also robust to allowing the export status to be endogenous and using an Instrumental Variables (IVs) strategy.

Hence, exporting appears to positively affect a firm's product innovativeness. Our opininion is that, given the level of development of Italy, this is more likely to be generated by interactions with the demand-side (buyers) than with the supply-side of foreign markets (suppliers and foreign researchers). This speculation is supported by two findings. First, export status has a much lower effect on process innovativeness, for which interactions with the supply-side of foreign markets are likely to be more important, than on product innovativeness. Second, product innovativeness, unlike the process innovativeness, is positively affected by the number of aggregated geographical areas to which a firm exports over and above export status. This last result could be explained by cross-country heterogeneity in consumer tastes, which induces exporters to modify or improve their products to meet the requirements of heterogeneous foreign customers.

Tables

Table 1: Descriptive statistics for the SIMF's 1998-2000 cross-section and the 1998-2003 panel

Variable	1998-2000 wave			1998-2003 panel		
	N. obs.	mean	s.d.	N. obs.	mean	s.d.
% exporters in 2000	4,667	0.679	0.467	2,047	0.681	0.466
% group members 1998-2000	4,667	0.205	0.404	2,044	0.201	0.401
no. employees 2000	4,675	87.561	364.198	2,050	97.231	417.150
capital intensity 2000[a]	4,018	0.038	0.049	1,825	0.038	0.046
R&D intensity in 2000[b]	3,814	0.015	0.392	1,735	0.020	0.551
skill-ratio 2000[c]	4,675	0.347	0.184	2,050	0.336	0.173

Notes. [a] real capital stock per worker in thousands of Euros (at 2000 prices); [b] no. of R&D employees over total number of employees; [c] number of non-production (white collars) over production workers (blue collars).

Table 2: Descriptive statistics for non-exporters and exporters (1998-2003 SIMF's panel)

Variable	N. obs.	mean	s.d.
Non-exporters in 2000			
% made product innovations in 2001-2003	642	0.241	0.428
% group members 1998-2000	651	0.144	0.352
no. employees 2000	652	41.095	164.193
capital intensity 2000[a]	562	0.040	0.052
R&D intensity in 2000[b]	544	0.003	0.011
skill-ratio 2000[c]	652	0.319	0.178
Exporters in 2000			
% made product innovations in 2001-2003	1,371	0.508	0.500
% group members 1998-2000	1,390	0.227	0.419
no. employees 2000	1,395	123.636	490.921
capital intensity 2000[a]	1,262	0.036	0.044
R&D intensity in 2000[b]	1,190	0.028	0.666
skill-ratio 2000[c]	1,395	0.345	0.170

Notes. [a] real capital stock per worker in thousands of Euros (at 2000 prices); [b] no. of R&D employees over total number of employees; [c] number of non-production (white collars) over production workers (blue collars).

Table 3: Probability of introducing product innovations in 2001-2003 (linear probability model)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Exporter (d)	0.264***	0.206***	0.183***	0.147***	0.145***	0.144***	0.143***	0.143***	0.144***	0.135***
Year of constitution			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Group membership (d)			0.062*	0.059*	0.054	0.054	0.050	0.052	0.052	0.045
Spin-offs (d)			-0.016	-0.025	-0.028	-0.027	-0.031	-0.029	-0.028	-0.020
Mergers or acquisitions (d)			0.096**	0.060	0.060	0.061	0.061	0.064	0.065	0.055
Size			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Real capital intensity			-0.408	-0.434*	-0.434*	-0.406	-0.402	-0.398	-0.397	-0.375
Unit labor costs			-0.353***	-0.281**	-0.261**	-0.249**	-0.235**	-0.240**	-0.238**	-0.239**
% R&D to introduce new products				0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.001**
R&D intensity on employment				1.235***	1.244***	1.240***	1.180***	1.182***	1.199***	1.146***
Invested in ICT (d)				0.106***	0.104***	0.104***	0.103***	0.103***	0.104***	0.090***
Variation in real capital stock				0.000	0.000	0.000	0.000	0.000	0.000	0.000
FDI flows (d)					0.175**	0.174**	0.171**	0.172**	0.174**	0.161**
Bought patents abroad (d)					-0.090	-0.090	-0.111	-0.106	-0.109	-0.114
Foreign ownership (d)					-0.009	-0.011	-0.012	-0.011	-0.013	-0.030
Border province (d)					0.005	0.006	0.008	0.015	0.014	0.015
Decentralized management						-0.034	-0.042	-0.043	-0.043	-0.033
Return on investiment						0.001	0.001	0.001	0.001	0.001
Graduate ratio							0.393*	0.394*	0.396*	0.383*
Real cost per worker							-0.001	-0.001	-0.001	0.000
Bank branches per 10000 pop.								0.002	0.002	0.002
Banks' functional distance								0.000	0.000	0.000
R&D consortium (d)									-0.098	-0.080
Lagged product innovation (d)										0.133***
Region fixed effects	no	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry fixed effects	no	yes	yes	yes	yes	yes	yes	yes	yes	yes
R-squared	0.062	0.109	0.124	0.176	0.179	0.18	0.181	0.183	0.183	0.193
No. observations	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620

Note. * significant at 10% level; ** significant at 5% level; *** significant at 1% (standard errors robust to heteroskedasticity)
Dummy variables are indicated with (d) after the variable. Only selected variables are reported in the table. For the detailed description of the variables see the Appendix.

Table 4: Probability of introducing product innovations in 2001-2003 (linear probability model)

	(1)	(2)	(3)
1st stage: Export equation			
Instruments:			
Export distance (100 Km)	-0.019***	-0.020***	-0.019**
Unit labor costs 1998		-0.267**	-0.257**
ISO 9000 certification (d)			0.077***
F-test instruments (p-value)	11.47 (0.00)	7.64 (0.00)	8.53 (0.00)
Weak identification test[a]	12.43	8.35	9.41
Partial R^2 instruments	0.89%	1.16%	1.82%
2nd stage: Product innovation equation			
Export (d)	0.57*	0.469*	0.412**
Hansen J-statistic[b] (p-value)	-	0.648 (0.42)	0.77 (0.67)
Endogeneity test[c] (p-value)	2.247 (0.13)	1.5 (0.22)	1.547 (0.21)
No. obs.	1,620	1,620	1,620

Note. * significant at 10% level; ** significant at 5% level; *** significant at 1% (standard errors clustered at the province × industry level)

Dummy variables are indicated with (d) after the variable. Only selected variables are reported in the table. The models also include all covariates of Model (9) in Table 3. [a] Kleibergen-Paap rk Wald F-statistic (see Kleibergen and Paap, 2006); [b] Overidentification test. The joint null hypothesis is that the instruments are valid, i.e., uncorrelated with the error term, and that the excluded instruments are correctly excluded from the estimated equation. [c] The IVs models were estimated using the Stata command `ivreg2`. The endogeneity test implemented by `ivreg2` is defined as the difference of two Sargan-Hansen statistics: one for the equation with the smaller set of instruments, where the suspect regressor is treated as endogenous, and one for the equation with the larger set of instruments, where the suspect regressor is treated as exogenous. The null hypothesis is exogeneity. This test, unlike the Durbin-Wu-Hausman test, is robust to various violations of conditional homoskedasticity.

Table 5: Probability of introducing product and process innovations in 2001-2003 (linear probability models)

	Process innovation (1)	Product innovation (2)	Process innovation (3)	Product innovation (4)	Process innovation (5)
Export (d)	0.063**			0.050	0.033
No. export areas		0.045***	0.017**	0.038***	0.013
R^2	0.09	0.20	0.09	0.20	0.09
No. obs.	1,620	1,620	1,620	1,620	1,620

Note. * significant at 10% level; ** significant at 5% level; *** significant at 1% (standard errors robust to heteroskedasticity)

Dummy variables are indicated with (d) after the variable. Only selected variables are reported in the table. The models also include all covariates of Model (9) in Table 3.

Appendix: (Selected) Variables Description

Product innovation. It is the dependent variable, which takes value one if a firm improved substantially its products or introduced new products during 2001-2003. Source: SIMF, 9th wave.

Export status. It is a dummy variable which takes on value one if a firm exported in 2000 and zero otherwise. Source: SIMF, 8th wave.

Export distance. It is a sector specific measure of a firm from its potential export markets. See section 6 for more details. Source: export data from OECD's STAN Bilateral Trade Database, coordinates data from http://www.cepii.fr/anglaisgraph/bdd/distances.htm. Unit of measurement: 100 Km.

Size. Number of employees, 2000. Source: SIMF, 8th wave.

Real capital intensity. It is the ratio between the real capital stock and the number of employees in 2000. The nominal capital stock is derived from balance sheet data and is evaluated at the net 'historical cost' that is cost originally borne by a firm to buy the good reduced by the depreciation measured according to the fiscal law (*Fondo di ammortamento*), which accounts for obsolescence and use of the good. The real capital stock is obtained using capital stock deflators provided by the Italian National Statistical Institute (cf. Moretti, 2004). All variables are deflated with the appropriate three-digit production price index (ISTAT). Source: SIMF, 8th wave. Unit of measurement: thousands of 2000's euros.

Unit labor costs. Unit labor costs in 2000 are computed as the ratio between total real labor costs and real production. Real production is computed following Parisi et al. (2006) as the sum of sales, capitalized costs and the change in work-in-progress and in finished goods inventories deflated with the appropriate three-digit production price index provided by ISTAT. Unit labor costs in 1998 are used as an instrument for export status in 2000. Source: SIMF, 8th wave, 3-digit industry specific deflators from ISTAT. Unit of measurement: thousands of 2000's euros.

% R&D to introduce new products. It is the % of R&D borne by a firm in 1998-2000 to introduce new products. Source: SIMF, 8th wave.

R&D intensity on employment. It is the number of R&D employees over total firm employment in 2000. Source: SIMF, 8th wave.

Invested in ICT. It is a dummy variable that takes value one if a firm invested in ICT during 1998-2000 and zero otherwise. Source: SIMF, 8th wave.

Variation in real capital stock. It is the amount of real firm's investments during 1998-2000. Nominal investments are deflated with the appropriate three-digit production price index provided by ISTAT. Source: SIMF, 8th wave. Unit of measurement: thousands of 2000's euros.

FDI flows. It is a dummy variable that takes on value one if a firm performed FDI flows during 1998-2000 and zero otherwise. Source: SIMF,

8th wave.

Bought patents abroad. It is a dummy variable that takes on value one if a firm bought patents abroad during 1998-2000 and zero otherwise. Source: SIMF, 8th wave.

Foreign ownership. It is a dummy variable that takes on value one if a firm is foreign owned in 1998-2000 and zero otherwise. Source: SIMF, 8th wave.

Border province. It is a dummy variable that takes on value one if a firm is located in a province bordering a foreign country and zero otherwise. Source: SIMF, 8th wave.

Decentralized management. It is the ratio between entrepreneurs, managers and cadres over total number of employees in 2000. Source: SIMF, 8th wave.

Return on investment. ROI index in 2000. Source: SIMF, 8th wave.

Graduate ration. It is the fraction of total firm's employment with a university degree in 2000. Source: our computation on SIMF, 8th wave.

Real cost per worker. It is total labor cost divided by the number of employees (real average wages) in 2000. Nominal labor costs are deflated with the appropriate three-digit production price index provided by ISTAT. Source: our computation on SIMF, 8th wave. Unit of measurement: thousands of 2000's euros.

Bank branches per 10,000 population. Source: kindly provided by Alessandrini, Presbitero and Zazzaro (Alessandrini et al., 2008).

Banks' functional distance. It is the average distance between a bank's head quarter and local branches at province level. Source: kindly provided by Alessandrini, Presbitero and Zazzaro (Alessandrini et al., 2008). Unit of measurement: Km.

R&D consortium. It is a dummy that takes value one if a firm participated to an R&D consortium consortium in 1998-2000 and zero otherwise. Source: SIMF, 8th wave.

Lagged product innovation. It is a dummy variable that takes value one if a firm introduced product innovations during 1998-2000 and zero otherwise. Source: SIMF, 8th wave.

Process innovation. It is a dummy variable which takes value one if a firm introduced process innovations during 2001-2003 and zero otherwise. Source: SIMF, 9th wave.

ISO 9000 certification. It is a dummy that takes on value one if a firm has a ISO 9000 certification in 1998-2000 and zero otherwise. Source: SIMF, 8th wave.

Number of export markets. It is the number of export geographic areas to which a firm exports in 2000, as grouped by the SIMF: EU15, Eastern Europe, other European countries, Africa, US and Canada, Central and South America, Asia, China, Oceania, and other countries. Source: SIMF, 8th wave.

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