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Abstract

Recent empirical studies have reported strong firm-level evidence of 'learning by exporting' in product innovation. In this paper we consider a specific channel which might contribute to explain the innovation premium of exporters, by focussing on the information exchange between firms establishing buyer-supplier relationships related to production to order (PTO). Using new European firm-level data, we first provide some descriptive evidence that suppliers doing PTO for foreign firms are more innovative than suppliers producing only for domestic firms. We rationalize this evidence in a theoretical framework where firms are heterogeneous in the characteristics of their products and where buyers, searching for a specialized input, have to match either with a domestic or with a foreign supplier in order to produce a final good. A successful match requires the intermediate good's adaptation/modification ('innovation') which can be carried out either by the buyer or by the supplier. In a framework where information is imperfect and contracts are incomplete, we single out the conditions for which different internationalization and innovation strategies are implemented, and in particular suppliers are likely to adapt their products for foreign buyers (i.e., 'learning by exporting'). Our results are driven by the interplay between the innovation costs' structure, the internationalization costs and the density of suppliers in the different countries.

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1 Introduction and motivation

Building on the abundant research on the impact of firms' export status or export intensity on productivity (see, for instance, Wagner, 2007; Crespi et al., 2008; Serti and Tomasi, 2008; Fryges and Wagner, 2008; Park et al., 2010), scholars have recently started to become interested in the effect of firms' internationalization activities also on their capacity of introducing product innovations. Recent contributions include Salomon and Shaver (2005), Liu and Buck (2007), Fafchamps et al. (2008), Lileeva and Trefler (2010), Bustos (2011), and Bratti and Felice (2011), among others. All these papers find evidence that exporters are more likely to introduce product innovations, i.e. evidence of 'learning-by-exporting'. Yet what still remain to be ascertained are the exact pathways of this effect. Why should firms learn from their exporting activities, especially when selling to similarly developed foreign economies?

Researchers have tried to give an answer to this question. Crespi et al. (2008) show that past exporting is significantly associated with more learning from customers (either firms or consumers) relative to other sources, such as suppliers, competitors and trade associations, and that firms which have an increase in learning from customers also have higher subsequent productivity growth. Baldwin and Gu (2004) report that exporters learn from foreign buyers through R&D agreements. Fafchamps et al. (2008) explain their evidence on learning-by-exporting as the need of Moroccan firms—mainly specialized in consumer items such as garment, textile, and leather—to design products that appeal to foreign consumers. Lileeva and Trefler (2010) interpret the positive effect of improved access to foreign markets on productivity and innovation as the result of an increased return of investing in innovation for exporters. Bratti and Felice (2011) show that, at least for Italy, the positive effect of exporting is not completely mediated by a higher formal innovative effort, e.g., by higher R&D, and put forwards that the effect may be partly demand-induced.

Although 'learning' is often suggested as an important channel through which involvement in foreign markets improves a firm's innovation capacity, previous studies rarely give detailed insights into what 'learning' is in this specific context, and into how it materializes.

By contrast, there is a widespread business and management literature, which despite not focusing explicitly on international markets, stresses the role of buyer-supplier collaborative relationships as a fundamental source of mutual learning. Innovation is described as a process that no longer happens exclusively within the firm, but which rather involves the entire supply chain or a network of actors (Bidault et al., 1998; Schiele, 2006). This literature also stresses that due to the need to deal with rapid changes in customer preferences, and shorter product life, there has been a gradual switch from a competitive model in which buyers were trying to minimize costs and using several suppliers to minimize risk, towards a cooperative model in which buyer-supplier relationships plays an important role in their ability to innovate (Roberts, 2001).

Another relevant stream of contributions, focusing on incremental innovation carried out by firms such as the introduction of a new design, not necessarily a path-breaking innovation, have underlined that users with specific needs are a fundamental source of information for developing new products (Hippel, 1988; Herstatt and von Hippel, 1992; Baldwin and von Hippel, 2010). The innovation process does not always originate from

a firm profiting from selling the innovation to users (i.e., customers), but it is spurred by a firm directly benefiting from the use of the innovation outcome.

In particular, cooperative relationships may emerge when the buyer requires parts and components that must be adapted to his product or process, i.e. for specialized intermediate goods. Specialized goods are usually traded under a *production to order* (PTO, hereafter) regime, i.e. firms produce following an order by other firms (Casaburi and Minerva, 2011). The larger the role played by product characteristics, the higher the informational frictions and therefore the need to build a relationship in order to exchange the specific good. PTO entails complex buyer-supplier relationships and a non-negligible exchange of information between business partners, from which we may expect a substantial amount of learning, since highly differentiated goods, by definition, require specialization. What is worth noting in this framework is that any innovation carried out by a downstream firm to sell a new product in the final market, by inducing the need of new inputs (and machinery) can potentially generate some collaboration in innovation activities with a supplier providing the required intermediate input for the downstream firms. In downstream firms product innovation can be induced by the interactions with consumer preferences, either directly through market research or indirectly, through intermediaries, while in upstream firms the demand side source of innovation is represented by the downstream firm's demand, i.e., the needs of another firm. We argue that interactions with final consumers differ substantially from those with other firms under several respects, which call for investigation.

The literature on innovation in international buyer-supplier relationship is still scant, despite some exceptions. Egan and Mody (1992) give several useful hints on the characteristics of these relationships when they are developed in different countries. First, a relationship often begins with a short-term agreement between the buyer and the supplier through which they learn each other's demands and capabilities. Egan and Moody report for instance how 'no matter how careful the selection process, the real test of a buyer's decision comes when the buyer and the supplier are working together. For this reason, buyers tend to remain cautious after the final selection. For example, buyers often begin with small orders, perhaps for a simple product, and let the relationship build gradually' (p. 330). We will refer to this feature as 'starting small' (see, among others mentioned in the section below, in particular the contribution of Rauch and Watson, 2003): the buyer may want to buy the intermediate good provided by the supplier as it is, before starting with him a permanent relationship and asking to substantially modify it. On the one side, suppliers often collaborate with buyers' product designers and may play a crucial role in developing new products, by cutting costs and improving quality. On the other side, learning may be transferred to suppliers in a variety of forms such as worker training or specific lessons on product details.

These complex relationships are characterized by imperfect information, agency problems and contractual frictions, this implying also that both the relationship and the knowledge transfer are likely to evolve differently when firms are based in different countries. Moreover, a key feature of buyer-supplier relationships is that both buyers and suppliers not only have benefits but also bear costs to invest in this collaborative relationship, and these costs may differ in international and domestic matches.

Is the potential explanation for 'learning by exporting' that we are considering in this paper quantitatively relevant? On the one side, a high and increasing percentage

of international trade is in specialized goods (Rauch, 1999; Artopoulos et al., 2011), and in particular in intermediate goods (WTO, 2008), which usually imply complex buyer-supplier interactions. On the other side, PTO is widespread among European firms. The European survey used in this paper (EFIGE) shows that 86 percent of Manufacturing firms produce to order, and about 77 percent produce for other firms. Among the latter, on average 82 percent of total turnover is produced to order. Thus, in analyzing buyer-supplier relationships, we are considering an innovation channel which is potentially relevant to a vast majority of manufacturing firms in Europe. Using the same data, we provide some descriptive empirical evidence that firms doing PTO for foreign firms (exporters) are indeed more likely to introduce product innovations than firms doing PTO for domestic buyers. Moreover, new exporters are less likely to introduce product innovations than firms having already an established presence in foreign markets, a feature which is more in line with 'learning' than with firm's 'self-selection' into foreign markets.

Thus, taking as a starting point the existing evidence on 'learning by exporting' provided by recent empirical studies (plus further new descriptive evidence provided in Section 2), and the detailed insights of the studies on buyer-supplier relationships mentioned above, in this paper we aim to bridge the two literatures to go a step forward towards dissecting the mechanisms of the effect of exporting on product innovation.

We build a theoretical model along the lines of the literature introducing incomplete contracts, agency frictions and imperfect information in international trade related to the provision of specific inputs (Rauch and Trinidade, 2003; Grossman and Helpman, 2005; Puga and Trefler, 2010). In our approach firms are heterogeneous in their product characteristics (i.e., location in the product characteristics space) and are involved in a PTO relationship. Like Araujo et al. (2012), we abstract from firms' heterogeneity in productivity since we aim to focus on a different mechanism based on heterogeneity in firms' products. By assuming firms' boundaries as given, we also abstract from the so called 'make or buy' decision.

We consider a framework in which two firms, a downstream producer and an upstream producer, interact under a PTO mode; in order for the final good to be produced firms have to match and the buyer must buy a specialized input by a supplier. In order for the input of the supplier to match the buyer's needs, some adaptation is always required, i.e. filling the 'distance' between the intermediate good he requires and the one provided by the supplier. We are mainly interested in 'incremental innovation', that is, in all the changes that firms develop in their product in their day-by-day activities. In case of a successful match, when distance is not too large, a cooperative relationship starts, where buyers and suppliers exchange information under the form of project or design activities or mutual assistance. This form of cooperation requires bearing some costs, even in case an actor is not directly responsible for the implementation of the innovation (some costs are related to the distance in needs, 'implementation costs', while some others are related to providing instructions and assistance). Implementing the innovation by the supplier following the buyer's specifics is likely to be more costly when the new intermediate good to be produced is more distant from what he is already producing, i.e. his 'core competency'. So in our framework, according to this distance in the product characteristics space, the buyer may ask the supplier to adapt his good following his specific instructions or he can directly manage the adaptation process, assisted by the supplier. Firms often find themselves the suitable solution to their specific needs and

develop product design; they often transfer their innovations (design or product), for instance process equipment, to suppliers in order to obtain a source of supply for their innovation that is cheaper than in-house production. On the other side, several studies have reported that firms modify in-house the components produced by suppliers in order to make them suitable for their process (see the recent work of Gault and von Hippel, 2009; de Jong and von Hippel, 2009, and the review of the recent literature included in their studies).

In both cases a collaboration in innovation between the two emerges, but what we define 'product innovation' arises when the supplier modifies the input following the buyer's order. Either buyer's or supplier's innovation can be implemented when firms are located in the same or in different countries. We single out and compare the distance intervals in the product characteristics space as a function of the innovation and internationalization costs' parameters and the densities of suppliers in different countries. In these intervals different innovation and internationalization strategies are implemented.

By incorporating many real-world features highlighted by the literature outlined above, our model is also in line with some well established empirical facts.

First, we use a framework of imperfect information in foreign markets. Buyers can match with a domestic supplier, or, alternatively, they can search for a supplier closer to their needs in the foreign markets. As a result of buyers' decisions on whether to search abroad or not, different internationalization strategies emerge, depending on the distance between buyers' needs and the characteristics of the supplier's good in the domestic match, this, in turn, implying some heterogeneity across suppliers: some of them selling only domestically, some of them exporting.

Second, buyers do not know the characteristics of foreign inputs, and a successful match requires a first meeting in which suppliers sell their existing intermediate goods. Through this test ('start small') the buyer learns the characteristics of the product, i.e. the 'distance' between the intermediate good he requires and the one provided by the foreign supplier. In case the distance is too large in the foreign match, however, the first meeting will not lead to a successful match, and the buyer who was looking for a partner in the foreign market will go back home to continue his search for a suitable supplier in the domestic market. In this case, the firm will be involved in temporary trade. There is indeed increasing evidence that export values are usually small when a firm enters a new market and that the export flows have a very short duration (one or two years), while few survive for a longer period (Lawless, 2009) or that a high percentage of firm-product destinations are temporary (Békés and Muraközy, 2012). In our framework temporary trade is generated by the supplier's intermediate good being bought by a foreign buyer (firm) to test it with the possibility of the business relationship breaking down in case the intermediate good supplied is too distant from the buyer's needs. As a consequence, temporary traders are less likely to innovate, a feature which is observed in the EFIGE data.

Third, in a successful foreign match, depending on the distance, there are heterogeneous decisions across buyers on whether to directly adapt or ask the supplier to adapt the input, this in turn generating heterogeneous innovation strategies among the suppliers, some of them selling the existing input, and some of them innovating. We explore under which circumstances suppliers of specialized goods engaged in international matches with foreign buyers may show a higher propensity to introduce product innovations and adapt

their goods to the buyer's needs than suppliers engaged in domestic matches (i.e., 'learning by exporting'). We single out and discuss the conditions under which this happens, which are related to the interplay among the innovation cost parameters, a per-period fixed internationalization cost, and the number of suppliers in both the supplier's and the buyer's countries.

From a policy perspective, on the one side, our work highlights that a reduction in trade barriers may positively affect an economic system by improving the innovative performance of existing firms acting as suppliers and not only through the well known selection mechanism by which only ex-ante more innovative firms survive the international competition. On the other side, it suggests that policy interventions are called for in order to enforce an adequate institutional system capable of supporting firms' activities in international markets. This is particularly relevant for those small-medium firms which do not have the scale to bear the high cost of R&D and for which the relationships with foreign buyers represent an important opportunity for innovation.

Related literature

We depart from the existing work, as recent contributions in the heterogeneous firms' international trade literature have endogenized firms' decisions to invest in R&D to enhance either the quality of their goods (Costantini and Melitz, 2008; Atkeson and Burstein, 2010; Bustos, 2011), or the number of product varieties in multiproduct firms (Bernard et al., 2011), or both (Eckel et al., 2010). Indeed, this literature has mainly emphasized asymmetries between products on the final demand side, while product innovation induced by interactions with firm-buyers' needs, to the best of our knowledge, has not been addressed by previous contributions yet. It is worth mentioning that, in a different framework, Artopoulos et al. (2011) explain the differences in export performance across developing countries by highlighting that product adaptation (in order to satisfy needs of more advanced economies), possibly through interactions with foreign distributors, it is a necessary but not a sufficient condition to export. What is determinant for succeeding in foreign markets is to develop adequate 'export business strategies', in particular, by following an export pioneer in the sector, who has developed a new way of conducing business and knows how foreign markets operate.

The contributions closest to our work are those belonging to the large literature on global sourcing, in particular those introducing contractual incompleteness and imperfect information in international trade models with product specialization (Grossman and Helpman, 2005; Rauch and Trinidade, 2003; Puga and Trefler, 2010). These works are concerned with firms' decisions on the geographical location of the partner in production, when products are specialized and countries differ in labor costs, technological levels and quality of institutions. Our contribution departs from those of Grossman and Helpman (2005) and Rauch and Trinidade (2003) mainly in the analysis of the innovation process. In Grossman and Helpman (2005) only the subcontractors adapt their inputs to match the buyers' needs, while in Rauch and Trinidade (2003) firms do not change location in the product space, i.e., they do not adapt their product. Therefore, in these contributions, decisions do not involve innovation strategies, but instead whether and where to match. These works aim at highlighting the role of institutions (affecting the enforceability of contracts) in differently developed countries (Grossman and Helpman, 2005) and the role of information barriers and that of network ties in overcoming these

barriers (Rauch and Trinidade, 2003), in affecting the volume of trade across countries when products are differentiated. Different innovation strategies are instead investigated by Puga and Trefler (2010), where a buyer located in a Northern technologically advanced country decides where to buy the component he needs among several developing countries differing in labor costs and technological levels and whether or not to involve the supplier in the innovation process. In this work suppliers are heterogeneous in the 'residual incompatibilities' they would imply for the buyer if they carry out the innovation effort and firms are involved in medium-long term relationships. Our work borrows extensively from the analysis of the innovation process carried out by the authors, while, abstracting from countries' differences in the level of development, we depart from their work in two main directions. Firstly, we focus on firm heterogeneity in the product characteristics space, highlighting how firms' location in the product space induces different innovation and internationalization strategies, this way encompassing the case that also the supplier may bear adaptation costs which are related to distance. Secondly, we also consider short-term relationships where temporary trade may emerge (i.e., when the relationship breaks down).

Our model also captures another stylized fact recently highlighted by the empirical literature: the existence of temporary trade (Békés and Muraközy, 2012). Indeed, in our framework suppliers may be engaged in a temporary match with foreign buyers, this match may break down later on as the latter may realize that the input is not fit to produce their products, that is it would require an excessive adaptation. So key in our model is the role of uncertainty in the features of the intermediate good (and in the related innovation or adaptation costs) provided by the foreign supplier. Therefore, our work is also related with the recent literature providing a potential interpretation of the existence of temporary trade relationships, in particular to those contributions stressing asymmetric information and incomplete contracts emerging when the attributes or the reliability of the trading partner cannot be easily observed (Rauch and Watson, 2003; Besedes and Prusa, 2006; Aeberhardt et al., 2011; Araujo et al., 2012; Békés and Muraközy, 2012). This approach helps explain the initially small and then growing export values, the low surviving rates of many export activities, the positive relationship between quality of institutions in destination countries and export surviving in a framework of contractual incompleteness. This literature provides interesting insights into the determinants of export decisions and duration, where the 'learning' process is not related to product characteristics, as in our framework. [1]

Since in our work we do not investigate the determinants of firms' boundaries, we depart from the global sourcing literature focusing on the determinants of firms' offshoring mode (i.e., 'make or buy' decision: vertical integration vs. outsourcing in a foreign

[1] In the literature, temporary trade has been modeled in a number of ways. Some authors explain it with uncertainty on productivity coupled with sunk and a certain fixed per-period cost of exporting (Ghironi and Melitz, 2005). Others assume instead uncertainty in the per-period fixed costs of exporting (Segura-Cayuela and Vilarrubia, 2008). In both cases temporary shocks in the uncertain variable may push firms to enter or exit from foreign markets. Some authors consider multi-product firms and model entry and exit in terms of product destinations (Crozet et al., 2008). Other contributions stress the possibility of the firm to choose a marketing technology in a framework in which costly advertising is needed to reach more consumers. Among the contributions in this line there are Arkolakis (2010), Arkolakis and Muendler (2010), Buono et al. (2008), and very recently Békés and Muraközy (2012), to which we refer for a more detailed review of recent developments.

country) and looking in particular either at the role of International Property Rights' protection in the destination countries (Glass and Wu, 2007) or at the technological content of the goods (Acemoglu et al., 2010) or at both (Naghavi et al., 2011). Nevertheless, we are close to these works, in focusing on what we may call the 'innovation boundaries', since we deal with who between the two partners should adapt the intermediate good.[2]

The structure of the paper is as follows. Section 2 provides some descriptive empirical evidence on the differential product innovativeness of firms producing to order for foreign buyers vs. domestic buyers. In section 3 we develop the theoretical model to interpret the empirical evidence. Section 4 concludes.

2 Descriptive empirical evidence

As we already said, in this paper we try to offer a new reading for the evidence on learning-by-exporting in product innovation. Our theoretical explanation is mainly focused on the demand channel, concerns interactions between firms and is based on PTO relationships between buyers and suppliers of specialized intermediate goods. However, to the best of our knowledge, there is still lack of descriptive evidence specifically on the association between exporting and product innovation for firms doing PTO for other firms. For this reason, the aim of the present section is twofold. First, we provide evidence on the potential relevance of our explanation, assessing the incidence of the particular way of organizing production that we consider (PTO). Second, we offer some *descriptive* evidence on the association between PTO for foreign firms and product innovativeness, which will motivate our theoretical model. The model will try to 'match' some of the empirical facts reported in this section and the past literature.

2.1 The EFIGE data

We use the EFIGE dataset which was collected within the project 'EFIGE - European Firms in a Global Economy: internal policies for external competitiveness'. The EFIGE survey gathers firm-level data on Manufacturing firms in seven countries: around 3,000 firms for France, Germany, Italy and Spain, 2,000 for the UK, and 500 for Austria and Hungary. The survey questionnaire is mainly focused on 2008, with some questions on firm activities in 2009 and in previous years. The data set includes data on 14,911 firms. The survey gathers a wealth of information on firm international activities, innovation, and organization, which are complemented with balance sheet data from AMADEUS, a database of comparable financial information for public and private companies across Europe, collected by the Bureau van Dijk.

EFIGE provides information on the firm's production mode, in particular firms were asked if they made PTO for other firms, the public administration or final consumers. For the purpose of this paper, we select only firms which make some PTO for other firms. In the original sample 86.7 percent of firms are engaged in PTO, while 77.21 per cent do PTO

[2]On another side, innovation costs are a relevant determinant of firms' decisions, like in our work, in the literature analyzing the determinants of firms' R&D offshoring given the multinational structure of the firm (Sanna-Randaccio and Veugelers, 2007). Beyond the fact that these works are developed in an oligopoly framework and deal with vertically integrated firms, we depart from them in the role we assign to firms' heterogeneity in product characteristics.

for other firms. Among those firms doing PTO for other firms, on average 82 per cent of turnover is produced to order; the first quartile is 80 per cent and the median 100 per cent. These figures show that PTO for other firms is widespread in Manufacturing, and may represent a very important means through which relevant information is exchanged between buyers and suppliers.

We drop from the sample all firms producing for other firms which belong to the same group (1628 observations), as buyer-supplier relationships may be very peculiar for this specific group, and the sample falls to 10,222 firms, accounting for about 68 percent of the original sample. These criteria select 55.9 percent of Austrian firms, 82.8 percent of French firms, 68.5 percent of German firms, 85.7 percent of Hungarian firms, 86 percent of Italian firms, 67.2 percent of Spanish firms and 77.1 percent of UK firms.

The EFIGE questionnaire includes the following multiple question

> **C14**. On average in the last three years (2007-2009), did the firm carry out any (multiple answers allowed):
>
> - product innovation (i.e. introduction of a good which is either new or significantly improved with respect to its fundamental characteristics; the innovation should be new to your firm, not necessarily to the market)
> - process innovation (i.e. the adoption of a production technology which is either new or significantly improved; the innovation should be new to your firm; your firm has not necessarily to be the first to introduce this process)
> - none of the above.

in particular, we define a product innovation dummy which takes value one in case the firm answered positively to the first sub-question and zero otherwise. As it is clear, our product innovation variable nests both radical and incremental innovations.

First, we look at the raw data in search for evidence that PTO for foreign firms may induce firms to introduce more product innovations. In Table 1 we split the estimation sample (see below) of firms doing PTO between those matched with at least one foreign customer and those which are producing to order only for domestic customers, and report some descriptive statistics. Firms matched internationally are about 49 percent of the sample. The raw statistics in Table 1 confirm that they have an advantage in the likelihood of introducing product innovations, but also that they are different in a number of observable characteristics which may explain the positive association between exporting and product innovativeness: on average they are larger and more capital intensive, invest more in R&D, have lower labor unit costs, hire more university graduates, are more likely to be importers or invest in FDI, and be part of a domestic or foreign group of firms.

We said that Crespi et al. (2008) report that exporting firms are relatively more likely to learn from customers with respect to non-exporters, and this was the only difference in the sources of learning between the two types of firms. Similarly, we want to assess in this section whether producers (to order) matched to foreign firms are relatively more likely to innovate their products, and if this association is robust to controlling for the observable differences outlined above. We start with a very simple empirical specification

$$y_i = \alpha_0 + \alpha_1 FORCUST_i + \alpha_2 x_i + \epsilon_i \tag{1}$$

where y_i is a dichotomous variable which takes on value one in case firm i introduced product innovations and zero otherwise, $FORCUST_i$ is a dichotomous variable that is

equal to one in case the firm produced to order for a foreign customer and zero otherwise, x_i a vector of control variables and ϵ_i an error term. α is a vector of parameters to be estimated. Using cross-section data, we have no time variation.

As we said, EFIGE asks whether firms made PTO for foreign firms ($FORCUST_i$), and whether they exported (i.e. they sold their products abroad). Firms can of course export their products either directly and/or can make PTO for foreign firms, however PTO suppliers of foreign firms will be 'exporters' by definition. Put in other words, the data do not allow us to know whether PTO suppliers are directly exporting on top of the production they are making on order for foreign customers. An implication of this is that a dummy for being a PTO supplier for foreign firms will not exhibit any additional variation over and above a dummy for exporter status, and the two effects cannot be separately identified. For this reason, the exporter dummy is excluded from the regression, and we drop from the analysis firms who produced to order for domestic firms and declared to be exporters (1,342 firms). Doing this way the *control group* becomes firms who made PTO for domestic customers and are not involved in foreign markets (through direct exporting).

For the purpose of the analysis in this section, we are simply interested in documenting statistically and economically significant *associations*, and we neglect any potential source of endogeneity, using OLS. We have already said that some studies interpret the fact that exporters are also more likely to innovate as a potential consequence of the exchange of knowledge with foreign customers, leading to product innovations. Compared to those studies, here we analyze a more specific type of interactions, those taking place *between firms*, and in particular those where there is a *buyer which purchases an intermediate input from a supplier, who is producing to order*.

Table 2 shows the OLS estimates. In order to purge out the association between exporting and product innovation from potential contextual factors affecting the exporting and innovation decisions, we include control variables for firm size (number of employees), R&D employment share, capital-labor ratio, unit labor costs, graduate employment share, importer status, FDI investor status, participation in a domestic group, participation in a foreign group, 4-digit NACE industry fixed effects and country fixed effects, all variables which have been indicated by previous research as potentially important determinants or correlates of both innovation and exporting decisions (for the choice of the set of control variables, see Bratti and Felice, 2011). We have to drop some observations due to missing value in the covariates. The final estimation sample includes 6,125 observations. The OLS estimates in column (1) show that $FORCUST$ is associated with an about 12 per cent points higher probability of introducing product innovations. Other factors positively and significantly associated with product innovation are firm size, R&D investment, graduate employment share and importer status. [3]

Using the answer to another question asking if before 2008 the firm has exported any of

[3]As we said, the data does not allow us to say whether the association between $FORCUST$ and product innovation is due to producing to order for foreign customers or exporting directly (as some of these firms may also export directly their goods), however this problem can be partly addressed by focusing only on the (4,171) firms which produce 100 per cent of their turnover on order. OLS estimates on this subsample return a coefficient on $FORCUST$ of 0.12 stastically significant at the 1% level, which is very similar to the one obtained in the full sample and suggests that most exports of producers to order are likely to be accounted for by PTO for foreign buyers — also given the very high average percentage of turnover produced on order in the estimation sample (87%).

its products, we assess the importance of export experience in column (2). There are three possible answers to that question: exported regularly, sporadically and never. We distinguish firms selling internationally between long-term or regular exporters ($FORCUST = 1$ and exported regularly before 2008), sporadic exporters ($FORCUST = 1$ and exported sporadically before 2008), and new exporters ($FORCUST = 1$ and never exported before 2008). The point estimate of the coefficient on regular exporters turns out to be larger than the one on sporadic exporters (although the two coefficients are not statistically different at the 5% level), and on new exporters, which is not statistically significant. Thus the experience gained by firms in the foreign markets seems to be positively associated with their product innovativeness. As stressed by Fafchamps et al. (2008) this evidence may be interpreted as consistent with learning-by-exporting. Indeed, one may expect the coefficient on export status not to depend on exporting experience if firm self-selection into export markets is the main explanation for the positive association, and new exporters to be as much as innovative as 'old' exporters. In the theoretical model in the next section we will try to provide an explanation for both these empirical facts.

3 A model of exporting and innovation when trade is between firms

In the framework of the literature introducing incomplete contracts and search due to imperfect information in international trade (in particular, Rauch and Trinidade, 2003; Grossman and Helpman, 2005; Puga and Trefler, 2010), we propose a theoretical model to explain why we may observe a product innovation premium from producing to order for foreign customers, and what are the variables that strengthen or weaken such a positive association.

3.1 Set up

In our setting, there are two types of agents engaged in production: downstream producers (i.e., buyers) who purchase an input from upstream producers (i.e., suppliers). We develop a model to analyze alternative innovation strategies adopted by a firm, while taking as given its boundaries. Therefore, the downstream producers do not decide whether to buy the intermediate input from the supplier or to vertically integrate producing the intermediate input. Buyers and suppliers are distributed over the product characteristics unit circle.

We develop a partial equilibrium model, with two identical countries (i.e. neither income nor the level of technology differ)—except for (possibly) the number of both suppliers and buyers—where, in order to produce, buyers and suppliers have to match. The price of the intermediate good p_x, the price of the final good p_y, wages and operating profits are given and equal in the two countries.

For a match to work, some product adaptation (incremental innovation) is needed, depending on the distance between the buyer's needs and the supplier good's characteristics. Since both the buyer (B) and the supplier (S) can adapt, there are two possible innovation strategies: B can purchase the supplier's input as it is, and then adapt it (changing either the input or his needs, i.e. Buyer Innovation mode—IB); or B can pro-

vide the supplier with a 'project' according to which the Supplier adapts the input to fit his needs (i.e., Supplier Innovation mode—IS). As for the IS strategy, think of 'black box systems' where the supplier of the intermediate good executes the detailed design of a component based on specifications provided by the buyer (Bidault et al., 1998), who however may assist the supplier through in-plant worker training or specific lessons on product details.

In both strategies, some of the innovation costs to be borne in order to fill the distance and match are related to the distance in the product space between the B's needs and the characteristics of the input produced by S. B and S can be located either in the same or in different countries and they can implement either of the two strategies, both in domestic and in international matches. In this setting, B must make two decisions, one on the nature of the match (i.e. domestic vs. international) and one on the innovation mode (IS, IB), as described above, under S participation constraint.

Z_{ij}, with i, j the countries where B and S, respectively, are located, is the distance along the circle between B's 'needs' and S good's 'characteristics'. Z_{ii} and Z_{jj} are the distances between B and S in a Domestic match (D), in B and S countries, respectively; Z_{ij} is the distance between B and S in an International match (I). $Z_{ii} \sim U(0, 1/(2X_i)]$, Z_{ij}, $Z_{jj} \sim U(0, 1/(2X_j)]$, where X_i, X_j are the number of suppliers in the B's country and in the S's country, respectively. Information on Z_{ij} is imperfect (symmetrically) before matching (see section on timing below).

International matches differ from domestic ones for three reasons:

i Imperfect information on the location of suppliers in the foreign market. B initially knows the locations of all suppliers in his country and matches with the 'closest' supplier; B does not know the locations of suppliers in the foreign country, he only knows that suppliers are symmetrically distributed at the same distance under $Z_{ij} \sim U(0, 1/(2X_j)]$; they may be located at different points along the circle: a better match is potentially possible abroad, but this will be known only after 'trying'. Sunk search costs have to be borne by B to know the distance Z_{ij} in a random match with only one foreign supplier. These costs are a determinant of B decision to look for an international match.

ii International matches differ from domestic ones because they imply an additional cost: a per-period fixed 'internationalization' cost. Moreover, international matches differ from domestic matches because in the former firms ending up in a bad match can still go back home and match domestically, while in the latter this outside option is not allowed for, and bad matches imply no production and zero profits for both B and S. The 'internationalization' costs together with the opportunity to go back home not only affect the profitability of an international match with respect to a domestic one, but they also modify the relative profitability of the two innovation strategies in international vs. domestic matches.

iii The distance-related adaptation costs for B in the IB strategy may differ in international and domestic matches.

3.1.1 Innovation and costs

There is a sunk cost to enter the market and set up a core production line that each supplier must bear, together with some fixed costs in order to specialize the input for each buyer. Then, there are also some fixed costs that the supplier bears for each buyer each time that the customized good has to be produced and not once and for all (e.g. costs to switch to another line of production).

We consider that firms can be generally involved in two 'types' of innovation effort. A first type which is the outcome of a R&D investment autonomously carried out by a firm, from which emerge the 'ideation' of a new good. This process generates an order for the second type (or step) of innovation effort, to which we will refer in this paper as innovation. The latter is a process through which a new product or a change/improvement in an existing one become ready to be used. These are likely to be 'incremental innovations', that is, all the changes that firms develop in their product in their day-by-day activities. Both buyers and suppliers can engage in the first type of innovation: buyers invent a new product for the final market and suppliers invent a new core line. In particular, in order to enter the (domestic) market they have to. On the other side, the production of a new final good always involves a supplier-specific input, that may or may not already exist in the market. So the introduction of a new final good by a downstream firm may generate changes in an existing intermediate good.

In this paper, we are not interested in the first type of innovation effort, i.e., we are not interested in the process of entry, nor we are in the (always possible) strategy for both a downstream firm and an upstream firm of engaging in a R&D process in order to change location along the product characteristics circle after entering, or to add products (i.e., multiproduct firms). We are interested in singling out how B's needs may induce a deterministic process of product innovation for S (i.e. inducing S to adapt and specialize his good to match B's needs), through an order by B. This approach borrows from the literature on incremental innovation, highlighting the role of the demand side of the market as sophisticated needs inducing innovation, the role of the interaction with users as a source of innovation, the role of mutual learning in buyer-seller relationships, which we have mentioned in Section 1.

As a consequence of his successful introduction of a new final good (which we do not model, as pointed out above), there are two alternative strategies which B can choose between:

- *IB strategy* (buyer innovation-IB): B buying an existing S good, and adapting either his process or the acquired S good to his needs, by bearing a distance-related fixed cost, $b^{B_{ii}} Z_{ii}$, in a domestic match, and $b^{B_{ij}} Z_{ij}$ in an international match, where $b^{B_{ii}}$ and $b^{B_{ij}}$ are innovation costs per unit of distance in the product space, domestically and abroad respectively; in this case, S has to help B in adapting the input, by bearing a fixed cost F^S (for instance, the cost of technical assistance);

- *IS strategy* (supplier implementation-IS): B bearing the fixed cost F^B to solve the problem of figuring out what input exactly he needs to produce his good and asking S to produce it; it is the cost of providing the instructions of the design of the input he needs to another firm (i.e., the supplier). In this case S bears the distance-

related fixed cost $b^{S_{jj}} Z_{jj}$ in a domestic match and $b^{S_{ij}} Z_{ij}$ in an international match, where $b^{S_{jj}}$ and $b^{S_{ij}}$ are innovation costs per unit of distance in the product space, domestically and abroad respectively. That is to say S bears the cost of carrying out the design instructions.

The two strategies are modeled following the insights provided by the business literature mentioned in Section 1 and along the line of Grossman and Helpman (2005) and Puga and Trefler (2010) for the IS strategy, and Hesley and Strange (2002) for the IB strategy. [4]

It is worth noting that only the IS strategy translates into 'product innovation' (we refer to product as to the output produced by the supplier), since the intermediate input sold by the upstream firm is modified or improved, while the IB strategy does not, since is the process of the downstream firm which is changed (or alternatively the intermediate input bought by the downstream firm is changed by B, involving an 'input innovation').

There are other costs which have to be considered in the analysis:

- a *per-period fixed 'switching' cost*: σ, the cost that B and S have to bear each time that the customized good has to be produced.

- a *search cost*: η (sunk cost); B bears this cost when searching in the *foreign* market;

- a *per-period fixed 'internationalization' cost*: γ_{int}, a sum of costs that B and S have to bear whenever a relationship develops between different countries.

The role of sunk costs of internationalization, i.e., in our framework to import an intermediate good from a foreign country, has been highlighted and widely analyzed by the recent literature on global sourcing (Antràs and Helpman, 2004; Grossman and Helpman, 2005). The per-period 'internationalization' cost γ_{int} represents a collection of costs: the costs of insurance against exchange rate fluctuations, 'bureaucratic' costs (e.g., the costs of obtaining permissions and documents from foreign public offices), the costs of managing operations and of exchanging information between different countries. Since B is the downstream firm, the final product is assembled in his country; the S good has to travel from country S to country B; this generates some costs due to managing transport operations between different countries, not necessarily related to geographical distance (the latter could be relevant also within country, i.e., in domestic matches).

3.1.2 Timing and contract

Buyers and suppliers are initially involved in a domestic match; they are producing, respectively, a final good and a customized intermediate good (what we deal with here is 'innovation' by existing firms). We follow Grossman and Helpman (2005) in assuming that B knows the actual distribution of the domestic suppliers and he is matched with the closest one. B introduces an innovation in his product, this requiring a new specific

[4] Hesley and Strange (2002) investigate the role of space and proximity in the innovation process where input sharing encourage innovation by reducing the cost of realizing ideas for firms and where the buyer makes a decision on whether to buy existing inputs at lower costs or new inputs which better match his needs at higher costs. However, the model does not compare international versus domestic matches.

input (or adaptation in the one he is using).[5] Since B knows the actual distribution of suppliers in his domestic market, he also knows the location of the closest one (which could either be his current domestic supplier or a new one in the domestic market) in the product characteristics space for the new input he needs; therefore B decides whether to match and produce with the closest supplier in the domestic market or to look for a new supplier abroad. Since we are focusing on PTO relationships (following Grossman and Helpman, 2005; Puga and Trefler, 2010), we assume that the downstream producer, B, is the one searching abroad for a 'better' input. Therefore in our framework, the sunk cost of searching in the foreign market is born by the importing firm, B.[6]

B has imperfect information on the location of suppliers abroad: he only knows the number of suppliers and that they are symmetrically spaced in the product characteristics circle; so when searching in the foreign market B knows that it will match with an S at a random distance $Z_{ij} \sim U(0, 1/(2X_j)]$. Following Casella and Rauch (2003) the ones who go abroad pay a sunk cost to randomly match with one and only one foreign supplier. In this first meeting, they exchange the existing S good, and neither B nor S innovate. We assume that adaptation requires time and knowledge of the reciprocal characteristics (i.e., Z_{ij}). This is the reason why they engage in this first 'meeting'.[7]

As mentioned in Section 1, Egan and Mody (1992) point out several reasons why buyer-seller relationships grow incrementally and start usually with a short-term agreement. In our framework, 'trying the good' is necessary to reveal information about the location in the product space (i.e., on the relative distance between B needs and S characteristics). By randomly matching with S in a foreign match, B may have a profit loss which adds to the cost of searching, due to the fact that in this intermediate period, since no adaptation takes place, the S good does not fit his needs, and therefore the new final good cannot be produced. Indeed, B may directly sell the new input after having ascertained its characteristics.

After this temporary match, Z_{ij}, the distance between B and the randomly matched S, is revealed. By exchanging the existing good (i.e. from the S point of view, by exporting in t_0), B and S know each other and B decides whether to stay in the International match or not and, if so, under which type of innovation agreement (i.e., IS, IB). Only one attempt of international match is allowed for; we assume that the costs of searching

[5] B may want to introduce a new good because of changes in demand conditions or in the competitive environment; it is beyond the scope of this paper to analyze the determinants of B decision.

[6] There are several reasons why B may want to look for a new supplier abroad, as pointed out by Egan and Mody (1992). B may want to preserve credibility in negotiating prices and/or to protect against S non-performance; B may be looking for a new supplier for either current or future needs he foresees. What we are interested here in particular is the case in which B may be willing to introduce an innovation in his product, and therefore he needs a new specific input.

[7] We do not contrast here the 'learning by exporting' vs. the 'learning to export' hypothesis, according to which firms (suppliers in our framework) may carry out some innovation before entering the foreign market to meet some specific needs of the foreign buyers (Iacovone and Javorcik, 2010). We are interested in analyzing the innovation process whenever the costs of gathering information on the needs of a specific foreign buyer, and the costs of implementing some adaptation before 'meeting' are too high and the expected profits too uncertain to do it. On the other side, engaging in an R&D investment in order to discover new products without specific characteristics (i.e., a new core line in order to enter the foreign market) coincides with firms entering the foreign market with their own product, which is what S does here in the first meeting. Moreover, empirically we observe many small firms not engaged in R&D introducing product innovations.

again for an international match are too high to bear them a second time. If B and S end up in a bad international match they can only go back home, and match with a (possibly new) domestic partner. We follow Casella and Rauch (2003) and Rauch and Trinidade (2003) and allow firms ended up in a bad international match to go back and match domestically, differently from Puga and Trefler (2010) where firms have to remain in the match. Since here the intuition is that firms may match in a first meeting without carrying out innovation, in order to know each other and see whether it is worth matching internationally in a permanent way and how to do it (choice of the implementation or innovation mode), it would be unreasonable not to allow them to go back home when they have experienced a bad first match. Moreover, as mentioned above in this section, there is a wide evidence of low surviving rate of export activities and temporary trade. Following the job-search literature, we assume the knowledge of the domestic distribution in t_1 is imperfect for who went abroad in t_0 (i.e., there is no 'recall' of suppliers's locations), since the closest supplier previously identified by B could be no longer available.[8]

Buyers who do not find it convenient to search abroad, match with the closest supplier under IB or IS, in t_0, and keep on with the relationship in t_1.

Bargaining and contract

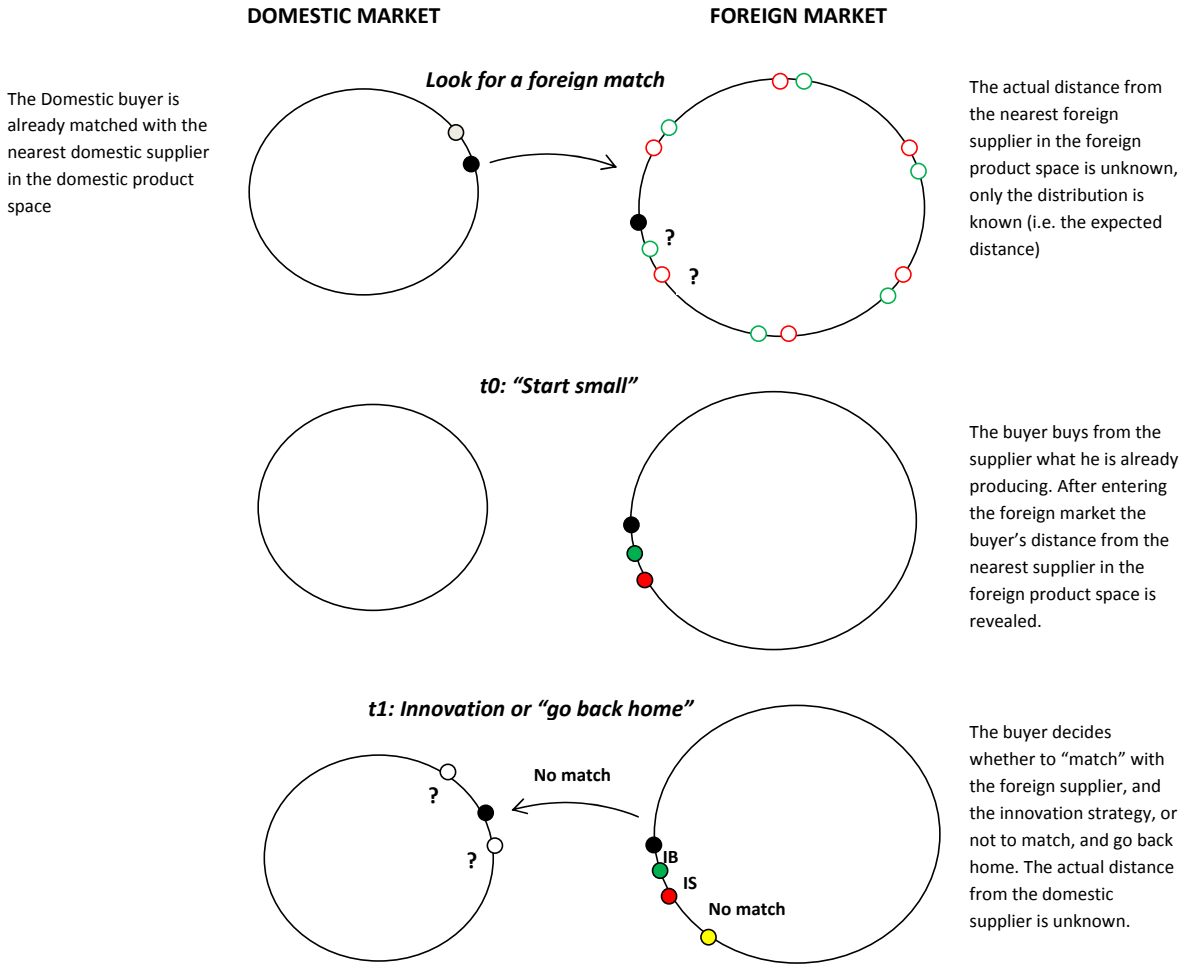
Since we are focusing on firms' strategies when firms are involved in PTO relationships, following Puga and Trefler (2010) in our framework B is the principal. Thus, both in the domestic and in the international matches, B offers an order contract to S that can either be IS or IB depending on what maximizes B profits, under S participation constraint (PC, hereafter).[9] When B decides the strategy, Z_{ii} and Z_{ij}, distances in the domestic and international matches, respectively, are known. After a decision is made, innovation costs are borne individually by B and S, depending on the strategy. The setting is one of incomplete contracts. We follow the literature on relation-specific investment (see, in particular, in a similar framework Grossman and Helpman, 2005; Antràs and Helpman, 2004; Puga and Trefler, 2010) in assuming that firms cannot sign ex-ante enforceable contracts specifying the innovation effort. When they sign the contract Z_{ij} is already revealed, but, due to the particular characteristics of the innovation effort, we assume that the contract is not contingent on Z_{ij}, since innovation effort is hardly verifiable by an external court and firms cannot commit not to renegotiate about profits after the innovation costs are born because the characteristics of the innovation effort (i.e., technical assistance quality, detail of the project, implementation) are revealed only after that the investment is sunk (Grossman and Hart, 1986; Hart and Moore, 1999).[10] Therefore, since it would be too costly to sign an ex-ante contract specifying all the states of the world, agents bargain ex post (i.e., ex-post Nash bargaining sharing rule). Under the IS

[8]This implies that the exact location of suppliers in the domestic market becomes unknown after having been abroad, while B continues to know their distribution function. A possible rationalization is that B looks for a new domestic supplier after having been abroad by posting an advertisement to which a domestic supplier randomly drawn from the domestic distribution answers.

[9]As previously mentioned, we take as given firms' boundaries, thus, we do not model the decision on ownership, assuming away vertical integration. S controls the production of the input and B controls the production of the final product. Moreover, we do not model the decision on who should decide the strategy and consider B as the principal.

[10]By contrast, the innovation effort is ex-post observable by B and S, symmetrically.

Figure 1: Timing of the process



strategy, B provides a project to S by bearing the cost F_B and S produces a prototype of the intermediate input following the order described in the project by bearing the distance-related costs. Under the IB strategy, S provides a sample of the intermediate input to B joint with the required technical assistance (bearing the cost F_S) and B finds out how to make the input fit his production process, bearing the distance related costs. Then the contract is signed, S produces and sells to B the intermediate input, B produces the new final good, profits are realized and all payments are made depending on the implementation strategy. The contract specifies what the payment will be contingent on production taking place, and on the type of innovation strategy (IS, IB). It is worth noting that, since we take as given the boundaries of the firm, in order to produce both partners have to contribute, thus their incentives are aligned once the innovation costs are born.

B and S, matching either domestically or internationally bargain over the operating profit Π, from selling the final good to the market. In a bad match, the operating profit will be $\Pi = 0$, since the new good is not produced, while in a good match, the profits will be $\Pi^{ij} = \Pi^{ii} = \Pi^{jj} = \Pi$ (the two countries are identical with respect to prices of both final and intermediate goods, wages and profits). No bargaining takes place in the exchange of the existing good in t_0: B gets Π_{fm}, the operating profit from selling directly the new input. We assume that B and S share the same bargaining power at the stage the contract is signed in both the strategies. Nevertheless, while in the domestic matches B and S equally split the 'pie', the revenue share may differ in the international matches since B and S in this case have the option to go back home and look for a partner in their own country. These options are the expected profits in the domestic matches, which are related to the number of suppliers in the domestic markets, which in turn may differ across countries. For this reason, on the one side, parties negotiate over a smaller revenue in the international matches, and on the other side either B or S may get a larger revenue share. It is worth noting that the outside options are affecting what B and S receive in the international matches symmetrically under both IB and IS strategies. Therefore, choosing a strategy does not imply choosing a different distribution of the revenue.

3.2 Equilibrium

Before continuing, we introduce some simplifying assumptions. We assume that the unitary distance-related cost (i.e., the cost per unit of distance in the product space) of adapting the good for S is the same in both international and domestic matches ($b^{Sjj} = b^{Sij} = b^S$). S receives an order from B with the exact specifics on what he needs, and S has to adapt following the order; moreover, S knows his own input; then, the difference in the adaptation costs in international vs. domestic matches should not be relevant for S. We express the unit of distance-related cost of adapting for B in terms of the cost for S and we allow it to be different in international and domestic matches, in particular, $b^{Bjj} = \alpha^D b^S$, $b^{Bij} = \alpha^I b^S$, where the α's are the buyer-supplier cost ratios. The cost for B to adapt his process or final product to a foreign intermediate good will be probably different (and most probably higher) from the cost of adapting for a domestic supplier. B, who is already matched with a domestic supplier, is likely to be 'less familiar' with a foreign supplier's intermediate good.[11] Moreover, different countries,

[11] This assumption is in line with Puga and Trefler (2010), in a slightly different framework.

even if similarly developed, may show technical incompatibilities which need fixing.[12]

We want to underline with these simplifying assumptions the role of the difference in the cost of adapting between B and S and how this difference may change in international matches. Moreover, we assume that the cost for S of assisting B in the IB strategy and the cost for B to provide a project for S in the IS strategy are the same ($F^B = F^S = F$). The model is solved by backward induction; we look for the Nash Bargaining solution.

In what follows, we assume both $\alpha^D \geq 1$ and $\alpha^I \geq 1$: the cost of adapting for B is at least as big as the cost of adapting for S for a given distance Z. We think it is reasonable to assume to be more costly for B to adapt to an existing input (for any given distance) than for S to modify his own good following an order by B.[13]

Table 3 summarizes the definition of variables and parameters.

3.2.1 Buyer's decision on the innovation strategy in the domestic matches (D)

In this framework, B chooses the strategy between IB and IS giving the higher operational profits net of the innovation costs under S participation constraint, where $\pi_B^{IB,D} = \frac{\Pi}{2} - \alpha^D b^S Z_{ii}$ and $\pi_S^{IB,D} = \frac{\Pi}{2} - F$ are the net total profits received by B and S, respectively, in a domestic match under IB; $\pi_B^{IS,D} = \frac{\Pi}{2} - F$ and $\pi_S^{IS,D} = \frac{\Pi}{2} - b^S Z_{ii}$ are the net total profits received by B and S respectively in a domestic match under IS; and where Π are the total operational profits (see Section 5.1 in the Appendix).

The solution of the B decision problem allows us to identify the following intervals of distances in the product space where either the IB or the IS strategy are implemented, respectively, or no match takes place (see Section 5.1, in the Appendix). Whenever $Z_{ii} \in [0, \underline{Z_{ii}}]$, the IB strategy is implemented in a domestic match, while whenever $Z_{ii} \in (\underline{Z_{ii}}, \overline{Z_{ii}}]$, the IS strategy is implemented. If instead $Z_{ii} \in (\overline{Z_{ii}}, \frac{1}{2X_i}]$, with X_i number of suppliers in B domestic market, the distance is too large, costs are too high and the match fails. In this last case the new final good is not introduced by B. The thresholds delimiting the intervals are the following:

$$\underline{Z_{ii}} = \frac{F}{\alpha^D b^S} \tag{2}$$

$$\overline{Z_{ii}} = \frac{1}{b^S}\left(\frac{\Pi}{2}\right) \tag{3}$$

[12]For instance, cars sold in the US are bigger than those sold in Italy; a US producer may find a components' producer in Italy producing exactly what he needs for his new car's model, but since the Italian components are designed for smaller cars, this would imply a higher per unit of distance cost of adapting the component to its production process that is targeted to larger cars.

[13]We have also considered the case in which the cost of adapting per unit of distance is higher for S, i.e. $\alpha^D < 1$ and $\alpha^I < 1$.

3.2.2 Buyer's decision on the innovation strategy in the international matches (I)

As we said, when B and S end up in a 'bad' international match, they can always go back home and look for a (possibly new) partner in the Domestic market. After the intermediate period in which they have been involved in the international match, information on the exact locations of the domestic suppliers and buyers, for B and S, respectively, is imperfect. Therefore the outside options in an international match are the expected profits of the domestic matches ($OUT_k^I = E(\pi_k^D)$, where $k = S, B$).

These outside options are given by:

$$E(\pi_S^D) \equiv \int_0^{\underline{Z}_{jj}} \pi_S^{IB,D} \cdot g(Z_j) dZ_{jj} + \int_{\underline{Z}_{jj}}^{\overline{Z}_{jj}} \pi_S^{IS,D} \cdot g(Z_j) dZ_{jj} \equiv G(X_j, F, \Pi, \alpha^D, b^S) \quad (4)$$

and

$$E(\pi_B^D) \equiv \int_0^{\underline{Z}_{ii}} \pi_B^{IB,D} \cdot h(Z_i) dZ_{ii} + \int_{\underline{Z}_{ii}}^{\overline{Z}_{ii}} \pi_B^{IS,D} \cdot h(Z_i) dZ_{ii} \equiv H(X_i, F, \Pi, \alpha^D, b^S) \quad (5)$$

where $E(\pi_S^D)$ and $E(\pi_B^D)$ are the expected profits of the domestic matches for S and B, respectively; $g(Z_j) = 2X_j$ and $h(Z_i) = 2X_i$ are the densities of the distances in the S and B domestic markets, respectively (see Section 5.2, in the Appendix) .

A buyer who has decided to look for a better match (i.e., a closer supplier) in the international markets will decide whether to stay or not in the randomly drawn match and under which innovation strategy, as opposed to going back to his domestic market only after that Z_{ij} is revealed. B chooses the strategy giving the higher operational profits net of the innovation costs under S participation constraint (see Section 5.2).

The outcome of the B decision process allows us to identify the intervals where either one of the two strategies are implemented or no international match takes place. Whenever $Z_{ij} \in [0, \underline{Z_{ij}}]$, the IB strategy is implemented, while when $Z_{ij} \in (\underline{Z_{ij}}, \overline{Z_{ij}}]$, B chooses the IS strategy; for distances in the interval $Z_{ij} \in (\overline{Z_{ij}}, \frac{1}{2X_j}]$ B chooses to go back home and look for a domestic supplier. The thresholds delimiting the relevant intervals are given by:

$$\underline{Z}_{ij} = \frac{F}{\alpha^I b^S} \quad (6)$$

$$\overline{Z}_{ij} = \frac{1}{2b^S} \left[\Pi - \gamma_{int} - E(\pi_B^D) - E(\pi_S^D)\right] \quad (7)$$

where X_j is the number of suppliers in the foreign market where B has searched.

3.2.3 Buyer's internationalization decision

As described in Section 3.1.2, at t_0, B decides whether to look for a international match or not. When making this decision B knows the actual distribution of suppliers in the domestic market, and then his own Z_{jj}, but not the actual distribution in the foreign market; the expected profits in the foreign matches are given by:

$$E(\pi_B^I) \equiv L(X_j, F, \Pi, \alpha^D, \alpha^I, b^S, \gamma_{int}) = \\ = \int_0^{\underline{Z}_{ij}} \pi_B^{IB,I} \cdot g(Z_{jj}) dZ_{ij} + \int_{\underline{Z}_{ij}}^{\overline{Z}_{ij}} \pi_B^{IS,I} \cdot g(Z_{jj}) dZ_{ij} + \int_{\overline{Z}_{ij}}^{\frac{1}{2X_j}} E(\pi_B^D) \cdot g(Z_{jj}) dZ_{ij} \tag{8}$$

where $E(\pi_B^D)$ are B expected profits in the domestic matches (5), $\pi_B^{IB,I}$ and $\pi_B^{IS,I}$ are the net total profits received by B under IB and IS strategy in the international matches, respectively, (24 and 26), and $g(Z_j) = 2X_j$ is the density of the distances in the foreign market where B searches.

In making his decision on whether to search abroad or not, B compares the profits of matching for two periods in the domestic market with the profits of searching in the international market.

$\pi_{B,0}^I = \Pi_{fm} - \eta$ are the total net profits that B gets at t_0, during the first meeting, if he decides to look for an international match; B bears a sunk cost of searching in the foreign market (η) and in the first meeting (fm, hereafter) B randomly matching with S, buys the existent input this implying a potential profit loss, ($\Pi_{fm} < \Pi$), since no adaptation takes place and the new good cannot be produced. $\pi_{B,0}^{IB,D}$ and $\pi_{B,0}^{IS,D}$ are the operating profits for B at t_0 in the case he decides to match domestically, under either the IB or the IS strategy, respectively, depending on the domestic distance with his nearest supplier; $\pi_{B,1}^D = \frac{\Pi - \sigma}{2}$ is what B gets at t_1, when he keeps on with the existent relationship in the domestic market. At this stage B and S already matched at t_0 do not have to bear again the innovation costs. The only cost they have to bear and split is σ, a cost for switching the line for S in order to produce for B.

At t_0, buyers whose nearest supplier in the domestic market is at a distance $Z_{ii} \in [0, \underline{Z_{ii}}]$, i.e., buyers who would be involved in a IB strategy in the domestic market, will go and look for an international match if

$$\pi_{B,0}^I + E(\pi_B^I) \geq (\pi_{B,0}^{IB,D} + \pi_{B,1}^D). \tag{9}$$

A buyer whose nearest supplier in the domestic market is at a distance $Z_{ii} \in (\underline{Z_{ii}}, \overline{Z_{ii}}]$, i.e., B who would be involved in a IS strategy in the domestic market, will go and look for an international match if

$$\pi_{B,0}^I + E(\pi_B^I) \geq (\pi_{B,0}^{IS,D} + \pi_{B,1}^D). \tag{10}$$

Finally, buyers whose nearest supplier in the domestic market is at a distance such that he will not produce the new good ($Z_{ii} \in (\overline{Z_{ii}}, \frac{1}{2X_i}]$), will go and look for an international match if

$$\pi^I_{B,0} + E(\pi^I_B) \geq 0. \tag{11}$$

The outcome of B decision problem allows us to identify the intervals in the domestic product characteristics space where B either stay in a domestic match or looks for a foreign match engaging in a first meeting abroad (See 5.3 in the Appendix).

For $Z_{ii} \in [0, \widehat{Z_{ii}})$, buyers match in the domestic market under IB strategy; for $Z_{ii} \in [\widehat{Z_{ii}}, \underline{Z_{ii}}]$, i.e. all buyers who would implement an IB strategy in the domestic market, search for a foreign partner, if the search costs are small enough ($\eta < \eta_0$). For $Z_{ii} \in (\underline{Z_{ii}}, \overline{Z_{ii}}]$, i.e. all buyers, who would implement an IS strategy in the domestic market, search for a foreign partner (iff $\eta < \eta_1 = \eta_0$). When distances in the domestic market are too large, $Z_{ii} \in (\overline{Z_{ii}}, \frac{1}{2X_i}]$, B who would not find a domestic partner all search for a foreign partner (iff $\eta < \eta_1$). The relevant thresholds in the domestic product characteristics space for B decision on whether to go abroad or not are given by: $\widehat{Z_{ii}} = \frac{1}{\alpha^D b_S}[\Pi - \Pi_{fm} - \frac{\sigma}{2} + \eta - E(\pi^I_B)]$, $\underline{Z_{ii}} = \frac{F}{\alpha^D b_S}$, $\overline{Z_{ii}} = \frac{1}{b_S}\frac{\Pi}{2}$.

The thresholds in the search costs evenly affecting all buyers are given by: $\eta_0 = \eta_1 = \Pi_{fm} - \Pi + F + \frac{\sigma}{2} + E(\pi^I_B)$, $\eta_2 = \Pi_{fm} + E(\pi^I_B)$.

It is worth noting that the sign of the relationship between the density of suppliers in B's country and the probability that buyers make an attempt to search for a foreign match is ambiguous, since two contrasting forces are at work (see Section 5.3 in the Appendix). On the one side, the higher the density of suppliers in B country the lower the need to search abroad for a good match, on the other side, the higher the density of the suppliers in B country, the higher the share of the potential revenue the buyers will receive in a successful international match. In the same way, the relationship between the density of suppliers in S country, where B would search, and the probability that buyers make an attempt to search for a foreign match is ambiguous since the higher the density of suppliers in the destination markets, the higher the probability to find a good match, but also the higher the revenue share of the potential partner.

3.3 Results

3.3.1 Heterogeneity in internationalization and innovation strategies

At t_0, B decides whether to search for a foreign partner by engaging in a first meeting abroad or stay in a domestic match. At t_1 the buyers who did not search abroad keep on with their domestic match, while the buyers who went abroad decide whether to continue the relationship with the foreign supplier under either IS or IB strategy or to discontinue it and go back looking for a new domestic match. In the previous sections (Sections 3.2.1, 3.2.2, 3.2.3) we derived the relevant intervals in which the different strategies are implemented.

It is important to note that we have two sources of firm heterogeneity in our model. A first source of (ex-ante) firm heterogeneity is in the location of buyers in the domestic product characteristics space. This source of heterogeneity determines heterogeneous buyers' behaviors in terms of going abroad. A second source of (ex-post) heterogeneity concerns the location in the foreign product characteristics space, which is revealed after the first meeting with the foreign buyer, and which determines heterogeneity in the innovation strategy (IB or IS). As a consequence we will have some firms matching only

domestically, under different innovation strategies (IB or IS); some other firms looking for a partner abroad; some firms keeping on in a foreign match under either IS or IB strategy; and some firms engaging only in a first meeting abroad and then going back home and looking for a new domestic partner.

By comparing the intervals in which the different strategies are implemented in the foreign and domestic matches, pointed out in sections 3.2.1 and 3.2.2, it emerges that the IB strategy is implemented for shorter distances, the IS strategy for larger distances, while no match takes place when the distance is too large.[14] This outcome is the consequence of the relative size of the distance-related versus the fixed costs in both innovation strategies. Since B is the principal, making the decision in order to maximize his profits under the S participation constraint, for relatively shorter distances it is more convenient for him to buy the input as it is and bear the distance related costs to introduce it in his production process, since the distance-related cost of innovation is relatively smaller than the cost of providing a project to S. Viceversa for larger distances.

International matches are implemented for shorter distances than domestic matches since, on the one side, matching internationally is more costly (i.e., both B and S bear the fixed internationalization cost γ_{int}), on the other side, both B and S face the alternative option of going back home. Therefore, firms stay in an international relationship only when they find a better match, i.e. when distances are shorter than at home.

Another implication of our model is worth mentioning. Exporting firms, which include both permanent and temporary exporters, will show a lower propensity to introducing product innovations than permanent exporters. This depends on the fact that temporary exporters in our model are never involved in product adaptation. This is consistent with the evidence provided by some empirical studies on 'learning by exporting' using panel data about the positive correlation between export duration and product innovation. Fafchamps et al. (2008) observe, for instance, that product innovativeness is positively related to the length of the exporting experience in a panel of Moroccan firms which they interpret as an instance of learning by exporting. We also provided evidence on this in Section 2 using the EFIGE data: in our sample of firms doing PTO for other firms regular exporters were significantly more likely to introduce product innovations than new exporters. In terms of our theoretical model, regular exporters can be assimilated to suppliers who found a 'good match', while for new exporters we do not exactly know if the relationship is going to last in the future. This group will include therefore some firms with good matches and some with bad matches (temporary traders), and in general the propensity to innovate will be lower than for regular exporters.

3.3.2 A condition for permanent exporting inducing innovation

We focus on firms which have achieved a 'good match' (implementing either IB or IS) — i.e. permanent or regular exporters— and study which of the two strategies (either IB or IS) are more likely in domestic or foreign matches. To analyze how the set of distances for which the IS strategy is implemented differs between international and domestic matches

[14]This is apparently in contrast with Puga and Trefler (2010) where when residual incompatibilities are too large the supplier is not involved in the innovation process, which is completely managed by the buyer. The main difference here is that innovation does not imply any residual incompatibility for B after the distance in the product characteristics space is revealed.

we consider the measure of the relative share of the IS interval over the sum of (IS+IB) distance intervals: $(IS)^D = (1 - \frac{Z_{jj}}{\overline{Z}_{jj}})$ and $(IS)^I = (1 - \frac{Z_{ij}}{\overline{Z}_{ij}})$. We compare this measure in domestic and international matches. The difference between $(IS)^I$ and $(IS)^D$ is given by:

$$(IS)^I - (IS)^D \equiv \Delta(IS) = \frac{2F}{\alpha^D \Pi} - \frac{2F}{\alpha^I \left[\Pi - \gamma_{int} - E(\pi_B^D) - E(\pi_S^D\right]}. \tag{12}$$

When this difference is positive (negative) the share of the set of distances for which IS is implemented over total good matches is higher (lower) in an international match than in a domestic one. One can easily see that a sufficient condition for this difference to be negative is $\alpha^I \leq \alpha^D$.

$\Delta(IS) > 0$ whenever

$$\alpha^I > \frac{\alpha^D \Pi}{[\Pi - \gamma_{int} - E(\pi_B^D) - E(\pi_S^D)]} \equiv \bar{\alpha}^I \tag{13}$$

which implies $\alpha^I > \alpha^D$.

We can conclude from this part of the analysis, that in order for S to have a higher probability to adapt to B needs in an international match (i.e., innovation is induced by exporting), the distance-related adaptation cost for B has to be higher in an international match than in a domestic one for any given distance Z ($\alpha^I > \alpha^D$). With $\alpha^I = \alpha^D$ (even more with $\alpha^I < \alpha^D$), B would be more likely to buy the existing good provided by S and adapt it to his needs in an international match than in a domestic one. This is due to the fact that the IS strategy is implemented for relatively larger distances both in domestic and in international matches (when Z is 'large' B asks S to adapt) and since international matches are successful for 'shorter' distances (due to the effect of γ_{int} and the outside options), the IS strategy set is smaller in this type of matches. However, if $\alpha^I > \alpha^D$, the higher cost of adapting for B in an international match can revert the previous result, causing a 'shrinking' of the IB strategy set, and increasing the relative share of the IS strategy set. A higher cost of adapting per unit of distance for B in an international match could be justified on the ground, for instance, that B comes from a domestic match and has a better knowledge of the domestic inputs' characteristics, or that asking for technical assistance from abroad may be more costly (see also Section 3.2).

It is also worth noting that $\bar{\alpha}^I$ is positively related to both X_i, i.e. the number of suppliers in the country of origin of B, and the internationalization cost γ_{int}. The higher the probability for B to find a good match in the domestic market, and the higher the cost of managing operations abroad, the shorter the set of distances for which an international match will be implemented, the more likely B will be to buy the input and adapt it by himself, unless the cost of adapting a foreign input is too high.

4 Concluding remarks

In this paper, we reassess the relationship between exporting and innovation, by focusing on knowledge flows between firms, and, in particular, on the exchange of information between firms engaged in a production to order buyer-supplier relationship.

By using the EFIGE dataset, a survey gathering firm-level data on Manufacturing firms in seven European countries, we first show that producing to order for foreign customers is positively associated with greater product innovativeness; the association is not only statistically, but also economically significant.

We provide a theoretical model in order to give a potential interpretation of this empirical evidence, in the framework of the incomplete contracts and imperfect information literature related to specific input provision in international trade. In our setting, there are two types of agents engaged in production: downstream producers (i.e., buyers) who purchase an input from upstream producers (i.e., suppliers). Buyers and suppliers are distributed over the product characteristics circle (product space).

In our set up, for a buyer-supplier match to work some adaptation is needed depending on the distance between the buyer's needs and the characteristics of the good produced by the supplier in the product space. Buyers can either purchase the intermediate good as it is and then adapt it or they can give suppliers a 'project' according to which the input must be adapted, bearing the relative costs. The imperfect information that buyers have on the actual distribution of suppliers abroad allow us to introduce 'learning-by-exporting' in a simple and intuitive way, that is to say that the buyer and the supplier must engage in a first meeting and know each other's characteristics in order to decide whether to go on with the relationship or not and under which innovation regime. The production to order relationship allows us to single out how the specific channel of knowledge transfer occurring between firms generate different innovation outcomes when the relationship is developed in domestic vs. foreign matches.

Two sources of firm heterogeneity are present in our model. A first source of (ex-ante) firm heterogeneity is in the location of buyers in the domestic product space. This source of heterogeneity determines heterogeneous buyers' behaviors in terms of searching for a business partner abroad. A second source of (ex-post) heterogeneity concerns the location in the foreign product space, which is revealed after the first meeting with the foreign buyer, and which determines heterogeneity in the innovation strategy. As a consequence we will have some firms matching only domestically, under different innovation strategies (either Buyer's or Supplier's innovation); some other firms looking for a partner abroad; some firms keeping on in a foreign match under either Buyer's or Supplier's innovation strategies; and some firms engaging only in a first meeting abroad and then going back home and looking for a new domestic partner ('temporary trade'). This in turn will imply some heterogeneity across suppliers: some of them selling only domestically, some of them only 'temporary exporting' their existing intermediate goods, and not introducing innovations, some of them engaging in long-term relationships both domestically and abroad, either by selling the existing input and assisting the buyer it or adapting their input to the buyer's needs.

We single out the distance thresholds (in the product space) delimiting the intervals for which different innovation and internationalization strategies are implemented as a function of the innovation costs' parameters, the internationalization costs and the number of suppliers in the different countries. We show the conditions under which suppliers are more likely to adapt their products for foreign customers than for domestic ones, this way highlighting a specific channel through which trade may induce product innovation by firms already operating in the market ('learning by exporting').

In summary, our model provides a framework in which firms may implement different

innovation and internationalization strategies *just depending on the characteristics of their products* (and not on differences in productivity). This may also provide some useful insights as to why also small and not very productive firms not engaging in formal R&D activities often manage to compete in both domestic and foreign markets (even in well integrated trade areas) by implementing successful innovation activities. Although in this paper our main aim is to stress the 'engines' potentially driving different innovation and internationalization strategies between firms located in similarly developed economies, a natural extension of our work would consider also the role of countries' differences in technology (and productivity), factor costs, income levels and quality of institutions.

5 Appendix

5.1 Derivation of pay offs in the domestic matches

The outside options in a D match are represented by $OUT_k^D = 0$, where $k = S, B$, since no production will take place. By assuming an ex-post splitting rule, with $\Pi = \Pi_B + \Pi_S$, we obtain $\Pi_B = \Pi_S = \frac{\Pi}{2}$. The pay offs in the domestic matches under IB strategy are given by:

$$\pi_B^{IB,D} = \frac{\Pi}{2} - \alpha^D b^S Z_{ii} \tag{14}$$

$$\pi_S^{IB,D} = \frac{\Pi}{2} - F \tag{15}$$

where Π, is the total operational profit, $\pi_B^{IB,D}$ and $\pi_S^{IB,D}$ are the net total profits received by B and S, respectively, in a domestic match under IB. It is worth noting that General Equilibrium conditions must hold so as the gains from trade (GFT) are non-negative and the participation constraints (PC) are satisfied:

$\frac{\Pi}{2} \geq 0$
$\pi_B^{IB,D} \geq 0 : Z_{ii} \leq (\frac{\Pi}{2})(\frac{1}{\alpha^D b^S})$
$\pi_S^{IB,D} \geq 0 : \frac{\Pi}{2} \geq F$

The pay offs in the domestic matches under IS strategy are given by

$$\pi_B^{IS,D} = \frac{\Pi}{2} - F \tag{16}$$

$$\pi_S^{IS,D} = \frac{\Pi}{2} - b^S Z_{ii} \tag{17}$$

where Π, is the total operational profit, $\pi_B^{IS,D}$ and $\pi_S^{IS,D}$ are the net total profits received by B and S, respectively, in a domestic match under IS. General Equilibrium

conditions must hold such that GFT are non-negative and the participation constraints (PC) are satisfied:

$\frac{\Pi}{2} \geq 0$
$\pi_B^{IS,D} \geq 0$: $\frac{\Pi}{2} \geq F$
$\pi_S^{IS,D} \geq 0$: $Z_{ii} \leq \frac{\Pi}{2}(\frac{1}{b^S})$.

In this framework, B chooses the IB strategy if

$$\pi_B^{IB,D} \geq \pi_B^{IS,D} \tag{18}$$

under S participation constraint, PC^S

$$\pi_S^{IB,D} \geq 0. \tag{19}$$

B chooses instead the IS strategy if:

$$\pi_B^{IS,D} > \pi_B^{IB,D} \tag{20}$$

under the S participation constraint, PC^S

$$\pi_S^{IS,D} \geq 0 \tag{21}$$

As a result of B decision we single out the thresholds delimiting the relevant intervals where different strategies are implemented, as reported in Section 3.2.1. It is worth noting that $\underline{Z}_{ii} < \overline{Z}_{ii}$ whenever $\Pi > \frac{2F}{\alpha^D}$ (when $\alpha^D > 1$ this constraint is not binding while it is the S participation constraint in IB; the opposite occurs when $\alpha^D < 1$).

5.2 Derivation of pay offs in the international matches

Pay offs in the international matches under IB and IS strategy

By solving the expression in (4) and in (5), we derive the explicit expressions for expected profits in the domestic markets:

$$E(\pi_B^D) = \frac{X_i}{b_S}[\frac{F^2}{\alpha^D} + \Pi(\frac{\Pi}{2} - F)] \tag{22}$$

and

$$E(\pi_S^D) = \frac{X_j}{b_S}[(\frac{\Pi}{2})^2 + \frac{F^2}{\alpha^D}(\frac{1}{\alpha^D} - 2)]. \tag{23}$$

Assuming again an ex-post splitting rule, from
$\Pi - \gamma_{int} = \Pi_B + \Pi_S$

and
$V = (\Pi_B - E(\pi_B^D))(\Pi - \gamma_{int} - \Pi_B - E(\pi_S^D))$

we obtain the following net total profits received by B and S, respectively, in an International match under IB:

$$\pi_B^{IB,I} \equiv \Pi_B - \alpha^D b^S Z_{ij} = \frac{1}{2}\left[\Pi - \gamma_{int} - E(\pi_B^D) - E(\pi_S^D\right] + E(\pi_B^D) - \alpha^D b^S Z_{ij} \tag{24}$$

and

$$\pi_S^{IB,I} \equiv \Pi_S - F = \frac{1}{2}\left[\Pi - \gamma_{int} - E(\pi_B^D) - E(\pi_S^D)\right] + E(\pi_S^D) - F \tag{25}$$

The GE condition for the International match to be profitable must hold (non negative GFT):
$GFT^{IB,F} : \left[\Pi - \gamma_{int} - E(\pi_B^D) - E(\pi_S^D\right] \geq 0$

We obtain the following net total profits received by B and S, respectively, in an International match under IS:

$$\pi_B^{IS,I} \equiv \Pi_B - F = \frac{1}{2}\left[\Pi - \gamma_{int} - E(\pi_B^D) - E(\pi_S^D)\right] + E(\pi_B^D) - F \tag{26}$$

and

$$\pi_S^{IS,I} \equiv \Pi_S - b^S Z_{ij} = \frac{1}{2}\left[\Pi - \gamma_{int} - E(\pi_B^D) - E(\pi_S^D)\right] + E(\pi_S^D) - b^S Z_{ij} \tag{27}$$

(the GE condition for the International match to be profitable which is the same as above).

B chooses IB internationally if:

$$\pi_B^{IB,I} \geq \pi_B^{IS,I} \tag{28}$$

under

$$\pi_S^{IB,I} \geq E(\pi_S^D) \tag{29}$$
$$\pi_B^{IB,I} \geq E(\pi_B^D). \tag{30}$$

B chooses IS internationally if:

$$\pi_B^{IS,I} > \pi_B^{IB,I} \tag{31}$$

under

$$\pi_S^{IS,I} \geq E(\pi_S^D) \tag{32}$$
$$\pi_B^{IS,I} \geq E(\pi_B^D). \tag{33}$$

As a result of B decision we single out the thresholds delimiting the relevant intervals where different strategies are implemented in the international matches, as reported in Section 3.2.2.

$\underline{Z}_{ij} < \overline{Z}_{ij}$ whenever GE is such that $\alpha^I \left[\Pi - \gamma_{int} - E(\pi_B^D) - E(\pi_S^D\right] > 2F$ (that is that when $\alpha^I > 1$ is not binding, PCs holding under the IB strategy, while the opposite happens with $\alpha^I < 1$).

5.3 Derivation of determinants of the Buyer searching abroad

Under IB in a domestic match ($0 < Z_{ii} < \underline{Z_{ii}}$), B will search abroad iff

$$\pi_{B,0}^I + E(\pi_B^I) \geq \pi_{B,0}^{IB,D} + \pi_{B,1}^D, \tag{34}$$

that is

$$\Pi_{fm} - \eta + E(\pi_B^I) \geq \Pi - \frac{\sigma}{2} - \alpha^D b_S Z_{ii}, \tag{35}$$

from which we obtain

$$Z_{ii} \geq \frac{1}{\alpha^D b_S}[\Pi - \Pi_{fm} - \frac{\sigma}{2} + \eta - E(\pi_B^I)] \equiv \widehat{Z}_{ii}. \tag{36}$$

In order to have an interval in which some B choose to look for an international partner instead of matching domestically under the IB strategy, it must hold $\widehat{Z}_{ii} < \underline{Z_{ii}}$, implying a condition on η:

$$\eta < \Pi_{fm} - \Pi + F + \frac{\sigma}{2} + E(\pi_B^I) \equiv \eta_0. \tag{37}$$

Under IS in a domestic match ($\underline{Z_{ii}} < Z_{ii} < \overline{Z_{ii}}$), B will search abroad iff

$$\pi_{B,0}^I + E(\pi_B^I) \geq \pi_{B,0}^{IS,D} + \pi_{B,1}^D, \tag{38}$$

that is

$$\Pi_{fm} - \eta + E(\pi_B^I) \geq \Pi - \frac{\sigma}{2} - F, \tag{39}$$

this implying that whenever $\eta < \Pi_{fm} - \Pi + F + \frac{\sigma}{2} + E(\pi_B^I) \equiv \eta_1 \equiv \eta_0$, all B which would implement an IS strategy in the domestic matches will make an attempt to look abroad for a better match.

Under no match acceptable in the domestic market ($\overline{Z_{ii}} < Z_{ii} < \frac{1}{2X_i}$), B will search for a partner in a foreign country iff

$$\pi_{B,0}^I + E(\pi_B^I) \geq 0, \tag{40}$$

that is

$$\Pi_{fm} - \eta + E(\pi_B^I) \geq 0, \tag{41}$$

this implying that whenever $\eta < \Pi_{fm} + E(\pi_B^I) \equiv \eta_2$ all B which would not find a partner in the domestic market will make an attempt to match in the international markets abroad.

By solving the expression in (8), we obtain

$$E(\pi_B^I) = \frac{X_j}{b_S}[\frac{F^2}{\alpha^I} + \frac{(\Pi - \gamma_{int} - E(\pi_B^D) - E(\pi_S^D))^2}{2} - F(\Pi - \gamma_{int} - E(\pi_B^D) - E(\pi_S^D))] + E(\pi_B^D) \tag{42}$$

From the expected profits in the international markets (8), we derive:
$\frac{\delta E(\pi_B^I)}{\delta X_i} = \frac{E(\pi_B^D)}{b_S}\frac{X_j}{Xi}[2E(\pi_B^D) + b_S + F(\frac{1}{\alpha^I} - \frac{1}{\alpha^D} - 1)]$.

In order to investigate how the probability to search abroad for a foreign supplier varies with X_i, we consider the relative size of the sum of intervals where B decides to search abroad (for sufficiently low search costs). This size is given by: $IMPsh = 1 - \hat{Z}_{ii}(2X_i)$, from which we derive: $\frac{\partial IMPsh}{\partial X_i} = -2\hat{Z}_{ii}(\epsilon_{\hat{Z}_{ii}} + 1)$, where $\epsilon_{\hat{Z}_{ii}}$ is the elasticity of the threshold to X_i. As one can immediately check, $\frac{\partial IMPsh}{\partial X_i} > 0$ for $\epsilon_{\hat{Z}_{ii}} < -1$ and $\frac{\partial IMPsh}{\partial X_i} \leq 0$ for $\epsilon_{\hat{Z}_{ii}} \geq -1$.

Therefore, in general, the sign of the relationship between $IMPsh$ and X_i is ambiguous, depending on $\epsilon_{\hat{Z}_{ii}}$.

The relationship between $IMPsh$ and X_j, given by $\frac{\partial IMPsh}{\partial X_j} = -2X_i\frac{\partial \hat{Z}_{ii}}{\partial X_j}$, where $\frac{\partial \hat{Z}_{ii}}{\partial X_j} = -\frac{1}{\alpha^D b_S}\frac{\partial E(\pi_B^I)}{\partial X_j}$, also shows an ambiguous sign.

Table 1: Summary statistics for firms doing PTO for domestic and foreign firms

	domestic customer$^{(a)}$	foreign customer$^{(b)}$
No. employees (/10)	1.662	2.072
R&D employment share	0.401	0.674
Capital intensity	0.386	0.461
Unit labor costs	0.304	0.259
Graduate employment share	6.072	9.802
Importer	0.226	0.573
Invested in FDI	0.008	0.058
Domestic group	0.097	0.144
Foreign group	0.019	0.096
Introduced product innovations	0.319	0.585

Notes. $^{(a)}$ Produces for domestic customers only. $^{(b)}$ Produces for at least one foreign customer. The descriptive statistics refer to the estimation sample (6,125 firms) and are weighted to population proportions. Capital intensity is measured as the capital stock divided by the number of employees (hundreds of Euros). Unit labor costs are measured as total labor costs divided by firm turnover.

Table 2: Producing to order for foreign customers ($FORCUST$) and product innovation

	(1)	(2)
$FORCUST$	0.119***	
	(0.016)	
Regular 'exporter'		0.135***
		(0.018)
Sporadic 'exporter'		0.079***
		(0.025)
New 'exporter'		0.068
		(0.045)
Number of employees (/10)	0.023**	0.021**
	(0.009)	(0.009)
R&D employment share	0.281***	0.280***
	(0.015)	(0.015)
Capital Intensity	-0.005	-0.005
	(0.012)	(0.012)
Unit labor costs	-0.005	-0.004
	(0.005)	(0.005)
Graduates' employment share	0.004***	0.004***
	(0.001)	(0.001)
Importer status	0.084***	0.082***
	(0.015)	(0.015)
FDI investor status	0.042	0.038
	(0.032)	(0.032)
Domestic Group	-0.051***	-0.052***
	(0.020)	(0.020)
Foreign Group	-0.047*	-0.049*
	(0.027)	(0.027)
country FE	yes	yes
NACE FE	yes	yes
N. observations	6125	6125
R^2	0.25	0.25

* ** *** significant at 10, 5 and 1 percent, respectively.

Notes. Column (1) includes only $FORCUST$, while in column (2) firms producing to order for foreign customers are distinguished according to export duration between those who exported regularly before 2008, those who exported sporadically before 2008, and those for which 2008 is the first year they exported. Standard errors are robust to heteroskedasticity. Observations are weighted to population proportions.

Table 3: Legend of variables and parameters

variable/parameter	definition
Z_{ii}	distance between B and S in domestic matches for B
Z_{jj}	distance between B and S in domestic matches for S
Z_{ij}	distance between B and S in international matches
$b^{B_{jj}}$	cost of adapting per unit of distance by B in domestic matches
$b^{B_{ij}}$	cost of adapting per unit of distance by B in international matches
$b^{S_{jj}}$	cost of adapting per unit of distance by S in domestic matches
$b^{S_{ij}}$	cost of adapting per unit of distance by S in international matches
F^B	B cost of providing a "project" to S
F^S	S cost of assisting B
a^D	ratio between costs in domestic matches ($b^{B_{jj}}/b^{S_{jj}}$)
a^I	ratio between costs in international matches ($b^{B_{ij}}/b^{S_{ij}}$)
γ^{int}	sum of B and S cost of internationalization
η	B search cost
assumptions/further definitions	
$b^{S_{jj}} = b^{S_{ij}} = b^S$	
$b^{B_{jj}} = (a^D)b^S$	
$b^{B_{ij}} = (a^I)b^S$	
$F^B = F^S = F$	

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