Buyer-Supplier relationships, exporting and innovation*

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Abstract

Starting from the empirical evidence on the causal effect of exporting on product innovation, in this paper we aim at exploring a potential channel through which the innovation-enhancing role of being involved in foreign markets may take place. We focus on a specific mechanism which acts between firms establishing buyer-supplier relationships related to production to order. After providing some empirical evidence that suppliers involved in international matches are more likely to introduce product innovations than those involved in domestic matches only, we introduce a theoretical model rationalising this empirical fact. In a theoretical framework with imperfect information and incomplete contracts, we show under which conditions the supplier innovates, and which variables are likely to affect this choice. Our model provides a framework in which firms may implement different innovation and internationaliziation strategies just depending on the characteristics of their products.

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1 Introduction and motivation

This paper aims at exploring some potential sources and pathways through which trade may induce product innovation by existing firms.[1]

There are several recent contributions showing a positive association between firms' international activities and innovation performance. This outcome seems to be present over and above the common incentive of better firms both to enter foreign markets and to renew their products (i.e., the self-selection mechanism on which there is already a wide consensus in the empirical literature). Some progress has been made since the literature review published by Wagner (2007), where just a minority of studies used to report evidence in favor of a positive causal relationship between exporting and productivity. Indeed, more recent studies have exploited longitudinal data or presumably exogenous 'export shocks' to identify the impact of a firm's export status (or intensity) on productivity, showing that firm self-selection into foreign markets is not the only source of the positive association between exporting and firm performance observed in the data, and that there are genuine causal effects (Crespi et al., 2008; Serti and Tomasi, 2008; Fryges and Wagner, 2008; Lileeva, 2008; Yang and Mallick, 2010; Park et al., 2010; Lileeva and Trefler, 2010; Bustos, 2011).

In particular, two challenging aspects emerge from this literature. Firstly, the positive association is robust to the inclusion of proxies of firm efficiency and quality, and of those covariates that are likely to mediate the effect of exporting on innovation in terms of higher 'formal' innovative efforts, such as R&D investments or acquisition of foreign patents (Salomon and Shaver, 2005; Liu and Buck, 2007; Fafchamps et al., 2008; Bratti and Felice, 2011).

Secondly, exporting is also an important correlate of firm product innovation, even when trade is between similar countries and is not induced by technological/income differences. Indeed, most of the above mentioned evidence comes from developed economies.

What still remain to be ascertained are the precise channels of these 'learning' effects. Why should firms innovate their products when selling them to similarly developed economies? What are the main sources of this learning effect? 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) show that exporters learn from foreign buyers through R&D agreements.

[1] In our framework, we refer to product innovation as to all those 'incremental' changes/improvements that firms introduce on their existing products or the introduction of new products (by existing firms), in the spirit of Puga and Trefler (2010), as opposed to radical innovations that are usually related to processes of invention; in our framework, 'innovation' can also be considered as product differentiation.

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. **?** shows that, at least for Italy, the positive effect of exporting in 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.

Taking as a starting point the existing evidence on 'learning by exporting', in this paper, we aim to go a step forward towards dissecting the mechanisms of the effect of exporting on product innovation, and focus only on the specific channel going through buyer-supplier relationships. We focus on the learning effect of trade in buyer-supplier interactions because a high percentage of international trade is in specialized goods (Rauch, 1999). On the one side, production and trade of specialized goods are dominated by imperfect information (Rauch, 1999; Rauch and Watson, 2003; Rauch and Trinidade, 2003; Puga and Trefler, 2010; Aeberhardt et al., 2011), this opening room for a learning process. On the other side, specialized goods are usually traded under a *production to order regime*, i.e. firms produce following an order by other firms (Casaburi and Minerva, 2011). This specific production mode 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. These complex relationships, where both the buyer and the supplier can potentially innovate, are characterized by agency problems and contractual frictions, this implying also that both the relationship and the knowledge transfer are likely to evolve differently in domestic and in international matches (Egan and Mody, 1992).

Production to order is widespread among European firms. The European survey used in this paper (EFIGE) shows that 86 percent of Manufacturing firms produce to order, with an average 85 percent of total turnover produced by the latter. Moreover, about 53 percent of all firms produce exclusively (i.e., 100 percent of turnover) to order. Thus, we are considering an innovation channel which is potentially relevant to a vast majority of manufacturing firms in Europe.

As a first step, we explore the relationship between innovation and production to order in international versus domestic buyer-supplier matches, by using the information gathered in the EFIGE firm-level dataset (see Section 2). We provide first evidence of a higher propensity to introduce product innovations by suppliers engaged in a match with foreign firms. As a second step, we develop a theoretical model in order to interpret the positive association between producing to order for foreign customers and product innovation, along the line of the contributions introducing incomplete contracts

and imperfect information in international trade related to specific inputs provision (Rauch and Trinidade, 2003; Grossman and Helpman, 2005; Puga and Trefler, 2010). In our approach firms are heterogenoeus in their product characteristics (i.e., location in the product characteristics space), while, 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.

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. 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. The model also shows that firms may have heterogeneous innovation and internationalization strategies simply due to the characteristics of their products. Our work adds to the existing literature, mentioned above in this section, on 'learning by exporting', by providing a theoretical interpretation stressing a specific channel through which trade may induce product innovation by existing firms. In our framework, imperfect information when product characteristics are relevant is what induces firms to meet and exchange products before taking a decision on whether or not to continue the relationship and on whether or not to adapt their products. The 'production to order' relationship when firms enter asymmetrically the relationship, i.e., when the buyer takes the final decision about the innovation strategy, opens room for showing why exporting may induce innovation depending on different buyers' incentives in domestic and foreign matches.

We depart from the existing literature, as recent contributions in the heterogeneous firms' international trade literature have either endogenized firms' decisions to invest in R&D to enhance the quality of their goods (Costantini and Melitz, 2008; Atkeson and Burstein, 2010; Bustos, 2011), the number of product varieties in multiproduct firms (Bernard et al., 2011), or both (Eckel et al., 2010). Indeed, this literature by focusing on the final demand has mainly emphasized asymmetries between products on the 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.

Moreover, our theoretical framework represents a first attempt to explain a stylized fact which in our view still remains unexplained by the recent literature: the high survival rate of small-low productivity-low R&D firms in highly commercially integrated area, where these firms manage to compete and to innovate. Razzolini and Vannoni (2011), for instance, find that sub-contracting firms display lower TFP values as compared with direct

exporters. Nevertheless, the 'production to order' organizational mode, by reducing uncertainty and costs, may allow small and less productive firms to adopt product competition strategies and to survive to tough competition.

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 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. Therefore, our work is also related with the recent literature focusing on contractual frictions to provide a potential interpretation of the existence of temporary trade relationships (Rauch and Watson, 2003; Aeberhardt et al., 2011; Araujo et al., 2012). 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, but to the 'reliability' of the two barganing parts.

Finally, our work is related to the large literature on global sourcing, in particular to those contributions 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 mainly concerned with firms' decisions on the geographical location of the partner in production, when products are specialized and countries differ in labour costs, technological levels, quality of institutions affecting the enforceability of contracts, highlighting the role of informational barriers in affecting the volume of trade across countries. In Section 3 we detail the relationship of our work with these contributions, but, generally speaking, while following their spirit, we focus on the choice of the innovation strategy where both sides of the business relationship can innovate and where the main mechanism is not driven by countries differences (e.g., North vs South).

A second stream of global sourcing literature focuses on the determinants of firms' offshoring mode (i.e., 'make or buy' decision: vertical integration vs. outsourcing in a foreign country) looking in particular either at the role of IPR protection in the destination countries (**?**) or at the technological content of the goods (**?**) or both (Naghavi et al., 2011). We do not deal here neither with firms' boundaries, since we look at those types of firms' relationships where the buyer and the supplier are two separate units, nor with differences in North-South institutions, like IPR protection. 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 product. Nevertheless, differently from them, our main mechanism rests on the cost structure when products are heterogeneous and in a asymmetric relationship between the partners.

On another side, innovation costs are a relevant determinant of firms'

decisions in the literature analysing the determinants of firms' R&D offshoring given the multinational structure of the firm (Sanna-Randaccio and Veugelers, 2007; Belderbos et al., 2008). 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.

Generally speaking, our model is developed in the spirit of the above mentioned contributions, while departing from them in some relevant dimensions, namely, the role of 'production to order' mode (i.e., they always have to match to produce and they enter asymmetrically the relationship), the innovation strategy, where both partners can innovate, the structure of the innovation costs, related to the location in the product characteristics space, which is also our source of heterogeneity in firms' behaviour. Lastly, imperfect information allows us to capture relevant stylized facts.

From a policy perspective, on the one side, our work highlights that a reduction in trade barriers positively affects 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 of innovation.

The structure of the paper is as follows. Section 2 briefly describes the dataset and reports the empirical analysis. In section 3 we develop the theoretical model to interpret the empirical evidence. Section 4 concludes.

2 Stylized facts

2.1 The EFIGE data

In this paper, 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.

For the purpose of this paper, we select only firms which make some *production to order for other firms*, restricting the sample to 11,850 firms. Moreover, we drop all firms producing for other firms which belong to the same group, as buyer-supplier relationships may be very peculiar for this specific group of firms, and the sample falls to 10,222 firms, accounting for about 70 percent of the original sample size. These criteria select 60.35 percent of Austrian firms, 83.32 percent of French firms, 68.64 percent of German firms, 80.74 percent of Hungarian firms, 84.97 percent of Italian firms, 67.88 percent of Spanish firms and 79.02 percent of UK firms.

Our hypothesis is that producing to order for foreign customers may induce firms to introduce more product innovations. In Table 1 we split the sample of firms producing to order between those matched with a 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, market innovations and of applying for patents. In what follows, we go beyond the simple bivariate associations by controlling for observable heterogeneity between firms with different types of matching, and check whether this association survives.

2.2 Empirical evidence

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. 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. In what follows, we will omit the firm's subscript i to simplify notation. The α's are parameters to be estimated. Using cross-section data, we have no time variation.

At this stage of the analysis, 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*. A positive association between $FORCUST$ and y could be interpreted in loose sense as a higher 'incentive' for the supplier which sells abroad to innovate the product that is selling with respect to a supplier which only sells domestically. In what follows, we will use the term 'supplier' to indicate a firm that is producing to order.

We start the analysis by considering as dependent variable the answer to 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.

Table 2 shows the OLS estimates. In column (1), we report the simple association between $FORCUST$ and product innovativeness from a regression without controls. $FORCUST$ is associated with a 0.21 increase in the probability of introducing product innovations. In column (2) we include country and 4-digit NACE fixed effects, which account for the potential greater diffusion of both product innovativeness and 'trade openess' in some countries/sectors, and observe a slight decrease in the coefficient of $FORCUST$ which becomes 0.18. In column (3) we introduce some measures of firm heterogeneity, in particular firm size, capital intensity, unit labor costs and the R&D employment ratio.[2] In this case, the coefficient of $FORCUST$ drops to 0.12, suggesting that a great part of the previous positive association was due to other firm characteristics, but it remains nonetheless large and statistically significant.[3]

[2]Firm size is controlled for using four categories (10–19, 20–49, 50–249, 250 or more); capital intensity is the firm capital stock over total employment (in 10,000 of euros) from AMADEUS; unit labor costs is the ratio of the cost of employees on turnover from AMADEUS; R&D employment ratio is the share of R&D employees over total employment.

[3]To note that due to missing values the sample size falls to 6980 observations. Missing

In table 3, we investigate the 'degree' of product innovation. Indeed, the EFIGE questionnaire also asks

> **C16**. Are the corresponding products innovative also with respect to the market?
>
> - yes
> - no

and

> **C17**. on average in the last three years (2007-2009) did your firm?[4]
>
> - apply for a patent
> - register an industrial design
> - REGISTER a trademark
> - claim copyright

we defined accordingly five additional dummies, the first that takes value one in case product innovations also represent innovation to the market, and zero otherwise, and the remaining four taking value one in case the firm applied for a patent, registered an industrial design, registered a trademark, claimed a copyright, respctively, and zero otherwise. With these additional information, we check whether $FORCUST$ is also positively associated with all these additional outcomes. Column (1) of Table 3 shows that firms matched internationally are 11 percent points (p.p.) more likely to introduce market innovations. $FORCUST$ is also strongly positively associated with all the other outcomes considered, except for the probability of claiming copyright. Thus, involvement in foreign markets under the form of being a supplier for a foreign firm appears to be associated with various innovation outcomes.

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 observe a product innovation premium from producing to order for foreign customers, and what are the variables that may strenghten or weaken such a positive association. Despite being developed in a similar framework, those works

values mostly concern balance sheet data, in particular capital intensity and unit labor costs.

[4]This question does not necessarily refer to product innovations, but may also refer to process innovations.

deal with different questions. Grossman and Helpman (2005) develop a general equilibrium model to study firms' decisions about where to outsource, where downstream producers located in the North decide whether to buy a customized input from a specialized upstream producer in the North or in the South. Locations differ in the level of wages, the number of suppliers located in the product characteristics space and the quality of institutions affecting the enforceability of contracts. In their framework, only the supplier can adapt the product, so decisions do not involve the 'innovation' strategy. The role of location in the product space is also considered in Rauch and Trinidade (2003), where two firms have to match in order to produce and the higher the distance in the product space, the higher the quality of the match since the two firms provide complementary services in the production process. This work is interested in highlighting the role of information barriers in affecting the volume of trade across countries when products are differentiated and on the role of network ties in overcoming these barriers, where domestic and foreign matches differ in trade and labour costs. Firms do not change location in the product space, i.e., they do not adapt their product, therefore decisions do not involve innovation strategies. Our work is close to the contribution of 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 which differ in labour costs and technological levels. The buyer decides also whether or not to involve the supplier in the innovation process, depending on the trade-off between the lower cost of the innovation when carried out by the supplier and the potential residual incompatibilities that the buyer may have to manage when the supplier innovate. The authors are interested in the implication of innovation strategies for the choice between foreign locations differing in labour costs and technological development. In their work firms supplier are heterogeneous in the residual incompatibilites they would imply for the buyer if they carry out the innovation effort. Our work borrows extensively from the deep investigation of the innovation decision process carried out in Puga and Trefler (2010), but addressing different questions and focusing on firms' heterogeneity in the product characteristics space.

3.1 Set up

In our setting, there are two types of agents engaged in production: downstream producers (i.e., Buyers, B) who purchase an input from upstream producers (i.e., Suppliers, S). 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 is needed, depending on the distance between the Buyer's needs and the Supplier's good characteristics. Since both the Buyer and the Supplier can adapt, there are two possible innovation strategies: the Buyer 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 the Buyer can provide the Supplier with a 'project' according to which the Supplier adapts the input to fit his needs (i.e., Supplier Innovation mode—IS).

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 Buyer's needs and the characteristics of the input produced by the Supplier. The Buyer and the Supplier 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, the Buyer 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 the Supplier partecipation constraint.

Z_{ij}, with i, j countries where the Buyer (B) and the Supplier (S), respectively, are located, is the distance along the circle between B '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 markets, 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 (simmetrically) 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, do 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.

Depending on the distance between B's needs and S's characterists in the Domestic match, there are heterogenous decisions across Buyers on whether to look for an International match or not; depending on the distance in an International match, there are heterogenous decisions across Buyers on whether to stay in an International match and to adapt or ask the Supplier to adapt the input. This, in turn, will imply some heterogeneity across Suppliers: some of them selling only domestically, some of them 'exporting', and, in both cases, some of them changing their good to match Buyers' needs and others selling their existing input.

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, it is reasonable to imagine that 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).

Following the innovation literature, firms can be generally involved in two 'types' of innovation effort. A first type, which we call 'invention' (I), and which is usually the outcome of a stochastic process (e.g. it may be the outcome of R&D investments). The output of this process is the 'ideation' of a new good. This process generates an order for the second type (or step) of innovation effort, which we call 'implementation' and to which we will refer in this paper as 'innovation' (II). The latter is a deterministic process through which a new product or a change/improvement in an existing one become ready for the market. Both buyers and suppliers can engage in (I): 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 implementation stage for a downstream firm may generate changes in an existing intermediate good.

In this paper, we are not interested in 'inventions', 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 stochastic R&D process in order to change location along the 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 (Vernon, 1966; Rosenberg, 1982; Hippel, 1988; Egan and Mody, 1992). To summarize, both downstream firms and upstream firms share R&D investment as a source of product innovation from the supply side, while they differ in the sources of innovation from the demand side. In downstream firms product innovation is spurred by the interactions with consumer preferences, while in upstream firms the demand side source of innovation is represented by the upstream firm's demand. We argue that interactions with final consumers differ substantially from those with other firms under several respects, which call for investigation.

As a consequence of his 'invention' effort (which we do not model, as pointed out above), there are two alternative implementation strategies which B has two choose between:

- *IB strategy* (Buyer Implementation-IB): B buying an exisiting 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. 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.

The IS strategy is modeled borrowing from Grossman and Helpman (2005) and Puga and Trefler (2010), while the IB strategy follows the intuition in Hesley and Strange (2002). [5]

It is worth noting that only the IS strategy turns in '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 downstrean firm which is changed (or alternatively the intermediate input bought by the downstream firm is changed by the Buyer, 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 analysed 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, 'burocratic' costs (e.g., the costs of asking certificates to 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

[5] 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 takes 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.

of the domestic Suppliers and he is matched with the closest one. B introduces an innovation in its product, this requiring a new specific input (or adaptation in the one he is using). Since B knows the actual distribution of Suppliers in his domestic market, he knows the location of the closest one (which could either be his domestic Supplier or a new one in the domestic market); therefore B decides wether to match and produce with the closest Supplier in the domestic market or to look for a new Supplier abroad. As in Grossman and Helpman (2005) 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; 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 S. 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]

Egan and Mody (1992) point out several reasons why buyer-seller relationships grow incrementally and start usually with a short-term agreement, through a deep investigation of case studies. The need of a first exchange before engaging in an investment in order to reveal partners' characteristics and/or reliability has been initially analysed by Rauch and Watson (2003), followed by several contributions investigating both theoretically and empirically the determinants of export decision and duration, considering export activities as relationship specific (Aeberhardt et al., 2011; Araujo et al., 2012; Békés and Muraközy, 2012), as well as the determinants of innovation

[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 forsees. 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 inputs.

[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 assume that 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 which introduce product innovations.

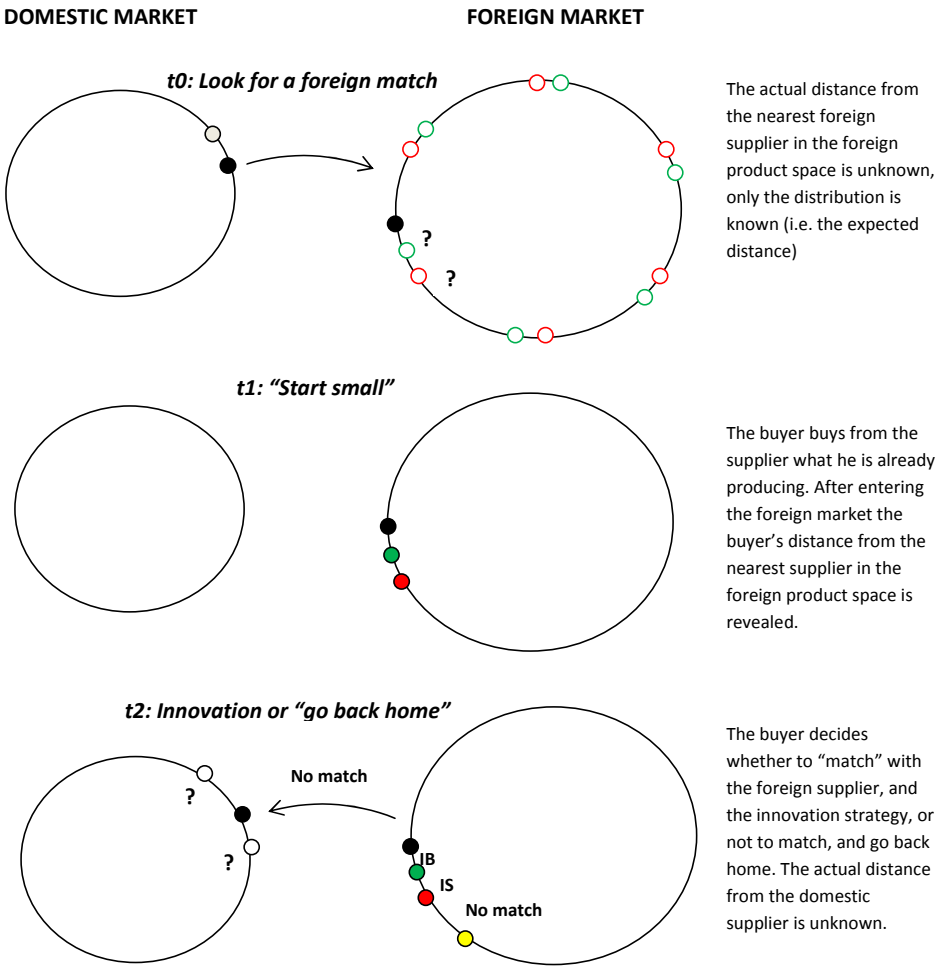
mode as in Puga and Trefler (2010). This approach help explaining the initially small and then growing export values, the low surviving rates of many export activities, the positive relationship between quality of institutions in destination countries and export surviving in a framework of contractual incompleteness. In our framework, geographical proximity 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. B may either use the input bought by the new S abroad to produce his existing good together with the old input, or he 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 meet, 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; so far, we have assumed that the costs of searching 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) in allowing 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 mode), it would 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), since the closest Supplier previously identified by B could be no longer available.[8]
[9]

[8]This implies that the exact location of suppliers in the domestic market becomes unknown after having been abroad, while the Buyer continues to know their distribution function. A possibile rationalization is that the Buyer 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]For S, it means matching with a new domestic B, replacing the foreign B which he was matching with in the bad international match (we are assuming that in t_0 S has a large enough productive capacity to add a B); for B it means that not necessairily his

Figure 1: Timing of the process



Buyers who do not find convenient to search abroad, match with the closest S under IB or IS, in t_0, and keep on with the relationship in t_1, paying only the switching cost σ.

Bargaining and contract

Both in the Domestic and in the International matches, B offers a contract to S that can either be IS or IB depending on what maximizes his profits. S can accept or turn down the offer (i.e., B maximizes his profits under S participation constraint – PC, hereafter). Whenever B knows S will not accept his first best strategy, B offers S the alternative one, if it is still

previous domestic S is still the closest one.

convenient to both. B decides the strategy after that Z_{ij} is revealed in the international match. We assume that in deciding the strategy B owns all the power. After a decision is made, innovation costs are borne individually by B and S, depending on the strategy. Under the IS 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 and B finds out how to make the input fit his production process, bearing the distance related costs. Then the contract is signed, the intermediate input is sold, the production of the final good takes place, profits are realized and all payments are made depending on the implementation 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 verifyible by an external court and firms cannot commit not to rinegotiate about profits after the innovation costs are born because the characterisitics of the innovation effort (i.e., technical assistance quality, detail of the project, implementation) are revealed after that the investment is sunk (Grossman and Hart, 1986; Hart and Moore, 1999). 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). After the innovation strategy is decided and innovation costs are born, B and S sign the contract. It is worth noting that, since we take as given the boudaries of the firm, in order to produce both the partners have to contribute.

The contract specifies what the payment will be contigent on production taking place, and on the type of innovation strategy (IS, IB). We assume that B and S share the same (exogenous) 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 negotiates about a smaller revenue in the international matches, on the other side either B or S may show a stronger bargaining power traslating into a larger revenue share. It is worth noting that the outside options are affecting what B and S receive in the international matches simmetrically under both IB and IS strategies. Therefore, choosing a strategy does not imply choosing a different distribution of

bargaining powers.

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 no production takes place, 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, the operating profit either from selling his old final good produced in part with the new input or by selling directly the new input (net of the expenditure for the intermediate good bought from S), in both cases B bearing a profit loss γ_l and a sunk cost to search in the foreign market η.

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 product distance) 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 paricular $b^{Bjj} = \alpha^D b^S$, $b^{Bij} = \alpha^I b^S$, where the α's are the buyer-supplier cost ratios. The cost for B to adapt his process or product to a foreign good will be probably different (and most probably higher) from the cost of adapting for a domestic S. B, who is already matched with a domestic S, is likely to be 'less familiar' with a foreign S intermediate good.[10] Moreover, different countries, even if similarly developed, may show technical incompatibilities which need fixing.[11] Even more important is the difference in managing assistance between different countries. Under the IB strategy, S bears a fixed cost to provide B with the initial instructions and assistance to install the machine or use the input. Nevertheless, once that B has bought the input, each 'empasse' he incurs in, and for which he has to ask S's help, will be much more costly when S is located in a different country.

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

[11] 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 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.

With these assumptions, we want to underline here 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 given 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. Nevertheless, we also consider the case in which the cost of adapting per unit of distance is higher for S, $\alpha^D < 1$ and $\alpha^I < 1$.

Table 4, summarizes the definition of variables and parameters.

3.2.1 Buyer's decision in the Domestic Matches (D)

In this framework, B chooses the IB strategy if

$$\pi_B^{IB,D} > \pi_B^{IS,D} \tag{2}$$

under S partecipation constraint, PC^S

$$\pi_S^{IB,D} \geq 0. \tag{3}$$

B chooses istead the IS strategy if:

$$\pi_B^{IS,D} > \pi_B^{IB,D} \tag{4}$$

under the supplier's partecipation constraint, PC^S

$$\pi_S^{IS,D} \geq 0 \tag{5}$$

where Π are the total operational profits and $\pi_B^{IB,D} = \frac{\Pi}{2} - \alpha^D b^S Z_{ii}$ 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 (for derivation see section 5.1).

The solution of the B's decision problem allows us to identify the following intervals where either the IB or the IS strategy are implemented, respectively, or no match takes place.

IB: $Z_{ii} \in \{0, \underline{Z}_{ii}\}$

IS: $Z_{ii} \in \left\{\underline{Z}_{ii}, \overline{Z}_{ii}\right\}$

no match: $Z_{ii} \in \left\{\overline{Z}_{ii}, \frac{1}{2X_i}\right\}$

(with X_i number of S in B Domestic market)

and where

$$\underline{Z}_{ii} = \frac{F}{\alpha^D b^S} \tag{6}$$

$$\overline{Z}_{ii} = \frac{1}{b^S}(\frac{\Pi}{2}) \tag{7}$$

$$\tag{8}$$

are the relevant distance thresholds in a domestic match.

$\underline{Z}_{ii} < \overline{Z}_{ii}$ 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 $\alpha^D < 1$).

3.2.2 Buyer's decision in the International Matches (I)

The outside options in an international match are $OUT_k^I = E(\pi_k^D)$, where $k = S, B$. Indeed, 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 locations of the domestic suppliers and buyers, for B and S, respectively, is imperfect.

These outside options are given by:

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

and

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

where $E(\pi_S^D)$ and $E(\pi_B^D)$ are the expected profits of the Domestic matches for S and B, respectively; $g(Z_{jj}) = 2X_j$ and $h(Z_{ii}) = 2X_i$ are the densities of the distances in the S and B domestic markets, respectively.

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 go back to its domestic market only after that Z_{ij} is revealed.

B chooses IB internationally if:

$$\pi_B^{IB,I} > \pi_B^{IS,I} \tag{9}$$

under

$$\begin{aligned} \pi_S^{IB,I} &\geq E(\pi_S^D) && (10)\\ \pi_B^{IB,I} &\geq E(\pi_B^D). && (11) \end{aligned}$$

B chooses IS internationally if:

$$\pi_B^{IS,I} > \pi_B^{IB,I} \tag{12}$$

under

$$\begin{aligned} \pi_S^{IS,I} &\geq E(\pi_S^D) && (13)\\ \pi_B^{IS,I} &\geq E(\pi_B^D). && (14) \end{aligned}$$

where $\Pi - \gamma_{int} = \Pi_B + \Pi_B$ is the total operational profits and $\pi_B^{IB,I} = \Pi_B - \alpha^D b^S Z_{ij} \equiv \frac{1}{2}\left[\Pi - \gamma_{int} - E(\pi_B^D) - E(\pi_S^D)\right] + E(\pi_B^D) - \alpha^D b^S Z_{ij}$ and $\pi_S^{IB,I} = \Pi_S - F \equiv \frac{1}{2}\left[\Pi - \gamma_{int} - E(\pi_B^D) - E(\pi_S^D)\right] + E(\pi_S^D) - F$ are the net total profits received by B and S respectively in an International match under IB; $\pi_B^{IS,I} = \Pi_B - F \equiv \frac{1}{2}\left[\Pi - \gamma_{int} - E(\pi_B^D) - E(\pi_S^D)\right] + E(\pi_B^D) - F$and $\pi_S^{IS,I} = \Pi_S - b^S Z_{ij} \equiv \frac{1}{2}\left[\Pi - \gamma_{int} - E(\pi_B^D) - E(\pi_S^D)\right] + E(\pi_S^D) - b^S Z_{ij}$ are the net total profits received by B and S respectively in an International match under IS (for derivation see section 5.2).

The outcome of the B's decision process allows us to identify the following intervals where either of the two strategies are implemented or no international match takes place:

IB: $Z_{ij} \in \left\{0, \underline{Z}_{ij}\right\}$

IS: $Z_{ij} \in \left\{\underline{Z}_{ij}, \overline{Z}_{ij}\right\}$

no International match: $Z_{ij} \in \left\{\overline{Z}_{ij}, \frac{1}{2X_j}\right\}$

with X_j being the number of suppliers in the foreign market where B has searched, and where

$$\begin{aligned} \underline{Z}_{ij} &= \frac{F}{\alpha^I b^S} && (15)\\ \overline{Z}_{ij} &= \frac{1}{2b^S}\left[\Pi - \gamma_{int} - E(\pi_B^D) - E(\pi_S^D\right] && (16)\\ & && (17) \end{aligned}$$

are the relevant theresholds in an international match.

$\underline{Z}_{ij} < \overline{Z}_{ij}$ 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 $\alpha^I < 1$).

3.3 Results

3.3.1 Heterogeneity in internationalization and innovation strategies

As described in 3.1.2, at t_0, B decides whether to look for a International match or not. In taking 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, so expected profits in the foreign matches are considered. B goes and looks for an international match if $\pi_{B,0}^I + E(\pi_B^I) \geq (\pi_{B,0}^{IB,D} + \pi_{B,1}^D)$ under IB in the best domestic match, and if $\pi_{B,0}^I + E(\pi_B^I) \geq (\pi_{B,0}^{IS,D} + \pi_{B,1}^D)$ under IS in the best domestic match, where $\pi_{B,0}^I = \Pi - \eta - \gamma_l$ are the total net profits that B receives during the first meeting (with η and γ_l respectively the sunk cost of searching and the profit loss). $E(\pi_B^I)$ are the expected profits of the international match. $\pi_{B,0}^{IB,D}$ and $\pi_{B,0}^{IS,D}$ are the domestic profit under IB and IS strategy, respectively, at t_0 when adaptation occurs, and $\pi_{B,1}^{IB,D}$ and $\pi_{B,1}^{IS,D}$ are the profits at t_1 in a D match when S and B bear the switching cost σ only.

The outcome of B decision problem are the relevant intervals on the domestic product characteristic space where B either stay in a domestic match or looks for a foreign match engaging in a first meeting abroad. We obtain the theresholds on the domestic distance according to which the buyer decides whether to search for a foreign supplier or not, these theresholds depending on the innovation costs parameters and on η and γ_{int}, respectively the sunk cost of searching and the profit loss.

At t_1 the buyers who did not search abroad keep on in their domestic match, while the buyers who went abroad decide whether to keep on with the foreign supplier under either IS or IB strategy or to break the relationship and go back looking for a new domestic match. In the previous two sections, 3.2.1 and 3.2.2, we derived the relevant intervals in which the different strategies are implemented.

As a result of this decision process we obtain heterogeneous behaviours across firms which originally are heterogenous only in the characteristics of their product (i.e., location in the product space), with firms matching only domestically, under different innovation strategies (IB or IS); firms looking for a partner abroad; firms keeping on in a foreign match under either IS or IB strategy; and firms enagining 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 shorther distances, the IS strategy for larger distances, while no match takes place when the distance is too large. 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, taking the decision in order to maximize his profits under the S partecipation constraint, for 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 to go back home. Therefore, firms match internationally only when they find a better match, i.e. when distances are shorter.

3.3.2 A condition for exporting inducing innovation

To analyse how the set of distances for which IS strategy is implemented differs between International and Domestic matches we consider the measure of the relative share of the IS interval over the sum of (IS+IB) 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. One can easily check that the difference between $(IS)^I$ and $(IS)^D$ is given by:

$$(IS)^I - (IS)^D \equiv \Delta(IS) = \frac{2F}{\alpha^D \Pi} - \frac{2F}{\alpha^I \left[\Pi - \gamma_{int} - E(\pi_B^D) - E(\pi_S^D\right]}. \quad (18)$$

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

$$\alpha^I > \frac{\alpha^D \Pi}{\left[\Pi - \gamma_{int} - E(\pi_B^D) - E(\pi_S^D)\right]} \equiv \bar{\alpha}^I \quad (19)$$

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 succesfull 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. By contrast, 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 weight of the IS strategy set. An 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 domestic inputs' characteristics, or that asking for technical assistance from abroad may be more costly (see also 3.2).

It is also worth noting that $\bar{\alpha}^I$ is positively related to both X_i, the number of suppliers in the country of origin of B and γ_{int}, the internationalization cost. The higher the probability for the Buyer to find a good match in the domestic market, the higher the cost of managing operations abroad, the shorter the set of distances for which an international match is implemented, the more likely B buys 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 the knowledge transfers running between firms, and, in particular, on the information exchange 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 to 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. We then provide a set up in which for a Buyer-Supplier match to work, some adaptation is needed depending on the distance between the Buyer's needs and the

good produced by the Supplier. 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 distance-related costs. The imperfect information that Buyers have on the actual distribution of suppliers abroad allow us to introduce learning 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 occuring between firms generate different innovation outcomes when the relationship is developed in domestic or foreign matches. We single out the distance thresholds (in the product space) as a function of the innovation costs' parameters, the internationalization costs and the number of suppliers in the different countries, delimiting the intervals for which different innovation and internationalization strategies ar implemented. 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 in the market. In summary, our model provides a framework in which firms may implement different innovation and internationaliziation strategies just depending on the characteristics of their products. This may also provide some insights to explain why also small and perhaps not very productive firms not doing formal R&D manage to compete in both domestic and foreign markets even in well integrated trade areas by implementing successful innovation activities.

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:

$$\pi_B^{IB,D} = \frac{\Pi}{2} - \alpha^D b^S Z_{ii} \tag{20}$$

$$\pi_S^{IB,D} = \frac{\Pi}{2} - F \tag{21}$$

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

$$\pi_B^{IS,D} = \frac{\Pi}{2} - F \tag{22}$$

$$\pi_S^{IS,D} = \frac{\Pi}{2} - b^S Z_{ii} \tag{23}$$

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:

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

5.2 Derivation of pay offs in the International matches

Pay offs in the International Matches under IB and IS strategy

Assuming again an ex-post splitting rule, with the above specified outside options, 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, under the IB strategy:
$\pi_B^{IB,I} \equiv \Pi_B - \alpha^D b^S Z_{ij} = \frac{1}{2}\left[\Pi - \gamma_{int} - E(\pi_B^D) - E(\pi_S^D\right] + E(\pi_B^D) - \alpha^D b^S Z_{ij}$

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

The GE condition for the International match to be profitable must hold (non negative GFT):

$GFT^{IB,F} : \left[\Pi - \gamma_{int} - E(\pi_B^D) - E(\pi_S^D\right] \geq 0$

$\pi_B^{IB,I}$ and $\pi_S^{IB,I}$ are the net total profits received by B and S, respectively, in an International match under IB.

We obtain the following net total profits, under the IS strategy:

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

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

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

$\pi_B^{IS,I}$ and $\pi_S^{IS,I}$ are the net total profits received by B and S, respectively, in an International match under IS.

Table 1: Summary statistics on firm's innovation by domestic and foreign matches

Type of match	product innovation (share)	market innovation (share)	applied for patents (share)
Domestic customer$^{(a)}$	0.388	0.219	0.067
Foreign customer$^{(b)}$	0.584	0.409	0.186

Note. $^{(a)}$ Produces for domestic customers only. $^{(b)}$ Produces for at least one foreign customer.

Table 2: Producing to order for foreign customers (FORCUST) and product innovations (OLS)

	(1)	(2)	(3)
FORCUST	0.213***	0.175***	0.115***
	(0.013)	(0.014)	(0.014)
R&D employment ratio			0.307***
			(0.014)
capital intensity			0.001
			(0.011)
unit labor costs			-0.005
			(0.005)
firm size fixed effects (4 categories)			yes
country fixed effects		yes	yes
NACE fixed effects		yes	yes
N. obs.	6980	6980	6980
R2	0.05	0.14	0.22

*,**,*** significant at 10, 5 and 1 percent, respectively. Standard errors robust to heteroskedasticity. All regressions use survey weights.

Table 3: Producing to order for foreign customers (FORCUST) and 'degree' of innovation (OLS)

	market innovations (1)	patent (2)	design (3)	trademark (4)	copyright (5)
FORCUST	0.110***	0.056***	0.021***	0.039***	0.009*
	(0.013)	(0.009)	(0.006)	(0.010)	(0.004)
R&D employment ratio	0.235***	0.115***	0.043***	0.076***	0.019***
	(0.013)	(0.009)	(0.005)	(0.009)	(0.004)
capital intensity	0.005	0.010	0.011**	0.014	0.002
	(0.010)	(0.007)	(0.004)	(0.009)	(0.003)
unit labor costs	0.000	-0.000	-0.004*	-0.008	-0.005**
	(0.006)	(0.004)	(0.002)	(0.005)	(0.002)
firm size fixed effects (4 categories)	yes	yes	yes	yes	yes
country fixed effects	yes	yes	yes	yes	yes
NACE fixed effects	yes	yes	yes	yes	yes
N. obs.	6980	6980	6980	6980	6980
R2	0.19	0.16	0.13	0.15	0.12

*,**,*** significant at 10, 5 and 1 percent, respectively. Standard errors robust to heteroskedasticity.

Table 4: 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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