International cooperation on innovation: firm-level evidence from two European countries

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Abstract

This paper investigates the factors that lead firms to cooperate with partners from foreign countries on innovation activities. We find that the characteristics of firms engaging in innovation cooperation with domestic partners are different from those firms that cooperate with foreign partners. Data from the harmonised Community Innovation Survey allows comparing innovation cooperation behaviour of private firms in a highly innovative country with a high export share, Germany, and firms in a country with a negative trade balance, Portugal. Using a bivariate probit model, we show that – despite differences in the internationalisation of the two economies - the characteristics of firms cooperating with foreigners in both countries are fairly similar. International activities other than cooperation, firm size and the importance of protection methods for knowledge have a positive influence in both countries on the decision to cooperate with foreign partners.

Keywords: International cooperation, Innovation, Innovation Survey, Germany, Portugal
JEL-Codes: O32, O57

1 Introduction

Driven by increasing competition through globalisation and ever shorter innovation and product-life cycles, firms are faced with a demand for knowledge they cannot satisfy with their internal resources alone. “Tapping external sources of know-how becomes a must” (Tsang, 2000: 225). Firms have to look for partners for their innovation projects, which has led to an increase in the number of innovation cooperation agreements, documented by Hagedoorn (2002) and the OECD (1986), among others. The move to a more open innovation strategy has also contributed to the growing number of inter-firm partnerships. Following the seminal work of Chesbrough (2003a; 2003b), Laursen and Salter (2006) find that the open innovation model is being adopted by an increasing number of firms that invest resources to search for innovative opportunities through the establishment of external linkages.

The globalisation of firms’ activities has contributed to the pressure to become more innovative and to conduct R&D and innovation activities on a wider scale, including the establishment of international partnerships (Archibugi and Immarino, 1999). Furthermore, the type and structure of collaborations and partnerships between domestic and foreign partners has changed (Hagedoorn and Narula, 1996). While, in the past, international R&D and innovation alliances were mostly equity-based alliances, like joint-ventures, looser forms of collaboration between partners from different countries have emerged in recent years. Currently, most of the growth in international collaborative activities can be attributed to these looser and more flexible forms (Narula and Hagedoorn, 1999).

The increasing collaborative activities of firms and the exchange and flows of knowledge associated with them have attracted the interest of policymakers. Some

national and European-level funding agencies have established cooperation, and, in particular, international cooperation, as an essential condition for receiving support for innovation and R&D activities in order to foster the flow of knowledge between national innovation systems (Czarnitzki and Fier, 2003; Kingsley and Malecki, 2004; Eickelpasch and Fritsch, 2005).

The growth in international collaborative activities in innovation and R&D has led researchers from different areas to investigate the underlying motives for these kinds of agreements. Main contributions come from the international management literature, which is concerned with the strategic aspects of international innovation collaboration, and from economics, which looks at the growth of different forms of international alliances and their underlying motives. Our paper is closely related to the second of these two strands of literature. We look at the factors and firm characteristics that influence firms' decisions to collaborate with foreign partners on innovation and R&D activities. In other words, this paper seeks to identify the determinants behind firm level decision to source knowledge for innovation from outside its national innovation system through cooperation activities with partners from abroad. Following a number of papers that analyse the innovation cooperation process from both a theoretical and empirical perspective (see Röller et al. 2007, Marin et al. 2003 or Cassiman and Veugelers 2002 for a review), we investigate a topic for which there are still only few empirical findings: the factors that motivate firms to enter into international innovation cooperation networks.

The paper contributes to the existing literature in several ways. Firstly, we use a large scale survey (Community Innovation Survey) to tackle the question at hand and not a case study approach. Secondly, the data we have also allow us to take the looser forms of collaboration into account and focus on more than equity joint-ventures. Thirdly, we

compare the factors that drive international collaboration across two countries in order to analyse what role different internationalisation and innovation systems play in the decision to collaborate with foreign firms. To be more precise, we compare Germany, a very export-oriented country which has an established high-tech industry and a share of innovators of 54%, with Portugal, a country which has a negative international trade balance, where most exports come from labour-intensive sectors, which sees its strengths in the services sector and has a share of innovators of 44%. Given these differences, our firm-level data will allow us to analyse the international innovation cooperation behaviour in two different settings of internationalisation, i.e. firms in an economy which is highly involved in foreign product markets as opposed to a country which has less experience and fewer established links with foreign partners.

The paper is structured as follows: In the following section, we review the literature on innovation cooperation, with a focus on cooperation with foreign partners. This will be followed, in Section 3, by a description of the Portuguese and German datasets used in the empirical part of the paper. Section 3 will also provide information on the construction of our main variables, descriptive statistics, and the econometric model. In Section 4, we present our estimation results for the two countries before drawing some conclusions and discussing some policy implications in Section 5.

2 Conceptual Framework

In this section we will review the literature on motives for and determinants of cooperation on R&D and innovation of firms. The first part will focus on general determinants while the second discusses literature related to international collaboration specifically. The third part presents our hypotheses. In the fourth part of this section we present some figures on the internationalisation of the two countries' economies we analyse, Portugal and Germany.

2.1 Determinants of and motives for R&D and Innovation Cooperation

The boundaries of innovation are shifting from a situation where firms perform R&D activities mainly internally (Mowery, 1983; Nelson, 1990) to a reality where corporate partnering, collaboration, external sourcing in R&D and "open innovation" strategies are widely used (Chesbrough, 2003a; 2003b). In particular, cooperation has gained an important role in the innovation process of firms and multinationals as well as small and medium-sized firms are increasingly engaging in tighter relationships with other companies (Rosenfeld, 1996; Hagedoorn et al., 2000).

The empirical literature on cooperation has shown that firms undertake collaborative activities with other firms or institutions in order to access complementary (technological) resources and knowledge, to share costs and spread risk, to improve market access, and to realise economies of scale and scope (see e.g. Hagedoorn, 1993; Glaister and Buckley, 1996; Narula and Hagedoorn, 1999; Cassiman and Veugelers, 2002; Sakakibara, 1997; Miotti and Sachwald, 2003; Aschhoff and Schmidt, 2006).

In this paper we are concerned only with collaboration on innovation and R&D activities. For this type of collaboration between firms access to and sharing of

knowledge has been identified as one of the main motives (for empirical evidence see e.g. Cassiman and Veugelers, 2002; Bönte and Keilbach, 2005; Abramovsky et al., 2008; Gomes-Cassares et al., 2006). Innovation and R&D cooperation activities are usually characterised by intensive knowledge exchange and mutual learning (Dachs et al., 2004; Becker and Dietz, 2004) seeking to open up a range of technological opportunities (Mowery et al., 1998; Caloghirou et al., 2003). The classic perspective for analysing the decision to cooperate is therefore to see it as a balance between achieving a high level of knowledge inflow and the prevention of internal knowledge leaking out, i.e., the internalisation of spillovers (see e.g. D'Aspremont and Jacquemin, 1988; Kamien et al., 1992; de Bondt and Veugelers, 1991; Belderbos et al., 2004; Kaiser, 2002; Cassiman and Veugelers, 2002).

A crucial role in this respect is played by a firm's absorptive capacity, i.e., its ability to "identify, assimilate and exploit knowledge from the environment" (Cohen and Levinthal, 1989: 569). Firms can try to increase the extent of incoming spillovers within cooperative agreements and from the environment in general by investing in "absorptive capacity". The greater a firm's absorptive capacity, the more able it should be to access and use external knowledge (Cohen and Levinthal 1989, 1990). The capacity of firms to take advantage of knowledge generated elsewhere has a positive effect on the probability of being a successful innovator and is positively associated with the decision to undertake formal research collaboration with other firms and institutions (Abramovsky et al., 2008; Bayona et al., 2001[1]). However, *per se* the effect on the cooperation decision is unclear since higher absorptive capacity can make a firm less

1 The literature that finds a positive effect of own R&D on the probability of collaboration can also be seen as evidence that absorptive capacity has a positive influence on the likelihood of collaboration (e.g. Fritsch and Lukas, 2001; Fontana et al., 2005), since absorptive capacity is usually represented by a measure of in-house R&D activities in empirical models (see Schmidt, 2005 for a review).

likely to cooperate because it can obtain access to external knowledge without cooperating.

In addition to absorptive capacity, other factors have been considered in the literature to influence firms' cooperation decision: the research approach (basic vs. applied) (Cassiman and Veugelers, 2002), public R&D support (Abramovsky et al., 2008; Negassi, 2004; Busom and Fernandez-Ribs, 2004), export activities (Dachs et al., 2004; Busom and Fernandez-Ribas, 2004), size (Röller et al., 2007; Link and Bauer, 1987; Fritsch and Lukas, 2001), and industry (Dodgson, 1994; Tether, 2002). Since empirical evidence has shown that these aspects explain most of the differences between cooperative and non-cooperative firms, we will consider them in our empirical analysis and analyse whether they affect only domestic cooperation or also collaboration with foreign partners.

2.2 Determinants of and motives for international cooperation

Globalisation has contributed to a growing number of international R&D and innovation partnerships (Kafouros et al., 2008). The growth of international competition and cooperation is a natural outcome of the expansion of firms into new markets and countries since this process makes firms face new realities and challenges (Archibugi and Immarino, 1999). Some of the high costs of managing international projects (von Zedtwitz and Gassmann, 2002) have been reduced by the availability and wide diffusion of new information technologies (Li and Zhong, 2003; Dunning, 1994). Associated reductions in communication costs and increases in the potential to coordinate activities across countries have certainly contributed to the boom of international R&D cooperation. In addition, international R&D cooperation activities have been boosted by the increased investment of multinational firms in R&D activities performed abroad

(OECD, 2008; van Beers et al. 2008, Cheng and Bolon, 1993; Nobel and Birkinshaw, 1998), associated with the fact that the success of innovation activities is positively influenced by the degree of internationalisation (Kafouros et al., 2008). The move to more open innovation strategies has also contributed to the growing number of inter-firm partnerships (Chesbrough, 2003a; 2003b) with both domestic and foreign partners. A different explanation for the growing number of international cooperation agreements has been presented by Narula and Hagedoorn (1999). They argue that the fact that few firms have resources to duplicate value chains in different locations has led to more cooperation agreements.

The literature has identified a number of specific motives for individual firms to enter into international cooperative agreements. Glaister and Buckley (1996) analyse UK firms' international cooperation behaviour (in general and not just related to R&D) and show that motives related to technology development, such as sharing of R&D costs and exchange of complementary technology, are more important for cooperation with domestic partners than for cooperation with international partners. The opposite is true for market development motives, such as faster entry into markets, conforming to foreign government policies or facilitating international expansion. Despite these differences in the importance attributed to the different drivers of cooperation agreements, Glaister and Buckley (1996) show that R&D cooperation motives are similar for international and domestic partners.

Wu and Callahan (2005) analyse the motives behind multinationals' decisions to establish R&D alliances with organisations from host countries. They find that when establishing R&D cooperation agreements in China multinationals have two main objectives: the creation of vertical linkages and the search for human resources.

Von Zedtwitz and Gassmann (2002) analyse a database of 81 companies representing 1,021 R&D sites. They stress the significance of two main internationalisation drivers in R&D: access to local science and technology sources (see also Nobel and Birkinshaw, 1998), and access to local markets and customers. They find that technology-intensive firms are trying to exploit location-specific innovation advantages through the internationalisation of their R&D activities and are thus able to cope with the increasingly globalised environment. Firms no longer look for partners to share in R&D costs within their own country only, but also consider firms outside their country, leading to the observation that the motives for both types of R&D cooperation are similar. Other questions analysed by von Zedtwitz and Gassmann (2002) are what level and which type of R&D commitment are established by multinational firms in the host countries. Taking into consideration host country specifities, they conclude that complete integration of globally dispersed R&D activities can produce high coordination and social costs, which drive firms to invest in local product adaptation and in foreign science clusters, usually through looser forms of innovation cooperation[2].

Hagedoorn and Narula (1996) focus their analysis on the importance of international R&D alliances by inquiring into the industry differences concerning the choice of cooperation modes. They find that joint ventures are associated mainly with mature industries and that contractual alliances are the option of firms from high-tech industries.

The firm level choice of the specific form of international R&D partnership, paying attention to the different regimes of intellectual property rights that exist in different countries, is analysed by Hagedoorn et al. (2005). Their main finding is that, when

2 On different types of R&D partnerships see Schartinger et al. (2002)

facing less strict intellectual protection, firms choose R&D joint ventures rather than contractual partnerships.

A benefit of setting up international cooperative agreements is a potential increase in the competitiveness of the firm. Some empirical evidence stresses that dispersed R&D activities may contribute to firms' competitiveness when compared with centralised R&D operations since it is an opportunity to take advantage of host-country scientific inputs and reduce the uncertainty in unfamiliar business environments (Li and Zhong, 2003).

Finally, the involvement of public authorities through support systems can be expected to have an impact on the willingness of firms to engage in R&D cooperation across borders. In the European Union, for example, many funding schemes explicitly require firms to cooperate in order to gain access to funds for R&D and innovation projects (Czarnitzki and Fier, 2003; Kingsley and Malecki, 2004; Eickelpasch and Fritsch, 2005).

2.3 Hypotheses

The literature cited in the two previous sections makes it clear that several factors contribute to the decision of a firm to engage in collaborative R&D and innovation activities with foreign and domestic firms. There is some empirical evidence showing that the motives and drivers behind the decision to establish domestic and international innovation agreements are quite similar. According to the literature, firms collaborate domestically and abroad in order to expand their markets, gain access to complementary knowledge or share costs and risks. Even though the motives seem to be similar, it is not clear whether firms that cooperate with foreign firms are similar to firms that cooperate with domestic firms. Reasons for differences with respect to firm

characteristics can potentially be higher resource requirements for international collaboration (both in terms of quantity and quality), special capabilities necessary to overcome social and cultural barriers in other countries ("liabilities of foreigness"- Zaheer, 1995) or experience in dealing with foreign actors ("Learning by exporting" - Keller, 2004).

In this context our first hypothesis to be tested in the empirical part of the paper is:

H1: Firms engaged in innovation cooperation with domestic partners are different from those cooperating with foreign firms.

One of the aims of our paper is to shed some light on the way globalisation influences the collaboration decision, by analysing two different countries, with different types of exposure to globalisation of product markets and different R&D and innovation systems. In order to assess the importance of country-specific globalisation and innovation environments in the cooperation decisions, we test our first hypothesis with data from two different countries, leading us to the second hypothesis:

H2: Differences with respect to the internationalisation of firms' activities in a country lead to differences in the factors that influence innovation cooperation with foreign partners.

We choose Portugal and Germany as examples of countries with different types of internationalisation environments and innovation systems. The next section will briefly describe why these two countries are suitable for testing our second hypothesis.

2.4 Innovation and Globalisation in Portugal and Germany

Comparing Germany and Portugal is interesting because the two countries exhibit some similarities with respect to innovation cooperation but differ with respect to the share of innovative firms, their size, location within Europe, and their situation with regard to internationalisation of the two economies.

The German economy is known to be one of the leading exporters in the world. According to Eurostat's statistical yearbook (Eurostat, 2008), Germany exported goods valued at 780.2 billion Euro in 2005 and imported goods worth 622.2 billion Euro, leading to net exports of 158 billion Euros. Portugal on the other hand is a net importer (18.5 billion Euros) of goods. For services the opposite is true; Germany's is a net importer of services, whereas Portugal is a net exporter.

The FDI figures published by Eurostat also show that the Portuguese and German economies differ with respect to their internationalisation environment. In 2005 Portugal invested less abroad than foreign firms invested in Portugal (-1.582 billion Euro). German firms on the contrary invested 36.7 billion Euro in 2005 abroad while foreigners invested 26.3 billion Euro in Germany. These figures tend to fluctuate from year to year. A more accurate picture of aggregate FDI activities is therefore given by the FDI stocks. In 2005 net FDI stocks (Outward FDI – Inward FDI) in Germany were 466.1 billion Euros (UNCTAD, 2007) and -12.2 in Portugal[3].

The United Nations furthermore collect data on the importance of foreign affiliates in many countries. Their online-database (UNCTAD, 2008) shows that in 2003 about 9300 affiliates of foreign multinationals were operating in Germany, most of them in the tertiary sector. These firms were employing 2.1 million employees (roughly 4% of all

3 Note that the FDI concepts used by Eurostat and the United Nations differ.

employees in Germany). The number of affiliates is not available for Portugal, but employment figures are. In Portugal 150,355 people were employed by affiliates of foreign multinationals, i.e. roughly 2% of all employees in Portugal.

The two countries also differ with respect to their R&D and innovation activities. A recent report by the OECD (OECD, 2008) analyses the link between foreign ownership and R&D expenditure. According to this report about 50% of all R&D expenditure in Portugal is spent by affiliates of foreign multinationals, in Germany only 25% of R&D is conducted by foreign multinationals. The foreign multinational firms account for 25% of total turnover in Germany, but for only 14% of total turnover in Portugal. Not surprisingly, the R&D intensity (R&D expenditure divided by turnover) of foreign firms' affiliates in Portugal is much higher (ca. 0.6%) than for domestically controlled firms (ca. 0.1%). In Germany the intensities for both groups are similar, at 2.2% and 2.3 % respectively.

When it comes to the results of R&D activities and their commercialisation, the two countries also differ significantly. According to the Eurostat publication "Innovation in Europe" (Eurostat, 2004), 54% of all German firms with ten or more employees introduced product or process innovation between 1998 and 2000. In Portugal, the figure is 10 percentage points lower, at 44%. However, the percentage of innovators that cooperated is quite similar in both countries, at 16.8% in Portugal and 17.4% in Germany.[4] The structure of innovation cooperation with respect to domestic and foreign partners is also quite similar in both countries. Between 1998 and 2000, about 14% of German firms cooperated with partners within Germany and about 7% with partners in the EU. The respective figures for Portugal are 17% and 5% (Eurostat, 2004). It looks

4 Over the period 2002-2004, a similar structure emerges with respect to innovation cooperation: 16% of German innovation-active firms cooperated on innovation activities and 19% of Portuguese

like the innovators in both countries are quite similar with respect to their innovation cooperation behaviour, despite the different structure of their respective economies. In the empirical part of the paper, we analyse whether this similarity is just a phenomenon at the aggregate level or whether it also shows up in the factors that influence the decision to cooperate with domestic and foreign partners on innovation activities.

innovation-active firms (Eurostat, 2007a and 2007b). The gap between the share of innovative firms widened to 24 percentage points for the same period (Germany: 65%; Portugal: 41%).

3 Data, construction of the variables and empirical framework

For the empirical part of the study we use data from the Community Innovation Survey III (CIS III), which was undertaken by the member states of the European Union in 2001. The survey collects data on the innovation activities of firms in each country from both the manufacturing and service sectors. Its design, questions, concepts and definitions used are based on the Oslo Manual's second edition (OECD, 1992). The questionnaire itself and the methodology are harmonised across EU member states, making comparisons between the results for different countries possible. Some minor differences exist nonetheless, as countries are allowed to add questions to their questionnaire and to cover firms that are smaller than the threshold of ten employees or belong to industries outside the core coverage of NACE classifications.

The latter is the case for the German CIS III survey, which is part of a larger activity in collecting data on the innovation behaviour of private firms in Germany ("Mannheim Innovation Panel") through an annual innovation survey.[5] This annual survey is conducted by the Centre for European Economic Research (ZEW) on behalf of the German Federal Ministry of Education and Research. The German CIS III covers firms with five or more employees and includes, for example, the retail sector which is not part of the core NACE coverage of the CIS. The sample is stratified by region (East Germany and West Germany) in addition to size and industry. The questionnaire conforms fully the Eurostat recommendations.

5 For a more detailed description of the Mannheim Innovation Panels and the German CIS III, see Janz et al. (2001) and Rammer et al. (2005a).

The Portuguese questionnaire is mainly a translation of the harmonised Eurostat questionnaire, but includes some additional questions. Nevertheless, and owing to the experience of CIS II, a more comprehensive design of the questionnaire was developed with several notes and examples shown along with the questionnaire to make it easier for the respondent to understand the questions.

To make the results of the surveys and our econometric analysis in the two countries comparable, all variables were constructed in the same way, which was an easy task given the harmonised survey questionnaire. Additionally, firms with fewer than ten employees were deleted from the German dataset and the same sector coverage was applied to German and Portuguese data.[6]

Since most of the questions in the survey were to be answered only by innovative firms, i.e. firms that introduced at least one product or process innovation between 1998 and 2000 or had ongoing innovation activities during these years, we restricted our sample to this group of firms.

3.1 Construction of the variables and descriptive statistics

Below we describe the construction of the variables included in our empirical model. Our plan for the empirical part of the paper is to estimate equations with indicators of foreign and domestic cooperation as dependent variables and a number of potential determinants of international innovation cooperation and general firm characteristics as independent variables. The choice of independent variables for the empirical model is based on the literature review in Section 2.

Dependent variables

6 See Table 3 in the Appendix for details on the industries included.

Two dependent variables are constructed from a matrix-type question on R&D and innovation cooperation.[7] Each innovating firm was asked to indicate if it had "any cooperation arrangements during 1998-2000" (Eurostat CIS III Questionnaire). The question includes a definition of innovation cooperation: "Innovation cooperation means active participation in joint R&D and other innovation projects with other enterprises or non-commercial institutions. It does not necessarily imply that both partners derive immediate commercial benefit from the venture. Pure contracting out of work, where there is no active collaboration, is not regarded as cooperation." (Eurostat CIS III Questionnaire) If the firm answered 'yes', it was asked to indicate the partners with whom it had cooperated. Potential partners were combinations of the role of the partner (for example, other firms within the same group of firms[8], customer, supplier, competitor, consultants, and public institutions) and their location (domestic, EU/EFTA, USA, Japan and the rest of the world). We used this information to construct our dependent variables. The first variable indicates whether the firm had cooperated with at least one domestic partner (*cod*) and the second indicates if the firm had cooperated with at least one foreign partner (*coforeign*). Firms can have cooperated on R&D and innovation activities with both domestic and foreign partners, of course. In this case, both variables will be one. In Portugal, 205 innovative firms in the sample (26%) cooperated on innovation activities and the corresponding figure in Germany is 478 (32%). As Table 1 shows, 459 firms (96% of cooperating firms) in Germany were collaborating at least with domestic partners and 181 (38%) with at least one foreign partner. In Portugal, the first group consists of 175 firms (85%) and the second of 109

7 For a more detailed description of the construction of the dependent and independent variables, see Table 3 in the Appendix.

8 Firms cooperating only with partners from their own group were excluded from the analysis for two reasons: First, cooperation within a group is certainly different from cooperating with external

firms (51%). Splitting the cooperating firms into exclusive groups reveals that 96 Portuguese firms (47% of all cooperating firms) cooperate with only domestic partners, 30 (14%) with only foreign partners, and 79 (39%) with both domestic and foreign partners. In Germany, the respective figures are 297 (62%), 19 (4%) and 162 (34%)[9].

(Insert Table 1)

Independent variables

To structure the analysis we include three groups of potential determinants of international innovation cooperation and characteristics of firms in our empirical model.

A first group of variables is meant to capture the link between innovation cooperation and firms' other links with foreign countries. This group includes the export status of the firm (*exports*) in 1998[10] and an indicator variable taking the value one if the firm belonged to a multinational group with its headquarters in a foreign country (*multinational*) or not. As the descriptive statistics of our sample show, the percentage of both exporters and firms belonging to a multinational group is higher in the group of firms cooperating with foreigners than in the sample. This is the case for Portugal and Germany. This first group of variables represents factors that should mainly influence the decision to cooperate with a foreign partner on innovation activities. That said, firms selling goods and services in an international market might also be more likely to

partners, for example, with respect to trust and, second, only firms belonging to a group can cooperate within their group, while all the other partners can be chosen by all firms.

9 Comparing these figures with the weighted results published by Eurostat (Eurostat, 2004 – see also Section 2.3), cooperating firms and firms cooperating with foreign partners are over-represented in our sample. However, our sample differs from the Eurostat sample, since we excluded some industries from our analysis.

10 We included the export status in 1998 and not 2000 in order to reduce a potential endogeneity bias that may exist between exports and international innovation cooperation. See Ebling and Janz (1999) for a discussion of the endogeneity of exports and innovation.

cooperate with domestic partners than non-exporters, because they face greater competition than non-exporters or because they have to develop more innovative products to be successful in foreign markets.

The second group of variables is related to the innovation activities of the firm. We try to capture a variety of innovation activities, from variables related to a firm's absorptive capacity to variables capturing the innovation strategy of firms. Absorptive capacity is measured along two dimensions: in-house R&D activities (*Rnd*) and the skill level of firms' employees (*skills*). Information on these dimensions of absorptive capacity can be taken directly from questions included in both innovation surveys: *Rnd* is constructed based on a question that asks firms to indicate whether they had any continuous or occasional R&D activities between 1998 and 2000. A dummy for an above-average percentage of employees with a higher education degree is constructed using a question on the skill levels of employees. This variable takes the value one if the firm has a higher share than the median firm in the country.

That absorptive capacity has a positive effect on innovation cooperation in general has been established by ealier literature. Our descriptive statistics support this finding. In Portugal and Germany the group of cooperating firms (regardless of the nationality of their partners) exhibits a larger proportion of firms with an above-average share of high-skill labour and R&D performers than the group of non-cooperating firms.

We also include variables measuring the innovation intensity of a firm, i.e. the share of innovation expenditure in sales (*inno_int*). Innovation expenditure is taken directly from a question on different types of innovation activities in 2000, including in-house R&D, external R&D, acquisition of machinery and knowledge for innovation, training for innovations, and preparation of the market for the introduction of innovations. The innovation intensity is higher for cooperating firms than for non-cooperating firms in

Germany only. We include the innovation intensity also as a squared term *(inno_int²)* to allow for a non-linear relationship between innovation expenditure and the likelihood of collaborating with domestic or foreign partners. Firms spending more on innovation activities relative to their turnover may be less likely to collaborate on innovation activities because they are at the technology frontier and cannot find adequate partners or because they are able to satisfy their needs with in-house innovation activities.

Innovation cooperation is certainly part of the overall innovation strategy of the firm. As Cassiman and Veugelers (2002) and many other authors using their empirical model have shown, the generation and prevention of knowledge spillovers is particularly important in this respect. We include two measures of knowledge spillovers: incoming knowledge spillovers (*spill_in*) and outgoing spillovers (*spill_out*). The first measure is constructed from a question on information sources a firm uses for its innovation activities. It represents the importance a firm assigns to publicly available information from professional conferences, meetings, journals, exhibitions and trade fairs. Usually this variable is assumed to have a positive effect on innovation cooperation in general. The argument is that firms assigning a great importance to external knowledge have an incentive to cooperate in order to internalise spillovers. Given the construction of the variable, it is also conceivable that it has a negative impact on the likelihood of innovation cooperation. If the firm assigns major importance to freely available knowledge it might be less inclined to cooperate simply because it can obtain the knowledge it needs without cooperating on R&D and innovation.

The prevention of spillovers is measured indirectly: the higher the importance of patents and secrecy the lower will be outgoing spillovers (see Schmidt, 2006)[11].

11 Since the Portuguese version of the questionnaire does not include a question where firms can attribute levels of importance to different knowledge protection methods, the Portuguese analysis was made

Moreover, the outgoing knowledge spillovers variable also gives an indication of firms' strategies with respect to the protection of valuable firm-specific competitive advantages. If firms assign a high value to protection methods they might be less likely to cooperate because they do not want to expose their valuable assets to third parties. Our descriptive statistics point in another direction, however. Cooperating firms assign greater importance to both incoming and outgoing spillovers than do non-cooperating firms in both countries. This points to a potential endogeneity problem. Firms may be more likely to use protection methods if they cooperate in order to protect their knowledge from spilling over to the cooperation partner.

A special and distinct part of the innovation activities of a firm is public funding. As mentioned above in the literature review, public funding may be a factor influencing a firm's cooperation decision. We therefore include a dummy variable which takes the value one if the firm has received any public funding for its innovation activities from either domestic or international authorities.

Finally, some additional basic firm characteristics are included in our empirical model on the right-hand side of the equation. We include two size dummies, one for firms with 50 to 249 employees (*size2*) and one for large firms, with 250 and more employees (*size3*). Firms with 10 to 49 employees is the reference category. The industry group a firm belongs to is represented by five industry groups of dummies that are constructed in accordance with the OECD classification of knowledge-intensive services and manufacturing industries (for details see Table 3 in the Appendix). The reference category is low-tech manufacturing, which comprises firms in NACE 15 to 22, 26 and 37.

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using the sum of the number of strategic and formal protection methods for innovations (secrecy, complexity of design, lead-time advantage, patents, copyrights, trademarks, registered designs),

Even though we excluded firms which are cooperating only within their own group, we still control for being part of a group by including a dummy for multinationals and one for domestic groups. Belonging to a group allows firms to gain some experience with activities distributed over several locations and joint R&D activities with firms from their group. This should have a positive influence on the ability to handle and manage cooperative agreements and should thus lead to a higher probability of collaborating on R&D with all kinds of external partners.

Almost all studies on the innovation behaviour of German firms using data from the Mannheim Innovation Panel (both econometric and descriptive) take into account whether the firm is from Eastern or Western Germany. They frequently find a significant influence of the location on all kinds of innovation activities (e.g. Sofka and Schmidt, 2004; Rammer et al., 2005b). In order to take this into account we also include a dummy variable for Eastern Germany in the estimations on the German dataset.[12] The percentage of firms from Eastern Germany in the group of firms cooperating with foreign partners is about 23% and significantly lower than in the sample.

As far as these more general firm characteristics are concerned, our descriptive statistics show that the firms cooperating with foreign partners are, on average, larger than non-cooperating firms in both Portugal and Germany. In Germany, they are also more often from high-tech manufacturing industries, while in Portugal they are not. In Portugal, firms belonging to a multinational group are significantly more often cooperating with foreign partners than are non-cooperating firms.

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rescaled between 0 and 1.

12 To check whether this influences the results we also estimated the equations for Germany without the Eastern German dummy. All variables that are significant in the tables reported below retain their significance. The only difference is that the skills variable goes from the 95% to the 90% level for foreign partners. The coefficients and marginal effects change only slightly. The structure with respect to the marginal effects stays the same both within each equation and across equations. The estimation results without the Eastern German dummy are available upon request.

To conclude this section, we look at the differences between the Portuguese and German samples. It is, at first sight, surprising that in the Portuguese sample the share of exporters is greater than in the German one. Note, however, that we are not measuring the volume of exports but rather the percentage of firms reporting any exports. Except for the share of firms belonging to a group, most of the other values are significantly lower in Portugal than in Germany, most notably, the share of high-tech manufacturing firms, mentioned above. The comparison of the means reveals that intellectual property protection and other protection methods (outgoing spillover variable) are less important in Portugal than in Germany. This may be a result of different types of innovation and R&D activities in the two countries. More novel products usually require more protection than imitative innovations. The share of funded firms is not significantly different between Germany and Portugal.

The comparison of the means for German and Portuguese firms that cooperate with foreign partners provides some interesting insight as well. The percentage of exporters, R&D-active firms, and funded firms is not significantly different between the two countries. However, we find differences for the means with respect to firms cooperating with domestic partners on innovation activities. This indicates that firms cooperating only with foreign partners are quite similar in both countries, as are those cooperating with domestic and foreign partners. The percentage of large Portuguese firms cooperating with foreign partners is also similar to the percentage in Germany. This is the case for firms cooperating with domestic partners as well.

3.2 Econometric model

The structure of the data collected with the CIS III surveys on collaboration with foreign partners *per se* allows the choice of at least two different econometric methods,

multinominal logit or bivariate probit. The data could be arranged in a way that three exclusive categories would result, i.e. only domestic cooperation partners, only foreign cooperation partners and partners from both domains. The multinominal logit model would, however, also imply that the firm takes only one decision on the location of its cooperation partners, which is fairly unlikely, particularly since we look at the behaviour of the firm in general and not at single projects. We think that the decision to collaborate with a partner abroad is taken not once and for all, but for each project or potential collaborative activity separately. Consequently, we decided not to use the multinominal logit estimation procedure, but a bivariate probit model, which takes into account the fact that the decision to collaborate with domestic partners and the decision to cooperate with foreign partners are correlated[13]. This can be achieved by estimating the two decisions simultaneously and allowing the error terms in the two equations to be correlated. What is more, we do not have to split up our cooperating firms into exclusive combinations of partners' nationalities and can test if the decisions are independent of each other or not.

A second issue is selectivity. Only those firms that were involved in innovation cooperation activities between 1998 and 2000 were asked to provide answers on the location of their partners. This gives rise to a sample selection problem described by (Heckman, 1976; Heckman, 1979). The general idea behind Heckman's model is that the standard OLS or probit estimations are biased if the dependent variable which is supposed to be explained is only observed for a specific group of firms in the sample. The solution proposed by Heckman is to take this selection into account by estimating a two-equation model. However, in order to be able to apply his model one variable

13 In studies on similar topics other authors have also used multivariate probit models (see, for example, Belderbos et al., 2004 or Capron and Cincera, 2004).

would be necessary that influences only the decision to cooperate, but not the choice to cooperate with domestic or foreign partners. Obviously, such a variable does not exist in our data and the Heckman procedure cannot be applied. To arrive at consistent estimates we use a set-up similar to Belderbos et al. (2004) and Crapon and Cincera (2004)[14], i.e. we set our dependent variables to zero for firms that did not cooperate between 1998 and 2000. By applying this procedure, we analyse the decision to cooperate with a domestic partner or not to cooperate and the decision to cooperate with a foreign partner or not to cooperate. We shall not be able to address the decision to cooperate on innovation with a given partner conditional on having decided to cooperate on innovation (see Crapon and Cincera (2004) for a discussion of these issues). All the independent variables are unaffected by this procedure as they are available for cooperating and non-cooperating firms.

In the formal bivariate probit definition, the equation for innovation cooperation with domestic firms is given by

14 Belderbos et al. (2004) and Crapon and Cincera (2004) use this method to look at cooperation with different partners. Their survey is similar to the one we use, i.e. the partner is observed only if the firm cooperated. Miotti and Sachwald (2003) restrict their sample to cooperating firms and analyse the decision to cooperate with different partners for this sub-sample without taking selectivity into account. Because Heckman showed that these estimates are biased, we decided to employ the method of Belderbos et al. (2004) and Crapon and Cincera (2004) in the research reported here.

$$cod^* = \beta_1^{'} X + \varepsilon_1$$

where *cod* is a latent variable indicating if a firm is engaged in innovation cooperation activities with domestic partners

$$cod_i = \begin{cases} 1 \;\; if \; cod_i^* > 0 \\ 0 \;\; otherwise \end{cases}$$

The equation for innovation cooperation with foreign firms has the following structure,

$$coforeign^* = \beta_2^{'} X + \varepsilon_2$$

where *coforeign* is a latent variable indicating if a firm is engaged in innovation cooperation activities with at least one foreign partner

$$coforeign_i = \begin{cases} 1 \;\; if \; coforeign_i^* > 0 \\ 0 \;\; otherwise \end{cases}$$

In both equations, X represents the independent variables described above, β is a vector of structural coefficients, and ε_i is a stochastic disturbance.

The correlation of the error terms of both equations is not equal to zero:

$$Cov(\varepsilon_1, \varepsilon_2) = \rho_1$$

The last feature of the models allows taking into account the fact that the decision to collaborate with domestic partners and the decision to cooperate with foreign partners are correlated.

4 Results

In this section, we first compare our results for innovation cooperation with foreign partners in Portugal and Germany before providing some interpretation regarding specific variables and effects.

4.1 Innovation cooperation with foreign partners in Portugal and Germany

The estimation results (Table 2) show that in Germany and Portugal the variables that influence the probability of a firm cooperating with a foreign partner on innovation activities are quite similar.[15] In both countries several variables have a positive and significant effect on cooperation with foreign partners: absorptive capacities – measured by engagement in R&D, the share of highly skilled labour and the innovation intensity – public funding, outgoing spillovers and firm size. The industry to which a firm belongs does not have an additional influence on its cooperation behaviour in either country. What is also similar across countries is that the marginal effects for these variables are smaller for foreign cooperation than for cooperation with domestic partners when they are significant in both equations.

However, some differences exist between the two countries with respect to the internationalisation variables, export status, and being a multinational. These can be explained mainly by country-specific factors. In Germany, being an exporter has a positive and significant effect on the probability of cooperating with a foreign partner on innovation projects, whereas in Portugal this variable is insignificant. This can be

15 We do not discuss here the differences between the countries with respect to cooperation with domestic partners. It is noteworthy, however, that these results are also fairly similar. Two important differences are that the innovation intensity and the outgoing spillover variable are non-significant in Germany for domestic cooperation but significant in Portugal.

explained by the fact that Germany has more high-tech exports than Portugal. It might be easier for German firms to find partners for innovation and R&D cooperation abroad since they sell a large share of their products to foreign firms. Portugal's exports are relatively low-tech and provide fewer opportunities to collaborate on innovation and R&D activities[16]. In Portugal, being part of a multinational group with headquarters abroad has a significant effect on the probability of cooperating on innovation activities, while it is non-significant in Germany. This might have to do with the different type of multinationals with subsidiaries in both countries. Multinationals seem to come to Germany to collaborate on innovation activities with the domestic firms in order to exploit the German knowledge base, instead of being located there to conduct innovation activities in collaboration with partners outside of Germany.[17] In Portugal, by contrast, subsidiaries of multinationals seem to look for partners outside the country to cooperate on R&D and innovation activities. Together with the negative balance of trade in Portugal, this might indicate that foreign firms open subsidiaries in the country to boost their sales, but also use Portugal as a base for innovation and R&D activities with firms in other European countries.[18] The findings on the multinationals and export status variables confirm our second hypothesis, that different internationalisation settings in different countries do have an influence on the determinants of R&D and innovation cooperation with foreign firms.

16 Since our dataset does not allow us to identify individual collaborations we are not able to assess if German firms cooperate relatively more often with innovative foreign firms than do Portuguese firms.

17 Note that this is just one possible explanation for our findings. We have no information available on why firms actually established subsidiaries in the two countries and for what reasons. As pointed out by an anonymous referee firms may have established foreign subsidiaries in Germany by acquiring German firms which are already embedded in local innovation networks and therefore cooperate more within Germany.

18 It is not clear if this is really the case. Given that transaction costs are high for this setup this would be a rather ineffective strategy for firms.

The calculation of conditional marginal effects allows us to separate the factors that influence innovation cooperation in more general terms from those that have a specific influence on foreign cooperation. They will tell us which characteristics lead firms to collaborate with foreign partners on innovation activities, given that they already cooperated with domestic partners.[19] Our findings show that, for the conditional marginal effects, most of the similarities between the two countries remain.

The export status remains significant in Germany, whilst it is insignificant in Portugal, and being a multinational is significant in Portugal but not in Germany. This means that the internationalisation of firms' activities has – not surprisingly – a positive effect of cooperating with a foreign partner in addition to cooperating with a domestic one.

The skills variable loses significance in both countries, as does the public funding variable. This is a surprising result. We would have expected the absorptive capacity of a firm's employees to have an effect on its ability to cooperate and probability of cooperating with foreigners aside from its effect on domestic cooperation. The same is true of public funding. Given that we included funding received from European Union agencies alongside funding from regional and national authorities, it is surprising that this variable has no additional effect on international collaboration. Then again, the funding from regional and national authorities accounts for approximately 90% of total funding in Germany and this type of funding usually has a more local/domestic focus. In addition, firms that receive public funding may be the ones that cooperate with domestic firms and also cooperate with foreign ones.

Two noteworthy differences between the two countries occur when looking at the conditional marginal effects. Innovation intensity remains significant in Germany but

19 Note that the unconditional marginal effects on foreign innovation cooperation compare firms not cooperating or cooperating with domestic firms only with firms cooperating with foreign partners.

becomes non-significant in Portugal. For Portugal, the R&D status remains positive whilst it loses its significance in Germany. As far as the first finding is concerned, looking at the domestic cooperative activities helps to explain that difference. In Portugal, domestic innovation cooperation is influenced significantly by innovation intensity, in Germany it is not. The share of turnover spent on innovation activities thus seems to influence the cooperative behaviour of Portugal in a more general sense than in Germany and is not specific to foreign cooperation. The significance of the unconditional marginal effect of the innovation intensity in the foreign cooperation equation for Germany indicates that, for Germany, it is a specific factor. As far as the R&D engagement dummy is concerned, Portuguese firms which perform R&D and already cooperate with domestic firms seem to look abroad for potential partners whilst German firms do not. Again, one of the reasons might be that German firms can find suitable partners within Germany (see the positive effect on domestic cooperation) for their R&D activities, whereas Portuguese firms have to combine foreign and domestic partners to be successful in their R&D projects, because they lack an established high-technology industry at home.

In summary, by comparing Germany and Portugal we can identify, despite some differences in the specific variables, a set of characteristics and factors that seems to influence innovation cooperation with foreign partners. These are international activities of firms in areas other than R&D and innovation, the importance of intellectual property protection and firm size. We also find some support for a positive influence of highly-skilled employees. These factors influence the decision to cooperate on innovation in

Some part of the obtained effects may thus be attributed to cooperation in general rather than only foreign cooperation.

addition to innovation activities other than cooperation, which, not surprisingly, do have an impact.

4.2 Details of the determinants of innovation cooperation with foreign and domestic partners

So far we have mainly discussed the differences between Portugal and Germany with respect to innovation cooperation with foreign partners. In this subsection we take a closer look at each of the three groups of variables included in our model.

The first group of variables – other links with foreign countries – has been shown to have an influence on innovation cooperation with foreign partners in both Portugal and Germany. The argument presented in the previous section that international activities lead firms to be more active in pursuing collaborative innovation and R&D activities owing to the added pressure from international competition can, however, only partially be supported with our data. In both countries, international activities have no influence on domestic cooperation.

We find a number of significant positive effects for the second group of variables labelled “innovation activities”. In Portugal, all of our measures for the absorptive capacity of a firm are significant for cooperation with domestic and foreign partners. In Germany, the scope of the innovation activities of a firm, measured by innovation intensity, is not significant, but the other two measures are. It indicates that firms which are better prepared to absorb and exploit external knowledge are not just using publicly available knowledge for their innovation process, but are also trying to access the knowledge of other firms and institutions by cooperating with them. It might also be part of their knowledge exploitation strategy to cooperate on innovation activities with external partners and combine the knowledge absorbed with tacit knowledge held by the

partner. The conditional marginal effect for the indicator most closely related to absorptive capacity (skills) is not significant. Thus, it looks as though absorptive capacity is more generally influencing the decision for or against innovation cooperation, rather than the decision to cooperate with a foreign partner.

R&D involvement and innovation intensity also measure aspects of firms' innovation activities other than absorptive capacity. As discussed above, the findings differ on these variables for Portugal and Germany. R&D activities and the scope of innovation activities can nonetheless be seen as major drivers of innovation cooperation. Which type of cooperation they influence needs further investigation and seems to differ between countries.

In the light of the findings that absorptive capacity and knowledge play an important role in the cooperation decision, it is very surprising that the incoming spillover variable is not significant at all. This variable can be seen as a measure of the importance a firm assigns to publicly available sources of knowledge. The reason for the non-significance may be that two opposing effects are at work. The first is that the more knowledge a firm is able to acquire from publicly available sources, the less it will feel the necessity to collaborate in order to gain access to additional knowledge. The second effect is that firms would have an incentive to cooperate if the publicly available knowledge is easily absorbed by the firm when it cooperates with other institutions.

The marginal effects of the outgoing spillover variable are significantly positive for foreign cooperation in both countries. The use of protection methods may be a signal to a potential foreign partner regarding the innovative capability of the firm and make it easier for a firm to find a cooperation partner.[20] What is more, if a great deal of

20 See Penin (2005) and Bureth et al. (2005) for a discussion of the role of patents in innovation cooperation.

knowledge is safeguarded by protection methods that inhibit licensing agreements, the only feasible way to access external knowledge may be through innovation cooperation. The first of these arguments may help to explain the insignificance of the marginal effect for cooperation with domestic firms in Portugal, and also the significant effect for Germany. As the descriptive statistics show, German firms assign greater importance to protection methods than do Portuguese firms. It may thus be important for firms to signal their strength and bargaining power to potential partners with Germany as well, whilst for cooperation amongst Portuguese firms, this aspect is not a major concern. To draw strong conclusions from these findings raises problems, however. As other studies have shown (e.g. Cassiman and Veugelers, 2002), this variable may very well be endogenous. The argument presented in the literature is that firms have to protect proprietary knowledge from use by their cooperation partner and may thus be more likely to assign particular importance to protection methods if they cooperate, compared with a situation in which they do not cooperate.

(Insert Table 2)

The last group of variables concerns general firm characteristics. Here we find support for the common finding that larger firms are more likely to cooperate with both domestic and foreign partners than are smaller firms. This can be attributed to the fact that larger firms have more opportunities to cooperate because they have a higher number of innovation projects, which increases the probability that at least one project is performed in cooperation with external partners (see Fritsch and Lukas, 2001). They usually also have more resources to commit to innovation projects performed in collaboration with external partners. For a small firm it may not be feasible to engage in

cooperative innovation activities simply because it needs all of its personnel for in-house tasks.

For Portugal, belonging to a domestic group is significant for domestic cooperation only. For Germany it is not significant in either equation. As far as industry is concerned, only one marginal effect for the industry is significant in the domestic cooperation equation in each country. For cooperation with foreigners we find no significant effect of a firm's industry, as mentioned in the previous section. Finally, the Eastern German dummy is negative and significant in Germany for foreign cooperation and non-significant for domestic cooperation, supporting many other studies that find that former East and West German firms still differ in their innovation behaviour (Rammer et al. 2005b, Sofka and Schmidt, 2004).

We identified quite a number of dimensions along which firms cooperating with foreign firms are different from firms that cooperate only with domestic partners or not at all. Our first hypothesis is therefore supported. It is noteworthy that we mainly look at the standard set of explanatory factors for (domestic) collaboration and are not able to include many variables that could be considered specific determinants for foreign collaboration. In that sense, one might argue that we looked only at one side of the coin.

5 Conclusions

This paper analyses the decision of firms to cooperate with domestic and foreign partners on innovation projects. It compares a very export-oriented country with an established high-tech industry - Germany - with a country that has more imports than exports and sees its strengths in the services sector - Portugal.

Our first hypothesis stated that the characteristics of firms engaging in innovation cooperation with domestic partners are different from those that cooperate with foreign partners. The empirical analysis in both countries supports it, showing that the characteristics of innovative firms that cooperate only with domestic partners and firms that cooperate also with international partners are different. In other words, the internationalisation of innovation cooperation activities does imply specific capabilities different from those that are associated with the decision to cooperate with domestic firms.

Our study also shows that cooperation with foreign partners is linked to other international activities of firms in both countries: the specific framework and internationalisation situation of the two countries does play a role. The different structure of multinationals in Portugal and Germany and the differences in export intensities between the two countries seems to influence the decision to cooperate of exporters and firms that are part of a multinational group. The second hypothesis is supported: differences with respect to the internationalisation of firms' activities in a country lead to differences in the factors that influence innovation cooperation with foreign partners. However, the determinants of cooperating with foreign partners on innovation activities not related to internationalisation are in a broad way similar in Germany and Portugal. In other words, the typical internationally cooperative firm of a

small and less developed economy has some of the same characteristics as the internationally cooperative firm of a large and more developed economy: above-average absorptive capacities, receiving public funding, higher level of outgoing spillovers and above-average number of employees.

We corroborate the findings of the innovation cooperation literature that identifies specific capabilities that differentiate innovative firms engaged in cooperation activities from those that innovate without establishing cooperation agreements. Our main theoretical contribution is showing that firms establishing innovation-based links with foreign firms have different capabilities than firms establishing links only with domestic partners. Overcoming social and cultural barriers in other countries ("liabilities of foreigness"- Zaheer, 1995) or dealing with foreign actors ("learning by exporting" - Keller, 2004), seems to require different capabilities from those necessary to manage the relationship with partners from the same country.

These results stress the link between cooperation activities and innovation and overall performance, corroborating the importance of open innovation strategies. By focusing on the differentiation of innovation cooperation activities by partner location, and by providing evidence on two countries with different profiles - Germany and Portugal - this paper may offer an important step toward understanding the international innovation cooperation processes. In addition, our paper provides evidence substantiating public policies that promote firm level absorptive capacity and knowledge production capabilities since it identifies these concepts as drivers of collaborative innovation activities and internationalisation. Finally, the observed positive relationship between innovation cooperation with international partners and exports gives support to regional and national innovation policies that promote the creation of these kinds of cooperation agreements in order to stimulate competiveness.

Future research should complement this study. One possible line of development would be to deepen the analysis of the different types of partners, seeking to determine whether firms operating in different countries with different internationalisation settings choose similar or different types of international partners (e.g. competitors, suppliers or research institutes) to develop innovation collaborations. In addition, comparisons across more countries could provide further insight into the mechanisms behind international cooperation on innovation activities.

Through international collaboration between a researcher from Portugal and Germany we have shown how beneficial international partnerships can be. Further research is necessary to compare the effects of domestic collaboration and international collaboration on various microeconomic as well as macroeconomic outputs.

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Table 1 - Descriptive Statistics for Portuguese and German samples

Descriptive Statistics	Germany			Portugal		
Mean	Sample	cod=1	Coforeign=1	Sample	cod=1	coforeign=1
Number of observations	1510	459	181	774	175	109
as % of total sample	-	30%	12%	-	23%	14%
Exports status (1998)	0.697	0.756 [a]	0.862 [a]	0.787 [b]	0.840 [b]	0.899 [a]
	[0.459]	[0.430]	[0.346]	[0.410]	[0.368]	[0.303]
Multinational dummy	0.103	0.126	0.160 [a]	0.134 [b]	0.143	0.266 [a b]
	[0.304]	[0.333]	[0.368]	[0.341]	[0.351]	[0.444]
Domestic group dummy	0.162	0.152	0.138	0.269 [b]	0.469 [a b]	0.404 [a b]
	[0.368]	[0.360]	[0.346]	[0.444]	[0.500]	[0.493]
Skills dummy	0.503	0.678 [a]	0.696 [a]	0.348 [b]	0.491 [a b]	0.505 [a b]
	[0.500]	[0.468]	[0.461]	[0.476]	[0.501]	[0.502]
Engagement R&D dummy	0.643	0.882 [a]	0.912 [a]	0.609	0.794 [a b]	0.881 [a]
	[0.479]	[0.323]	[0.285]	[0.488]	[0.405]	[0.326]
Innovation intensity	0.068	0.102 [a]	0.119 [a]	0.057 [b]	0.058 [b]	0.052 [b]
	[0.109]	[0.144]	[0.163]	[0.101]	[0.083]	[0.072]
Public funding for innovation dummy	0.358	0.658 [a]	0.624 [a]	0.351	0.571 [a b]	0.532 [a]
	[0.480]	[0.474]	[0.486]	[0.478]	[0.496]	[0.501]
Incoming spillovers	0.550	0.601 [a]	0.620 [a]	0.414 [b]	0.492 [a b]	0.488 [a b]
	[0.268]	[0.253]	[0.239]	[0.305]	[0.306]	[0.320]
Outgoing spillovers	0.244	0.356 [a]	0.427 [a]	0.165 [b]	0.228 [a b]	0.288 [a b]
	[0.235]	[0.237]	[0.217]	[0.216]	[0.234]	[0.267]
Medium firm dummy (50 <=employees< 250)	0.352	0.333	0.293	0.416 [b]	0.417	0.459 [b]
	[0.478]	[0.472]	[0.456]	[0.493]	[0.495]	[0.501]
Large firm dummy (employees=> 250)	0.287	0.364 [a]	0.486 [a]	0.209 [b]	0.366 [a]	0.413 [a]
	[0.452]	[0.482]	[0.501]	[0.407]	[0.483]	[0.495]
Medium-Tech manufacturing firm dummy	0.399	0.420	0.425	0.310 [b]	0.326 [b]	0.376
	[0.490]	[0.494]	[0.496]	[0.463]	[0.470]	[0.487]
High-Tech manufacturing firm dummy	0.256	0.157 [a]	0.160 [a]	0.052 [b]	0.063	0.083
	[0.437]	[0.364]	[0.368]	[0.222]	[0.243]	[0.277]
Low-Knowledge intensive service firm dummy	0.117	0.092	0.061 [a]	0.130	0.097	0.064 [a]
	[0.321]	[0.289]	[0.240]	[0.337]	[0.297]	[0.246]
Knowledge-intensive service firm dummy	0.256	0.261	0.276	0.177 [b]	0.234	0.211
	[0.437]	[0.439]	[0.448]	[0.382]	[0.425]	[0.410]
Eastern Germany dummy	0.327	0.370	0.227 [a]	-	-	-
	[0.469]	[0.483]	[0.420]	-	-	-
a) significantly different from sample mean at least at 95% level						
b) significantly different from mean in Germany at least at 95% level						

Table 2 - Marginal effects of bivariate probit estimations

Bivariate probit estimation	Germany			Portugal		
Marginal effects	Domestic	Foreign	Conditional	Domestic	Foreign	Conditional
Exports status (1998)	-0.033	0.042***	0.144***	0.001	0.019	0.055
	[0.032]	[0.015]	[0.043]	[0.040]	[0.028]	[0.079]
Multinational dummy	0.033	0.011	0.009	0.009	0.108**	0.248***
	[0.043]	[0.021]	[0.053]	[0.049]	[0.046]	[0.085]
Domestic group dummy	-0.003	-0.004	-0.010	0.132***	0.044	0.006
	[0.034]	[0.018]	[0.048]	[0.042]	[0.029]	[0.065]
Skills dummy	0.099***	0.037**	0.044	0.099**	0.054*	0.056
	[0.029]	[0.015]	[0.041]	[0.039]	[0.028]	[0.064]
Engagement R&D dummy	0.142***	0.035**	0.010	0.083***	0.077***	0.149**
	[0.030]	[0.017]	[0.053]	[0.032]	[0.022]	[0.064]
Innovation intensity	0.080	0.257[zz]	0.699[zz]	1.144 [zz]	0.658**	0.798
	[0.026]	[0.130]	[0.360]	[0.453]	[0.326]	[0.886]
Innovation intensity (square)	0.270	-0.143[zz]	-0.592[zz]	-2.556 [zz]	-1.377	-1.517
	[0.449]	[0.188]	[0.541]	[1.133]	[0.867]	[2.386]
Public funding for innovation dummy	0.317***	0.084***	0.031	0.194***	0.061**	-0.002
	[0.030]	[0.019]	[0.039]	[0.036]	[0.025]	[0.058]
Incoming spillovers	0.076	0.032	0.046	0.078	0.034	0.023
	[0.048]	[0.025]	[0.068]	[0.051]	[0.036]	[0.094]
Outgoing spillovers	0.334***	0.147***	0.214***	0.254	0.349**	0.753**
	[0.059]	[0.030]	[0.078]	[0.207]	[0.138]	[0.351]
Medium firm dummy (50 <=employees< 250)	0.534	0.032*	0.056	0.070*	0.088***	0.172**
	[0.032]	[0.019]	[0.049]	[0.039]	[0.032]	[0.076]
Large firm dummy (employees=> 250)	0.169***	0.094***	0.132**	0.174***	0.145***	0.185**
	[0.039]	[0.026]	[0.054]	[0.059]	[0.052]	[0.092]
Medium-Tech manufacturing firm dummy	0.054	0.004	-0.023	0.048	0.041	0.068
	[0.045]	[0.023]	[0.062]	[0.040]	[0.029]	[0.068]
High-Tech manufacturing firm dummy	0.145**	0.014	-0.039	-0.037	-0.003	0.029
	[0.067]	[0.032]	[0.069]	[0.063]	[0.044]	[0.122]
Low knowledge-intensive service firm dummy	0.189***	0.027	-0.031	0.115*	0.014	-0.052
	[0.065]	[0.038]	[0.078]	[0.066]	[0.045]	[0.104]
Knowledge-intensive service firm dummy	0.087	0.032	0.034	0.090	0.035	0.016
	[0.055]	[0.032]	[0.076]	[0.060]	[0.041]	[0.091]
Eastern Germany dummy	-0.005	-0.047***	-0.136***	-	-	-
	[0.029]	[0.013]	[0.038]	-	-	-
Observations	1510			774		
Loglikelihood of biprobit	-1053.02			-549.19		
X^2 of biprobit	435.90			172.40		
Likelihood-ratio test of rho=0	175.34***			88.02***		

Standard errors in brackets

* significant at 90%; ** significant at 95%; *** significant at 99%; [zz] jointly significant at the 95% level

All dummy variables: dF/dx is for discrete change of dummy variable from 0 to 1

Appendix

Table 3 - Construction of the variables and industry coverage

Variable	Type	Construction
Dependent		
Cod	Dummy	One, if the firm cooperated with *domestic partners* between 1998 and 2000.
Coforeign	Dummy	One, if the firm cooperated with a *foreign partner* between 1998 and 2000.
Independent		
Exports	Dummy	One, if the firm had exports in 1998.
Group	Dummy	One, if the firm belonged to a domestic group of firms.
Multinational	Dummy	One, if the firm belonged to a multinational group of firms with headquarters in a foreign country.
Skills	Dummy	One, if the firm had a percentage of employees with a higher education degree in total employment in 2000 above the national median (Portugal: approx 10%, Germany approx 15%)
Rnd	Dummy	One, if the firm had any R&D activities between 1998 and 2000.
Inno_int	Share	Total expenditure on innovation activities as a percentage of total turnover in 2000.
Inno_int2	Share	Square of inno_int
Public	Dummy	One, if the firm received public funding from domestic or EU authorities for its innovation activities between 1998 and 2000.
Spill_in	Index	Sum of importance (number between 0 (not used) and 3 (high)) of professional conferences, meetings and journals and of exhibitions and trade fairs as sources of innovation. Rescaled between 0 (no spillovers) and 1 (maximum spillovers).
Spill_out	Index	Sum of importance (number between 0 (not used) and 3 (high)) of strategic and formal protection methods for innovations (secrecy, complexity of design, lead-time advantage, patents, copyrights, trademarks, registered designs). Rescaled between 0

		(not used) and 1 (highly important).
Size1	Dummy	One, if the firm had at least ten but fewer than 49 employees in 2000.
Size2	Dummy	One, if the firm had at least 50 but fewer than 249 employees in 2000.
Size3	Dummy	One, if the firm had 250 or more employees in 2000.
East	Dummy	One, if the firm is located in Eastern Germany (only German sample).
Industries		
Low-tech manufacturing	Dummy	One, if firm is from NACE 15-22, 36, 37
Medium-tech manufacturing	Dummy	One, if firm is from NACE 23, 24(excl.244), 25-29, 31, 34, 35(excl.353)
High-tech manufacturing	Dummy	One, if firm is from NACE 244, 30, 32, 33, 353
Low knowledge-intensive services	Dummy	One, if firm is from NACE 51, 60, 63
Knowledge-intensive services	Dummy	One, if firm is from NACE 61, 62, 64, 65, 66, 67, 72, 73, 74.2, 74.3

Table 4 - Coefficients of the bivariate probit model estimation

Bivariate Probit Estimation Coefficients	Germany		Portugal	
	Domestic	Foreign	Domestic	Foreign
Exports status (1998)	-0.103	0.347***	-0.002	0.123
	[0.098]	[0.136]	[0.152]	[0.193]
Multinational dummy	0.102	0.076	0.033	0.526***
	[0.129]	[0.146]	[0.180]	[0.185]
Domestic group dummy	-0.010	-0.031	0.457***	0.254
	[0.106]	[0.136]	[0.136]	[0.155]
Skills dummy	0.311***	0.277**	0.358***	0.313**
	[0.091]	[0.113]	[0.137]	[0.151]
Engagement R&D dummy	0.468***	0.2779*	0.327**	0.511***
	[0.105]	[0.144]	[0.130]	[0.162]
Innovation intensity	0.251	1.921 zz	4.341 zz	4.085**
	[0.880]	[0.973]	[1.742]	[2.079]
Innovation intensity (square)	0.847	-1.067 zz	-9.698 zz	-8.546
	[1.412]	[1.404]	[4.365]	[5.521]
Public funding for innovation dummy	0.942***	0.557***	0.681***	0.354***
	[0.089]	[0.108]	[0.122]	[0.136]
Incoming spillovers	0.239	0.243	0.296	0.211
	[0.149]	[0.189]	[0.194]	[0.221]
Outgoing spillovers	1.050***	1.102***	0.963	2.164***
	[0.184]	[0.219]	[0.783]	[0.834]
Medium firm dummy (50 <=employees< 250)	0.163	0.227*	0.260*	0.514***
	[0.099]	[0.129]	[0.142]	[0.178]
Large firm dummy (employees=> 250)	0.501***	0.581***	0.578***	0.695***
	[0.111]	[0.138]	[0.177]	[0.209]
Medium-tech manufacturing firm dummy	0.169	0.030	0.176	0.242
	[0.138]	[0.174]	[0.142]	[0.158]
High-tech manufacturing firm dummy	0.415**	0.102	-0.150	-0.020
	[0.178]	[0.215]	[0.272]	[0.280]
Low knowledge-intensive service firm dummy	0.535***	0.182	0.387*	0.084
	[0.171]	[0.234]	[0.202]	[0.258]
Knowledge-intensive service firm dummy	0.263*	0.222	0.313	0.202
	[0.160]	[0.202]	[0.194]	[0.216]
Eastern Germany dummy	-0.015	-0.382***		
	[0.091]	[0.118]		
Constant	-2.255***	-2.978***	-2.276***	-2.933***
	[0.186]	[0.255]	[0.221]	[0.291]
Observations	1510		774	
LL	-1053.02		-549.19	
X^2	435.90		172.40	

Standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%; zz jointly significant at the 95% level

All dummy variables: dF/dx is for discrete change of dummy variable from 0 to 1

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