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## A comparison of firm-level innovation cooperation in five European countries

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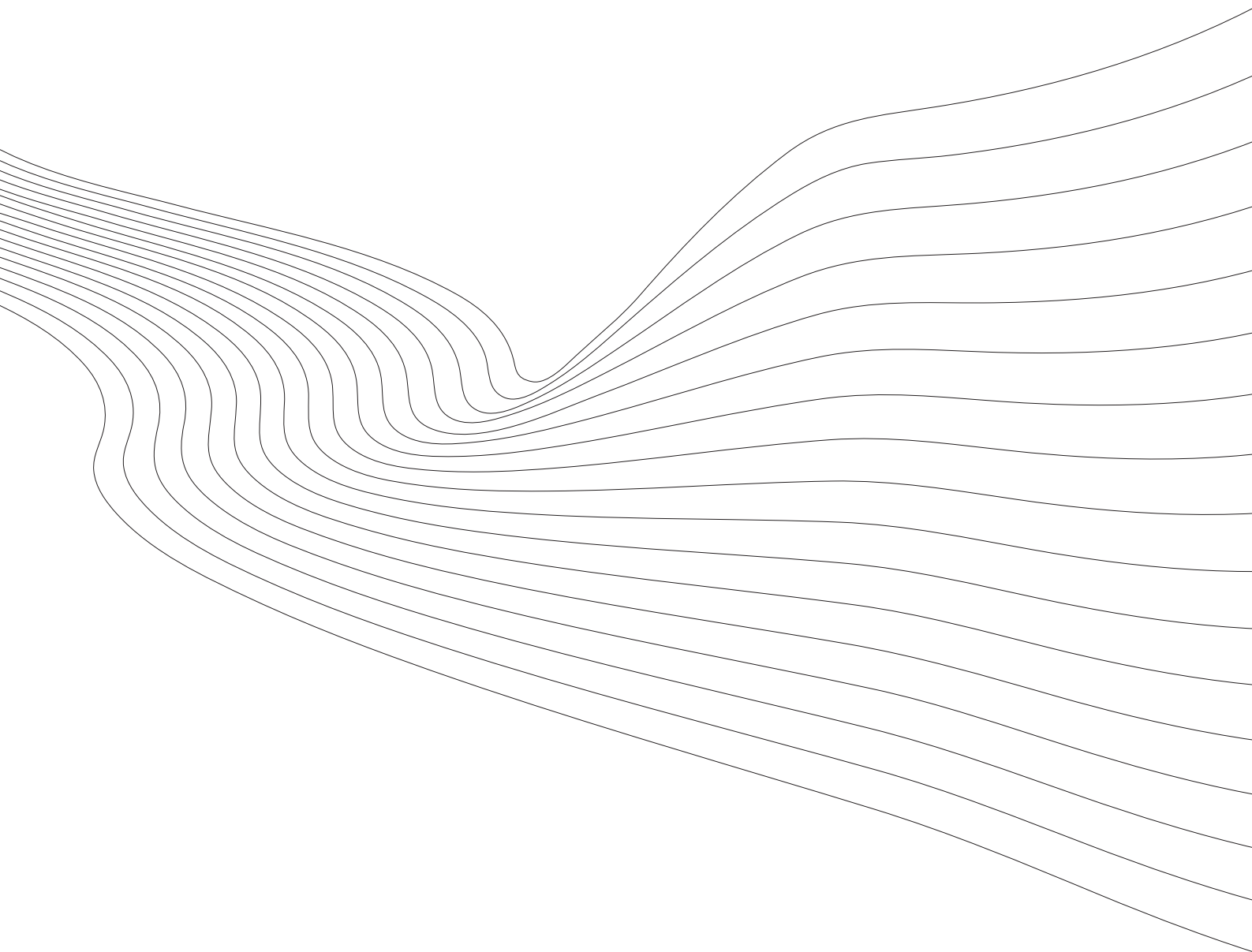
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# KOF Working Papers

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# A Comparison of Firm-level Innovation Cooperation in Five European Countries

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## **Abstract**

This paper compares the determinants and the effects of innovation cooperation on innovation performance at firm level in five European countries: Belgium, Germany, Norway, Portugal and Switzerland. In a first step we analyse cooperation agreements with national and international partners and in a second step cooperation with enterprises and research institutions. In a third step we investigate the impact of all four categories of cooperation on innovation performance.

JEL Classification: O30

Key words: national innovation cooperation; international innovation cooperation; innovation performance

## 1. Introduction

The goal of this paper is to extend the knowledge base and the understanding of the determinants of innovation cooperation and its impact on the innovation performance. The motivation to study the behaviour of firms in this respect stems from the growing importance of innovation networks. In order to keep up with the pace of the markets and to remain competitive, it is often no longer sufficient to rely on in-house innovation, but becomes more and more important to make the borders of the firms permeable, particularly for cooperation with partners from other countries as well as for knowledge transfer from universities. But while this concept is referred to by policy-makers regularly, our understanding of both determinants and impact remains incomplete.

The paper at hand attempts to answer some of the open questions by analysing the cooperation behaviour of innovative firms in 5 European countries: Belgium, Germany, Norway, Portugal and Switzerland. This sample of countries is varying in respect to the size of the economy and the cultural background. Furthermore, Belgium, Germany and Portugal are members of the EU while Norway and Switzerland are not. The data base consists of CIS3 data for the EU member states and Norway. For Switzerland we use a comparable survey.

We analyze cooperation agreements along four dimensions: national vs. international and enterprises vs. universities. More concretely, in a first step we separate our sample in three categories: firms that do not take part in innovation cooperation, firms that cooperate only nationally and firms that cooperate internationally. We analyse the determinants of national and international cooperation behaviour by estimating a multinomial probit estimation using the non-cooperating firms as base category.

In the second step, we estimate a tobit model using the share of sales generated by innovative products as dependent variable. The independent variables of interest besides a series of control variables are the dummy variables for exclusive national cooperation and for international cooperation. We test the cooperation variables for endogeneity and, if necessary, adjust the estimation procedure of the innovation equation for endogeneity.

We apply the same two-stage approach to the analysis of the determinants and effects on innovation of cooperation with enterprises and universities. We distinguish a first group of firms that cooperate exclusively with other enterprises and a second group of firms that have cooperation arrangements with universities. The base category remains the group of innovating firms that are not cooperating.

New elements of this study are the parallel investigation in a comparative study of five heterogeneous European countries (a) of the factors determining four important dimensions of innovation cooperation (national; international; enterprises; universities) and (b) of the impact of these types of cooperation on firm innovation performance.

The set-up of the paper is as follows: in section 2 of the paper the conceptual framework is presented. Section 3 consists of a literature survey. The data are shortly described in section 4. Section 5 presents the model specification and the estimation procedure. In section 6 the empirical results are discussed and section 7 concludes the paper.

## **2. Conceptual framework**

### *Basic theoretical concepts related to knowledge acquisition*

Our conceptual approach builds mainly on Industrial organization (IO) literature. An important strand of this literature is concerned with endogenous *absorptive capacity* (Cohen and Levinthal 1989, 1990). On a theoretical ground we know that the absorptive capacity of a firm is an important precondition to successfully capitalise on externally generated knowledge, i.e. knowledge generated by competitors, suppliers, customers, and/or public research institutions and universities. Firms with well-educated staff and permanent research activities are supposed to have higher absorptive capacity than firms lacking such characteristics. The exploitation of externally acquired knowledge depends crucially on a firm's absorptive capacity

The concept of *incoming spillovers* (see Cassiman and Veugelers 2002) is strongly related to the absorptive capacity of a firm. It indicates the "amount" of flows of exploitable external knowledge that come in the firm. The type of cooperation partner is an important characteristic of a cooperative project that helps better understanding such spillover effects. In cooperative agreement with universities or research organizations maximizing incoming spillovers is important for a cooperating firm. When collaborating with other enterprises (suppliers, customers or competitors) in addition to exploiting incoming spillovers cooperating firms should also care to minimize outgoing spillovers. *Outgoing spillovers* measure the amount of a firm's knowledge that seeps out of the firm and can be utilized by other firms. While incoming spillovers may motivate a firm to seek R&D cooperation, outgoing spillovers exert the opposite influence, i.e. they hinder innovative activities because of the risk of internal knowledge leaking out to competitors. The negative effects of outgoing spillovers can be attenuated through several formal (e.g., patents) and informal (e.g., secrecy, lead time over competitors) *appropriability mechanisms*. In a strategic way firms seek to limit outgoing spillovers through secrecy measures or greater complexity of developed products or lead time over competitors. Furthermore firms try to internalise outgoing spillovers by ensuring property rights (e.g., patents).

There is an inherent relationship between these three concepts: absorptive capacity is necessary for a firm in order to be able to exploit available external knowledge, i.e. to ensure knowledge flows to the firm (incoming spillovers: either through "buy" or cooperation or other channels) but also is interested in protecting its own knowledge base from being

exploited by other firms or institutions without paying for it, thus trying to keep outgoing spillovers under its control, e.g., through various protection mechanisms.

Cassiman et al. (2002) developed a theoretical model that links knowledge flows to and from a firm's innovation process with the firm's investment decisions with respect to innovation. The model contains a technologically leading firm and a competitive fringe. The leading firm considers three types of investment: investments in applied research, investments in basic research and investments in intellectual property protection. By conducting basic research the leading firm can effectively access incoming knowledge flows (incoming spillovers). These incoming spillovers serve to increase the efficiency of own applied research. The leading firm can try at the same time to keep outgoing spillovers low by investing in protection, thus improving its appropriability of innovation returns. In the long run a leading firm will invest in basic research, which is a precondition for improving its absorptive capacity, when market opportunities are high, legal protection is important and the pool of accessible and relevant external know-how is not limited, given a minimum size of the firm's budget for such investments.

#### *R&D cooperation as a means of knowledge acquisition*

R&D cooperation, particularly in the form of research joint ventures, is an important single knowledge acquisition strategy, which has been the subject of theoretical and empirical analysis since some years. Economic research in the field of R&D cooperation essentially aims at understanding why firms are undertaking such cooperation, how they do it, and with what result (see Kaiser 2002 and De Bondt 1996 for reviews of this literature).

Probably the most influential theoretical paper in this field is that of D'Aspremont and Jacquemin (1988). They derived a two-stage Cournot duopoly game in which firms decide upon R&D investment and then compete in the product market. R&D expenditures are larger in research joint ventures than in the competition case if (exogenous) spillovers exceed a critical value.

An interesting generalization of the framework of D'Aspremont and Jacquemin (1988) was achieved by Kamien et al. (1992). Key findings of this paper are that (a) effective R&D investment is larger under research joint ventures than under competition if spillovers are sufficient large, (b) an increase in spillovers leads to a reduction of research efforts if goods are complements (substitutes) and spillovers are large (small) and also tends to reduce incentives to collaborate in R&D, (c) an increase in market demand leads to an increase of research efforts both under research joint venture and research competition; an increase of market demand has a positive effect on the likelihood of R&D cooperation, and (d) increased research productivity leads to increased incentives to invest in R&D and also to conduct joint-research.



In a further paper Kamien and Zang (2000) tried to integrate in their theoretical framework the idea of endogenous absorptive capacity, i.e. the idea that firms can determine through their own research effort the extent of absorption of external knowledge. The most important empirically result of this paper is that research joint ventures are more likely to occur, the more “general” (in contrast to “specific”) the R&D agenda is.

These are the essential theoretical ingredients for specifying a vector of determinants of cooperative R&D in this study.

### **3. Survey of similar empirical studies**

We restrain our literature survey to recent studies focusing on the one hand on the effects of incoming spillovers, appropriability mechanisms and innovation characteristics on the propensity to cooperate in R&D (or generally in innovation activities), on the other hand on the impact of cooperation on innovation performance. Moreover, the studies reviewed here deal with different types of R&D co-operation and the relationship among them. Based on empirical data for different countries (Belgium, Netherlands, Austria, Finland, Germany, and UK) and different econometric approaches the results are characterized by a rather great diversity.

#### *Determinants of cooperation*

Cassiman and Veugelers (2002) investigate the effects of incoming spillovers and appropriability mechanisms on the probability to cooperate in R&D with suppliers/customers and public research institutions respectively. Based on an empirical analysis of 411 Belgium manufacturing firms it was found that it is very important to distinguish between incoming spillovers and appropriability as determinants for different types of R&D cooperations. Firms with higher incoming spillovers and better appropriation of knowledge have in general a higher probability of cooperating in R&D. Higher incoming spillovers positively affect the probability to cooperate with public research institutions, but have no effect on cooperation with customers or suppliers. Better appropriability of results of the innovation process, however, increases the probability of co-operating with customers or suppliers and is unrelated to cooperative agreements with research institutes. The results of this study demonstrate the relevance of distinguishing between incoming spillovers and appropriability.

Belderbos et al. (2004a) provide an interesting extension of the Cassiman and Veugelers (2002) results. Based on matched Dutch firm data for two cross sections (1996, 1998) the authors analysed four different types of R&D cooperation (competitors, customers, suppliers, public research institutions) and found that there are considerable differences with respect to the effects of various determinants on the various types of cooperation (heterogeneity of R&D cooperation strategies). The econometric methodology of the study allowed them to take into account (a) the fact that firms cooperate at the same time with various partners and (b) the

interdependency between R&D cooperation and R&D intensity. Different types of co-operation seem to be viewed by the firms as complements rather than substitutes.

Bönte and Keilbach (2005) focused on vertical R&D cooperation (customers and suppliers). They distinguished between formal and informal cooperation. They found only weak empirical evidence for the relevance of incoming spillovers for formal as well for informal cooperation. In contrast, a firm's ability to limit outgoing spillovers has a positive effect on a firm's propensity to engage in formal and informal cooperation at the same time. It does not affect, however, the probability of co-operating informally alone. The authors further emphasised the importance of absorptive capacity for informal cooperation and stressed that the existence of an R&D department has a positive impact on formal cooperation.

Also Dachs et al. (2004) pointed to the controversial results as to the relative importance of incoming spillovers and appropriability. In a comparative study they found that incoming spillovers are in general an important determinant of cooperation in Finland and in the case of horizontal spillovers in Austria as well. While sector affiliation and innovation intensity are further important driving factors, in Austria, appropriability and public funding activities are the main factors that promote R&D co-operations in Finland. In Austria public funding seems to be effective only in the case of co-operations with the university.

Schmidt (2005) using CIS 3 data for Germany focused on the role of spillovers in explaining R&D cooperation of various types: co-operations with suppliers and customers as well with research institutions. He found in accordance with results for Belgium and Spain a positive effect of knowledge flows on the likelihood of R&D cooperation. In addition, he could show that firms with high internal R&D budgets are more likely to cooperate with universities than with suppliers and customers. The results also suggest that firms' decisions to cooperate with specific partners are not independent from one another.

Although not assessing the relative importance of spillovers and appropriability, Tether (2002) provides us with an interesting analysis of R&D cooperation in relation with different types of innovation activities. Based on UK data the author found that R&D cooperation is more common among firms that introduce innovations new to the market. He also found that the existence of R&D activities as well as the intensity of such activities tend to increase the likelihood that a firm has R&D cooperations with external partners. More specifically, it was exhibited that the existence of continuous R&D activities shows a significant impact on the probability to cooperate with customers, competitors and consultants, while the intensity of R&D activities significantly correlates with R&D cooperations with suppliers and universities. Furthermore, greater customer resistance to innovation and higher levels of investment on externally developed technologies and services tend to be associated with more radical innovations.

In contrast to Tether (2002), Miotti and Sachwald (2003) found in a study based on French firm data that permanent R&D strongly influences the propensity to cooperate with public

science institutions, but does not significantly correlate with the propensity to cooperate with private partners (vertical and horizontal). They further found that vertical cooperation with suppliers and customers aims at pooling complementary resources and focus more on incremental innovations; they are less frequent in high-tech sectors and do not involve firms at the technology frontier. In turn, cooperation with science institutions shows a positive impact on patents and new market products. R&D cooperations with rival firms are mainly undertaken for sharing R&D costs.

Abramovsky et al. (2009) studied cooperative R&D activity in a comparative study for four European countries by using data from the CIS 3 for France, Germany, Spain and the UK. The authors built on Cassiman and Veugelers (2002). They found a positive relationship between the likelihood of cooperating in R&D and incoming spillovers as well as appropriability. These findings are in accordance with those of Cassiman and Veugelers (2002). They further showed that public support is also a factor enhancing the probability of R&D cooperations.

Finally, Faria and Schmidt (2007) investigated the cooperation propensity with domestic and foreign partners for Germany and Portugal but in a different setting and with a different method as in this study.

#### *Impact on innovation performance*

A number of empirical studies have found a positive impact of engaging in R&D cooperation on innovation performance usually measured by the sales share of innovative products (e.g., Klomp and van Leeuwen 2001; Lööf and Heshmati 2002; and Belderbos et al. 2004b). Other studies find little evidence for a significant correlation between cooperation and innovation performance (e.g., Kemp et al. 2003; Janz et al. 2003).

Distinguishing between cooperation with national and international partners, Miotti and Sachwald (2003) show that in France innovation performance is not affected by cooperation agreements with national partners but increased by cooperation with foreign partners. Similarly, Lööf (2009) finds that innovation performance is positively affected by the presence of foreign cooperation partners in the network. Lööf and Heshmati (2002) find positive effects of cooperation for both national and international partners.

Distinguishing between cooperation partners in different places of the value chain has produced ambiguous results. Belderbos et al. (2004) find that university cooperation increases the growth of innovative sales productivity while enterprise cooperation does not have a significant effect. Also using Dutch data, Kemp et al. (2003) do not find a significant impact of either enterprise or university cooperation. Janz et al. (2003) report the same for Sweden. For Germany they find a significantly negative effect of cooperation agreements with competitors. Miotti and Sachwald (2003) report that cooperation agreements with public institutions and competitors do not affect innovation performance while vertical cooperation

increases it. Lööf and Heshmati (2002) find that with the exception of domestic customers, cooperation agreements influence innovation performance positively.

#### **4. Data description**

The data for the four countries Belgium, Germany, Norway and Portugal were collected in the course of the Third Community Innovation survey (CIS3) covering the period 1998-2000 and were available as micro-aggregated data in the form usually provided by Eurostat. The Swiss data come from the Swiss Innovation Survey 2002 covering the period 2000-2002.<sup>1</sup> The Swiss innovation survey is based on a questionnaire quite similar to that of CIS3. Table A.1a and Table A.1b in the appendix show the composition of the data sets used in this study for all five countries by sector and firm size class. The data sets contain only innovating firms<sup>2</sup>, thus our inferences refer only to innovating firms.

The shares of firms cooperating in innovation only within the national borders vary between 7.8% for Belgium and 20.6% for Norway (Table A.1c in the appendix). The share of firms that cooperate also or exclusively with international partners across national borders is for all countries with the exception of Germany considerably higher, at lowest in Germany (12.4%), at highest in Norway (25.8%).

The share of firms cooperating with private partners exclusively is around 10% of innovating firms. The only exception is Norway, where the share is 21%. In Switzerland, only 10% of the innovating firms cooperate with universities. The highest share is found in Norway, where nearly 25% of firms cooperate with universities.

#### **5. Model specification and estimation procedure**

##### *Specification of the cooperation equations*

The first dependent variable this study is the nominal variable CO\_NAT\_INT that takes the value 0 for (innovating) firms that are not cooperating in innovation, the value 1 for firms that get engaged in cooperative projects with national institutions/enterprises *only* (NATCOOP) and the value 2 for firms that get involved in collaborations with international partners

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<sup>1</sup> Thus, there is a comparability problem of the Swiss data that we consider not to be serious given that many characteristics of cooperation behaviour have structural character, at least for the short period of time taken into account in this study.

<sup>2</sup> See Table A.2 for descriptive statistics of the used variables and Table A.3 and Table A.4 for the correlations between the model variables.

(INTCOOP),<sup>3</sup> i.e. including firms that cooperate with both national *and* international partners.<sup>4</sup> Thus, the group of non-cooperating firms serve as base category.

The second dependent variable we use is the nominal variable CO\_ENT\_UNI that takes the value 0 for (innovating) firms that are not cooperating in innovation, the value 1 for firms that get engaged in cooperative projects with enterprises *only* (ENTCOOP) and the value 2 for firms that get involved in collaborations with universities (UNICOOP),<sup>5</sup> i.e. including firms that cooperate with both enterprises *and* universities.<sup>67</sup> Also in this case non-cooperating firms serve as base category.

Our model contains variables measuring a firm's knowledge absorptive capacity, incoming and outgoing spillovers, the availability of qualified personnel, the extent of innovation risks, the extent of financial constraints, a series of control variables with respect to public promotion of innovation, affiliation to a group of enterprises, type of market in which a firm operates, firm size and sector affiliation (see Table 1a).

Absorptive capacity is measured by the natural logarithm of the number of employees with tertiary-level education divided by sales (variable lnHEPT; see Table 1a for the description of the variables).<sup>8</sup> A positive effect of this variable is expected. In addition, we use a variable for lack of qualified personnel (variable OSKILL), for which we expect a negative effect.

The variables measuring the importance of three external knowledge sources, namely knowledge from customers (variable KCUS), suppliers of materials, capital goods, etc (KSUP) and universities (KUNI), are used as proxies for incoming spillovers. We expect a (joint) positive effect of these three variables.

Outgoing spillovers are indirectly measured by the variable APPR, which is a dummy variable constructed on the basis of information on the availability and use of several means of protection of innovation returns. For firms that use such means a lot, we assume that they need them in order to improve the appropriability of their innovation revenues and to avoid APPRs of their knowledge. But this kind of measure does not denote in itself much about the

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<sup>3</sup> The labels NATCOOP and INTCOOP respectively are used not only for the levels 1 and 2 of the nominal variable CO\_NAT\_INT but also for the respective dummy variables used as right-hand side variables in the innovation equations (see below).

<sup>4</sup> The construction of a group of firms with *exclusively* international cooperation was not possible due to the low number of available observations for this cooperation category in most countries.

<sup>5</sup> The labels ENTCOOP and UNICOOP respectively are used not only for the levels 1 and 2 of the nominal variable CO\_ENT\_UNI but also for the respective dummy variables used as right-hand side variables in the innovation equations (see below).

<sup>6</sup> Also in this case the construction of a group of firms with *exclusively* university cooperation was not possible due to the low number of available observations for this cooperation category in most countries.

<sup>7</sup> ENTCOOP includes the following categories: Other enterprises within enterprise group, suppliers, customers, competitors, consultants and commercial laboratories. As these cooperation agreements are dominated by firm-to-firm relationships, we label the variable enterprise cooperation. UNICOOP includes universities as well as private and public research institutions. Since these cooperation agreements are mostly between the firm and a university, we refer to them as university cooperation.

<sup>8</sup> The variable usually used, number of employees with tertiary-level education, was not available in our Eurostat data.

effectiveness of these protection means. Unfortunately measures of the effectiveness of protection are not available in our dataset. Thus, we have to cope with the ambiguity of the expected effects of this variable on the cooperation propensity and make the best out of it. If protection is effective, appropriability is warranted and cooperation could not harm. If protection is ineffective, low appropriability would be a problem for the firm and cooperation would be avoided. A positive sign of the variable would be interpreted as a hint for the validity of the assumption of high appropriability (low level of outgoing spillovers), a negative sign as a confirmation of the assumption of low appropriability (high level of outgoing spillovers).

Further, in accordance to management literature (see, e.g., Hagedoorn et al. 2000) we take into consideration three additional motives for innovation (R&D) cooperation, namely sharing of (high) innovation (R&D) investment and sharing of (high) innovation risks. As proxies for these two motives we use the variables OFIN (for lack of funds for innovation) and ORISK (for high innovation risks) respectively.

Several additional firm characteristics are also taken into account: whether a firm receives public financial support (PUBFIN), whether a firm belongs to a group of enterprises (GROUP), and whether a firm is foreign or domestic (FOREIGN). For public support we expect a positive sign because in most countries public support is tied to the condition of cooperative projects. A positive sign is expected also for the variable GROUP. Firms that are embedded in a network of sister firms would show a higher cooperation propensity than firms without such ties. It is not a priori clear if there are differences with respect to cooperation behaviour between domestic and foreign firms.

Finally, dummies for firm size, sector affiliation, and for country (only in the pooled regressions) are included in the cooperation equations.

A formal expression of these equations for a firm  $i$  is as follows :

$$CO\_NAT\_INT_i (0; 1: NATCOOP_i; 2: INTCOOP_i) = \alpha_0 + \alpha_1 HEPT_i + \alpha_2 KCUS_i + \alpha_3 KSUP_i + \alpha_4 KUNI_i + \alpha_5 APPR_i + \alpha_6 OSKILL_i + \alpha_7 ORISK_i + \alpha_8 OFIN_i + \alpha_9 PUBFIN_i + \alpha_{10} GROUP_i + \alpha_{11} FOREIGN_i + control\ variables + u_i \quad (1a)$$

$$CO\_ENT\_UNI_i (0; 1: ENTCOOP_i; 2: UNICOOP_i) = \alpha'_0 + \alpha'_1 HEPT_i + \alpha'_2 KCUS_i + \alpha'_3 KSUP_i + \alpha'_4 KUNI_i + \alpha'_5 APPR_i + \alpha'_6 OSKILL_i + \alpha'_7 ORISK_i + \alpha'_8 OFIN_i + \alpha'_9 PUBFIN_i + \alpha'_{10} GROUP_i + \alpha'_{11} FOREIGN_i + control\ variables + u_i \quad (1b)$$

#### *Specification of the innovation equation*

Our innovation equation is specified based on a resource-based firm concept. Innovation performance is measured by the sales share of new and considerably modified products (see Table 1b). As independent variables we use proxies for the intensity of physical capital

(variable  $\ln\text{INVPT}$ ), the intensity of human capital (variable  $\ln\text{HEPT}$ ), the intensity of knowledge capital (variable  $\ln\text{FEPT}$ ), and a series of control variables for foreign or domestic ownership, firm size, sector affiliation and country (only for the pooled regression). Finally, we include also the following two dummy variable pairs: (NATCOOP; INTCOOP) and (ENTCOOP; UNICOOP).

We expect a positive effect of all three resource-related variables. According to theoretical arguments and existing empirical evidence the direction of the effects of the two cooperation variables is not a priori clear. A formal expression of these equations for a firm  $i$  looks as follows:

$$LNEWS_i = \beta_0 + \beta_1\text{NATCOOP}_i + \beta_2\text{INTCOOP}_i + \beta_3\ln\text{INVPT}_i + \beta_4\ln\text{FEPT}_i + \beta_5\ln\text{HEPT}_i + \beta_6\text{FOREIGN}_i + \text{control variables} + v_i \quad (2a)$$

$$LNEWS_i = \beta'_0 + \beta'_1\text{ENTCOOP}_i + \beta'_2\text{UNICOOP}_i + \beta'_3\ln\text{INVPT}_i + \beta'_4\ln\text{FEPT}_i + \beta'_5\ln\text{HEPT}_i + \beta'_6\text{FOREIGN}_i + \text{control variables} + v_i \quad (2b)$$

## 6 Empirical Results

### 6.1 Estimation procedure

In a first step, we estimated a multinomial probit model for equation (1a) and (1b) with the nominal variables  $\text{CO\_NAT\_INT}$  (0; 1: NATCOOP; 2: INTCOOP) and  $\text{CO\_ENT\_UNI}$  (0; 1: ENTCOOP; 2: UNICOOP) respectively. In both cases, the reference category 0 consists of those firms that do not have any cooperation agreements. Reported standard errors are heteroscedasticity-robust.

In a second step, we estimated tobit models for equation (2a) and (2b) with  $LNEWS$  as dependent variable that was downward censored at 0. Reported standard errors are also heteroscedasticity-robust standard errors as well. However, being involved in cooperation activities might not be exogenous to innovation activities. We tested endogeneity for all cooperation variables according to the following procedure (Rivers and Vuong 1988): instrument equations were estimated separately for each cooperation variable and each country (see Table A.5a and Table A.5b). Instrument choice was based on 3 criteria: significant correlation to the endogenous variable, insignificant correlation to  $LNEWS$  and insignificant correlation to the error term of the innovation equation. The residuals of the first stage equations shown in Table A.5a and A.5b were inserted in the innovation equation as additional regressors. Bootstrapping was used in order to correct the standard errors of the estimated parameters. If the coefficient of the residuals was statistically significant (at the 10%-test level), we have assumed that endogeneity is present and consequently based our inference on instrumented variables; also in this case standard errors were estimated by bootstrapping. In cases in which the coefficient of the residual was not statistically significant we have assumed exogeneity.

The results for the dichotomous variables NATCOOP and INTOOP are shown in Table A.6, which shows that the null hypothesis of exogeneity can only be rejected for INTOOP in Germany. Therefore the variable INTOOP for Germany in table 2b is instrumented. For the other countries, we assume that exogeneity holds.

Table A.9 indicates that ENTCOOP is endogenous in the pooled regression and UNICOOP in the regression for Portugal. As a consequence, the estimates for UNICOOP for Portugal reported in table 5 are based on the instrumental variable approach.

## **6.2 National versus international Cooperation**

### *Cooperation Propensity*

Table 2a and Table 2b show the multinomial probit estimates for the categories (exclusively) national and international innovation cooperation with respect to the reference category consisting of firms that do not conduct innovation cooperation. Furthermore, table A.7 in the appendix reports the corresponding marginal effects.

We find surprisingly little evidence for an effect of absorptive capacity as measured by  $\ln\text{HEPT}$ , the log of the number of employees with higher education scaled by the firms' sales and  $\text{OSKILL}$ , the relevance of lack of qualified personnel as an innovation obstacle. The human capital indicator  $\ln\text{HEPT}$  is significantly positively related to NATCOOP in the estimates for Switzerland and Norway, while it is insignificant for Belgium, Germany and Portugal. For INTOOP we find that the variable is only significant in the Norwegian equation. Furthermore, the negative relationship between cooperation and the lack of qualified personnel ( $\text{OSKILL}$ ) is found to be significant only in the Norwegian regression of national cooperation. While these results do not collide with the findings of Woerter (2007) for Switzerland, Faria and Schmidt (2007) find a significantly positive impact of human capital endowment for both Germany and Portugal based on a different specification of this variable (dummy variable with the value 1 when a firm has a share of employees with tertiary-level education higher than the sample median).

In accordance with the literature, we find a significantly positive effect of incoming spillovers as measured by the sum of the marginal effects of all three external knowledge sources (customers; suppliers; universities) for all countries and both national and international cooperation. This effect is driven mainly by the dominant influence of university spillovers; the respective variable  $\text{KUNI}$  is significantly positive correlated with the propensity for both cooperation types discussed here and for all five countries. The results with respect to the other two external sources are mixed. We could not find any effect of suppliers (variable  $\text{KSUP}$ ) on the propensity for national cooperation, but we could reveal a significantly positive effect for Norway and Portugal with respect to international cooperation. For customers as an external knowledge source (variable  $\text{KCUS}$ ) the estimates show a negative effect for national



cooperation in Belgium and Switzerland and a positive effect for intentional cooperation in Norway. The negative effect for Belgium and Switzerland could be interpreted as a hint that in these small countries, especially in Switzerland, the information exchange with customers at national level takes place rather through informal contacts than through formal agreements due to long-established trustworthy relationships. Faria and Schmidt (2007) found no significant effect for their variable measuring overall incoming spillovers for Germany and Portugal. Abramovsky et al. (2009) revealed a positive effect of incoming spillovers (also measured by an overall variable) for Germany after taking endogeneity of this variable into account.

In accordance to theoretical expectation but also to existing empirical evidence, the variable for appropriability (variable APPR) shows in general a positive effect on cooperation; this effect is statistically significant only for Germany in the case of national cooperation but for all countries with respect to international cooperation. We interpret the positive sign of this variable as evidence in favour of the assumption of high appropriability (low level of outgoing spillovers) that influences positively the cooperation propensity (see section 5). The results for Germany and Portugal are in line with the findings of Faria and Schmidt (2007), the German results also in accordance with Abramovsky et al. (2009).

The theoretical expectation with respect to innovation risk (as measured by the variable ORISK as a proxy for the risk-sharing motive of cooperation) is that it increases the cooperation propensity of firms. While we cannot confirm this prediction for national cooperation, we do find evidence for the presence of this positive effect in the context of international cooperation agreements, as the variable ORISK is significant for Belgium, Switzerland, Portugal. Miotti and Sachwald (2003) using a similar variable in their study do not find such a relationship for France.

Obstacles in respect to financing (OFIN) here serving as a proxy for the cost-sharing motive for cooperation do not affect the decision to cooperate significantly. The only exception is the INTCOOP equation for Germany and the significance level for OFIN there is merely 10%. The positive impact of public finance support (variable PUBFIN) on the propensity to cooperate both nationally and internationally for all countries reflects the common goal of technology policy in most countries of fostering cooperation by providing subsidies under the condition of cooperation either with universities or other firms.

In the group of variables capturing the market environment, operating in regional, national or international markets does not make a difference for national cooperation (with the exception of Norway, where firms operating in international markets show a lower propensity for national cooperation than firms operating in regional or national markets). However, show firms operating in international markets show as expected a significantly higher inclination for international cooperation than firms with regional or national action radius.

Furthermore, being member of an enterprise group of enterprises (variable GROUP) increases the likelihood of cooperation, both at national and international level; this effect is stronger for international cooperation. In the regression for Switzerland, Norway and Portugal the variable FOREIGN has a significantly negative sign, implying that the propensity to cooperate only on a national level is lower for foreign firms. In Belgium and Germany there appears to be no difference with respect to cooperative behaviour between domestic and foreign firms. As expected, foreign firms show a higher propensity to international cooperation than domestic firms but only for Germany and, Norway.

In all countries but Belgium and Switzerland, large firms with more than 250 employees cooperate within national borders more frequently than SMEs. For international cooperation, the coefficient of the dummy variable for larger firms is significantly positive in all countries and the marginal effect is larger than for national cooperation.

### *Innovation Output*

In the second step we analyse the impact of innovation cooperation on the innovation performance of firms by estimating a tobit model, where the dependent variable is the share of sales generated by innovative (new and considerably modified) products (see Table 3).

In accordance with our expectations, innovation expenditures (Switzerland: R&D expenditures; lnFEPT) are positively correlated to the share of innovative products. The only exception is Portugal, where the coefficient is positive but insignificant. Generally, the same is true for the employees with higher education (lnHEPT) for Switzerland, Germany and Norway but not for Belgium and Portugal. The variable for capital intensity (lnINVPT) is not significant but for Portugal, for which we find a significant negative effect. This might reflect the specific industry structure of Portugal, where oil refineries, cement production and paper industry are among the major industries, i.e. industries that are not particularly innovative industries but quite capital-intensive. The same argument applies to tourism, the most important service industry in Portugal.

In all five countries, foreign firms are as innovative as domestic firms. The effect of size is ambiguous, as it is positive in Belgium and Portugal and negative in Norway.

The results exhibit little evidence for an effect of the dummy variable which captures national cooperation (NATCOOP) on the innovation performance. The coefficients are negative for Belgium and Switzerland, but only the one for Belgium is significant. The effect is positive but insignificant in Norway and Portugal. The only exception is Germany, where we find a significant positive effect.

International cooperation (INTCOOP) on the other hand is clearly positively correlated to innovation performance. The coefficients are significantly positive in most of the regressions. The only exceptions are Switzerland and Germany, for which the coefficients are positive but statistically insignificant.

A potential interpretation of the significant impact of national cooperation in Germany is that the country is large enough to provide a sufficient range of profitable cooperation agreements within the country. The insignificance of the coefficient for international cooperation is consistent with this explanation. Since the available partners are more likely to be present, there is less need for international cooperation, which is generally more costly as the transaction costs are higher with increasing organizational and cultural distance.

These results are in line with the findings of Miotti and Sachwald (2003) that show that in France innovation performance is not affected by cooperation agreements with national partners but increased through cooperation with foreign partners. Similarly, Lööf (2009) finds for Swedish firms that innovation performance is positively affected by the presence of foreign cooperation partners in the network.

### **6.3 Enterprises versus Universities**

#### *Cooperation Propensity*

As for national and international cooperation agreements we first estimate a multinomial probit to investigate similarities and differences in the determinants of innovation cooperation with enterprises and universities. Tables 4a and 4b report the results with respect to the reference category consisting of firms that do not conduct innovation cooperation. Furthermore, table A.10 in the appendix reports the corresponding marginal effects.

Concerning absorptive capacity, we find some evidence for a positive relationship between the absorptive capacity and cooperation with enterprises, as the variable *lnHEPT* is significant in the Swiss and the Norwegian case. On the contrary, *OSKILL* is not significant in any of the estimates in Table 4a. Absorptive capacity appears to matter substantially more in respect to cooperation with universities though. The variable *lnHEPT* is significant throughout the estimates in Table 4b. *OSKILL* shows the expected negative sign merely in the German case. The available results for Germany are mixed. In line with our results for this country, Schmidt (2005) also finds a significant effect of human capital endowment (with a quite different specification of the respective variable) for cooperation with universities but not with enterprises. Abramovsky et al. (2005) on the other hand do not find an effect of absorptive capacity for Germany using R&D intensity as indicator for absorptive capacity in the equation for overall cooperation; but they find a negative effect for university cooperation and cooperation with customers and/or suppliers and no effect for cooperation with competitors. Similarly, Cassiman and Veugelers (2002) do not find a significant relevance of absorptive capacity (approximated by a dummy variable for permanent R&D) for Belgian firms cooperating either with research institutions (including universities) or suppliers and customers.

With the exception of a positive effect for Norway, incoming knowledge spillovers from customers are not relevant for ENTCOOP or for UNICOOP. Utilizing suppliers as a knowledge source appears to be positively correlated to cooperation with enterprises in Germany, Norway and Portugal, but shows no effect on the likelihood of cooperative agreements with universities (with the exception of Norway). The use of universities as knowledge source is significantly negative related to ENTCOOP in Germany and in Switzerland. Obviously, firms choosing to cooperate with other enterprises in these countries are firms that use university knowledge less intensive than non-cooperating firms. Not surprisingly, the effect of this external knowledge source is it is positive and significant in the regression for UNICOOP.

Appropriability is positively correlated to probability to cooperate with enterprises in the regressions for Belgium, Germany and Portugal. For university cooperation, the coefficient of the variable APPR is significant in all but the Belgian regression. The marginal effects are larger in the case of universities (with the exception of Portugal, where the marginal effects for university and enterprise cooperation are about the same). This is a rather astonishing result because our expectation has been that appropriability issues would be a more important factor influencing cooperation decisions in the case of enterprises as cooperation partners that could profitably exploit disclosed proprietary knowledge than in the case of universities that mostly show little interest for the economic implications of new knowledge. Some more detailed additional analysis should be needed in order to be able to explain this effect, e.g., by taking into account the fact that the knowledge and technology transfer between firms and universities are (still) not regulated efficiently in every university and in every country, so that firms consider high appropriability as pre-condition, as a kind of insurance for proprietary knowledge for cooperation with universities.

Our finding is in accordance to the findings of Schmidt (2005) and Abramovsky et al. (2009) for Germany. Belgium appears to be a different case, as appropriability is positive and significant for cooperation with enterprises but not for universities, which is in line with the results of Cassiman and Veugelers (2002).

Table 4a provides weak evidence for a positive relationship between risk as an innovation obstacle (ORISK) and the cooperation with enterprises, as the coefficients are significant in the Swiss and the Portuguese regressions. For universities, no such link exists as only the pooled regression shows a (weakly) significant positive coefficient. These findings indicate that sharing risks might constitute an important motive for cooperation with other enterprises, at least in some countries, but not for universities. A potential explanation may be found in the different incentives structures in the worlds of academics and business. In the former, a published paper counts more than a successful product, while the reverse is true in the business world. Furthermore, even a failed experiment might lead to a publication but not to the creation of a product. Cassiman and Veugelers (2002) for Belgium and Schmidt (2005) for

Germany find no link between innovation risk and cooperation with enterprises but even a significantly negative correlation between innovation risk and cooperation with universities.

The cost-sharing motive for cooperation (as approximated by the variable OFIN) appears to be not relevant for both cooperation with enterprises and cooperation with universities (with the exception of Germany, for which a positive effect for this variable was found).

As expected, the probability that a firm cooperates with a university increases if public funding was granted (variable PUBFIN). This effect was found in all five countries reflecting the existence of public funding schemes aiming at facilitating knowledge transfer. Public finance support is less important for cooperation with firms; Belgium and Portugal do not show such an effect. The marginal effects of university cooperation are substantially larger than those for enterprise cooperation in all countries.

Foreign owned firms are as likely to cooperate with enterprises and universities as domestic firms in all five countries; no significant effect for this variable could be found across all estimates.

Further, we find that the market orientation is a further firm characteristic that influences the choice of the cooperation partner. While cooperation agreements with enterprises are not affected by the market orientation, cooperation with universities is more likely if the firm serves an international market (with the exception of Portugal).

In line with the literature, we find that the probability to cooperate increases with the firm size. Similar to Cassiman and Veugelers (2002) and Schmidt (2005), our results suggest that the effect is more pronounced for the cooperation with universities, the coefficient of the dummy variable for larger firms is not significant in Switzerland, Germany and Portugal in the equation for cooperation with enterprises. Furthermore, the marginal effects are substantially larger for university cooperation.

### *Innovation Output*

Table 5 reports the tobit estimates for sales share of innovative products with the cooperation variables ENTCOOP and UNICOOP as additional right-hand variables. The results for the resource endowment variables are similar as in the estimates of the innovation equation with NATCOOP and INTCOOP as explanatory variables. R&D expenditures (lnFEPT) and human capital (lnHEPT) show in general the expected positive effects. The proxy for physical capital (lnINVPT) is not significant except for Portugal (with a negative sign). For all countries it does not make a difference if firms are domestic or foreign.

We find little evidence for a significant relationship between innovation performance and cooperation with enterprises. The coefficients are significantly positive only in the regressions

for Germany and Norway. They are insignificant for the other three countries Portugal, Belgium and Switzerland.

On the whole, our findings show little evidence for an overall positive relationship between innovation performance (as measured by the sales share of innovative products) and the likelihood of cooperation in innovation with enterprises. A significantly positive contribution of cooperation with universities to innovation performance is found in addition to Germany and Norway also for Portugal (and in the pooled regression).

Our findings are in line with those of Belderbos et al. (2004b), who show that university cooperation enhances the growth of innovative sales productivity, while enterprise cooperation does not show a significant effect. Kemp et al. (2003) do not find a significant impact of either enterprise or university cooperation. Janz et al. (2003) report the same for Sweden, but a significantly negative effect of cooperation agreements with competitors for Germany. Miotti and Sachwald (2003) report for France that cooperation with public institutions and competitors do not affect innovation performance, while vertical cooperation shows a positive impact. The heterogeneity of the findings of empirical studies might be explained by the diversity of countries, models and definitions of cooperation agreements and cooperation partners used in these studies.

## **7. Summary and Conclusions**

### *Determinants of cooperation*

Table 6 presents in summary the most important results of this study with respect to the determinants of cooperation, thus allowing a comparison of the empirical findings for five European countries and four cooperation dimensions (national vs. international partners, business partners vs. science-based institutional partners; using non-cooperating firm as reference) at a glance.

The choice of these four dimensions was driven by the hypothesis that these dimensions are empirically relevant and also important from the policy point of view. We concentrate here to the five theory-driven determinants of cooperation in innovation: absorptive capacity, incoming spillovers, appropriability, risk-sharing and cost-sharing as cooperation motives.

High knowledge absorptive capacity is clearly a specific characteristic of firms cooperating (even not exclusively) with universities, but not necessarily for the other three categories of cooperating firms discussed here, at least not for the majority of the five countries taken here into account, namely Belgium, Germany and Portugal. There is the remarkable exception of Norway, for which a high absorptive capacity is important for all four categories; this is also the case for Switzerland for three out of four cooperation categories.

Incoming spillovers, particularly these related to universities (and other science-based institutions) constitute a second important determining factor for all four types of cooperation and all five countries. This is an interesting finding that demonstrates the crucial role of science-based knowledge as basis for innovation cooperation. Spillovers coming from suppliers are relevant primarily for cooperation with enterprises, especially for Germany, Norway and Portugal. Incoming spillovers seem to be particularly important for Norwegian firms.

High appropriability is of special importance for international cooperation (all five countries) and cooperation with universities (four out of five countries), to some extent also for cooperation with firms (three out of five countries) but not for national cooperation (one out of five countries). Obviously the risk of proprietary knowledge being disclosed to partners without explicit permission of the involved firm is significantly higher in international cooperation than in national cooperation. The same rationale could explain the effect for cooperation with firms but not with universities. For the latter effect we could not find any persuading explanation until now. Some more detailed additional analysis should be needed in order to be able to explain this effect, e.g., by taking into account the fact that the knowledge and technology transfer between firms and universities are (still) not regulated efficiently in every university and in every country, so that firms consider high appropriability as pre-condition or as a kind of insurance for proprietary knowledge for cooperation with universities.

Risk-sharing as a motive of cooperation can be found primarily for international cooperation (Switzerland, Germany and Norway), to some extent also for cooperation with firms (Switzerland and Portugal).

Cost-sharing as a cooperation motive appears to have no relevance (all four types of cooperation; four countries out of five). Germany builds an exception, risk-sharing being of importance for both international cooperation and cooperation with universities.

#### *Impact of cooperation on innovation*

Table 7 shows in summary the findings with respect to the impact of cooperation on innovation. International cooperation and cooperation with universities show a significantly positive effect on innovation performance in three out of five countries. For Germany and Norway a positive effect could be found for three types of cooperation, on the other extreme no effect of cooperation could be found for Switzerland.

#### *Policy implications*

Two findings of this study seem to be of particular interest from the policy point of view: the relevance of university-based knowledge as a factor enhancing cooperation in innovation in general and the existence of positive effects on innovation performance especially for international cooperation and cooperation with research institutions. Both effects show in the

same direction, namely towards more intensive knowledge and technology transfer between enterprises and research institutions across national borders that could be further enhanced by technology policy by providing both sides more incentives for cooperation, e.g. fiscal facilitations and/or subsidies for enterprises that get engaged in collaborative projects with universities, additional funds for universities that achieve to get involved in such projects. At best, the support of cooperation between business and university should be pursued at trans-national level. According to our data, about two thirds of firms cooperating with international partners have agreements with universities.

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### **Literature**

- Abramovsky, L., Kremp, E., Lopez, A., Schmid, T., and H. Simpson (2009): Understanding Co-operative R&D Activity: Evidence from Four European Countries, *Economics of Innovation and New Technology*, 18(3), 243-265.
- Belderbos, R., Carree, M., Diesderen, B., Lokshin, B. and R. Veugelers (2004a): Heterogeneity in R&D Cooperation Strategies, *International Journal of Industrial Organization*, 22, 1237-1263.
- Belderbos, R., Carree, M. and B. Lokshin (2004b): Co-operative R&D and Firm Performance, *Research Policy*, 33, 1477-1492.
- Bönte, W. and M. Keilbach (2005): Concubinage or Marriage? Informal and Formal Co-operations for Innovation, *Research Policy*, 23, 279-302.
- Cassiman, B., Perez-Castrillo, D. and R. Veugelers (2002): Endogenizing Know-how Flows through the Nature of R&D Investments, *International Journal of Industrial Organization*, 20, 775-799.
- Cassiman, B. and R. Veugelers (2002): R&D Cooperation and Spillovers: Some Empirical Evidence from Belgium, *American Economic Review*, 92(4), 1169-1184.
- Cohen, W.M. and D.A. Levinthal (1989): Innovation and Learning: The Two Faces of R&D, *Economic Journal*, 99, 569-596.
- Cohen, W.M. and D.A. Levinthal (1990): Absorptive Capacity: A New Perspective on Learning and Innovation, *Administrative Science Quarterly*, 35, 128-152.
- Dachs, B., Ebersberger, B. and A. Pyka (2004): Why Do Firms Co-operate for Innovations? A Comparison of Austrian and Finnish CIS 3 Results, *Paper Presented at the Conference of the International Schumpeter Society (ISS) 2004*.
- D'Aspremont, C. and A. Jacquemin (1988): Co-operative and Non-co-operative R&D in Duopoly with Spillovers, *American Economic Review*, 78, 1133-1137.



- De Bondt, R. (1996): Spillovers and Innovative Activities, *International Journal of Industrial Organization*, 15, 1-28.
- Faria, P. and T. Schmidt (2007): International Cooperation on Innovation: Empirical Evidence for German and Portuguese Firms, *ZEW Discussion Paper No. 07-060*, Mannheim.
- Janz, N, Lööf, H. and B. Peters (2003): Firm Level Innovation and Productivity – Is There a Common Story Across Countries? *ZEW Working Paper 03-26*, Mannheim.
- Hagedoorn, J., Link, A.N. and N.S. Vonortas (2000): Research Partnerships, *Research Policy*, 29(4-5), 567-586.
- Kaiser, U. (2002): An Empirical Test of Models Explaining Research Expenditures and Research Cooperation: Evidence from the German Service Sector, *International Journal of Industrial Organization*, 20, 747-774.
- Kamien, M.I., Muller, E. and I. Zang (1992): Research Joint Ventures and R&D Cartels, *American Economic Review*, 82, 1293-1306.
- Kamien, M.I. and I. Zang (2000): Meet me halfway: Research Joint Ventures and Absorptive Capacity, *International Journal of Industrial Organization*, 18, 995-1012.
- Kemp, R.M.G., Folkeringa, M., de Jong, J.P.J. and E.F.M. Wubben (2003): Innovation and Firm performance, *Research Report H2000207*, SCALES, Zoetermeer.
- Klomp, L. and G. van Leeuwen (2001): Linking Innovation and Firm Performance: A New Approach, *International Journal of the Economics of Business*, 8(3), 343-365.
- Lööf, H. and A. Heshmati (2002): Knowledge Capital and Performance Heterogeneity: A Firm-level Innovation Study, *International Journal of Production Economics*, 76(1), 61-85.
- Lööf, H. (2009): Multinational enterprises and innovation: firm level evidence on spillover via R&D collaboration, *Journal of Evolutionary Economics*, Vol. 19, No. 1, 41-71.
- Miotti, L and F. Sachwald (2003): Cooperative R&D: Why and with Whom? An Integrated Framework of Analysis, *Research Policy*, 32, 1481-1499.
- Schmidt, T. (2005): Knowledge Flows and R&D Co-operation: Firm-level Evidence from Germany, *ZEW Discussion Paper No. 05-22*, Mannheim.
- Tether, B.S. (2002): Who Cooperates for Innovation and Why. An Empirical Analysis, *Research Policy*, 31, 947-967.
- Woerter, M. (2007): Driving Forces for Research and Development Strategies – An Empirical Analysis Based on Firm-level Panel Data, *KOF Working Paper No. 184*, Zurich.

## Tables:

Table 1a: Definition of the variables of the cooperation equation

Variables	Description
<b>Dependent Variables</b>	
CO_NAT_INT	Nominal variable; 0: no co-operation arrangements; 1: firms that have co-operation arrangements with other firms or organisations with <i>national</i> partners but <i>not</i> with <i>international</i> ones (NATCOOP); 2: firms that have co-operation arrangements with other firms or organisations with <i>international</i> partners (INTCOOP)
CO_ENT_UNI	Nominal variable; 0: no co-operation arrangements; 1: firms that have co-operation arrangements with <i>private partners</i> but not with <i>public organisations</i> (COOPENT); 2: firms that have co-operation arrangements with <i>public organisations</i> (UNICOOP)
<b>Independent Variables</b>	
<i>Absorptive Capacity</i>	
InHEPT	Log of the number of employees with tertiary-level education divided by sales (in 1000 €)
OSKILL	Dummy variable <sup>(1)</sup> ; 1: lack of qualified personnel is an important innovation obstacle; 0: otherwise
<i>Incoming Spillovers</i>	
KCUS	Dummy variable <sup>(1)</sup> ; 1: customers are an important external knowledge resource; 0: otherwise
KSUP	Dummy variable <sup>(1)</sup> ; 1: suppliers are an important external knowledge source; 0: otherwise
KUNI	Dummy variable <sup>(1)</sup> ; 1: universities are an important external knowledge source; 0: otherwise
<i>Appropriability</i>	
APPR	Dummy variable; 1: any of the following means to protect inventions or innovations were used: registration of design patterns; trademarks; copyright; secrecy; complexity of design; lead-time advantage on competitors; 0: otherwise
<i>Proxies for risk- and cost sharing</i>	
ORISK	Dummy variable <sup>(1)</sup> ; 1: risks of innovation projects are an important innovation obstacle; 0: otherwise
OFIN	Dummy variable <sup>(1)</sup> ; 1: difficulty to access to financial sources is an important innovation obstacle; 0: otherwise
<i>Market environment</i>	
MARKET_2	Dummy variable; 1: firm operating primarily in a <i>national</i> market; 0: otherwise
MARKET_3	Dummy variable; 1: firm operating primarily in an <i>international</i> market; 0: otherwise
PUBFIN	Dummy variable for public financial support in the respective reference period
<i>Control Variables</i>	
GROUP	Dummy variable; 1: firm is part of an enterprise group; 0: firm is independent
FOREIGN <sup>(2)</sup>	Dummy variable; 1: firm with foreign headquarter; 0: otherwise
SIZE_2	Dummy variable; 1: 50 to 249 employees; 0: otherwise
SIZE_3	Dummy variable; 1: 250 employees and more; 0: otherwise
SECTOR_2-SECTOR_7	7 sectoral dummies; see Table A1 in the appendix for the definitions; reference group: mining, construction, energy

(1): The dummy variable takes the value 1 if a firm reports the values 3 or 4 and the value 0 if a firm reports the values 1 or 2 on a four-point scale (1: ‘not relevant’: 4: ‘high importance’); Switzerland: the dummy takes the value 1 if a firm reports 4 or 5 and the value 0 if a firm reports 1, 2 or 3 on a five-point Likert scale (1: ‘not important’; 5: very important’); (2) For Switzerland the dummy variable takes the value 1 if the firm is foreign-owned.

Table 1b: Definition of the variables of the innovation equation

Variables	Description
Dependent variables	
LNEWS	Natural logarithm of the sales share of new or significantly improved products
Independent variables	
NATCOOP	Dummy variable; 1: firms that have co-operation arrangements with other firms or organisations with <i>national</i> partners but <i>not</i> with <i>international</i> ones; 0 otherwise
INTCOOP	Dummy variable; 1: firms that have co-operation arrangements with other firms or organisations with <i>international</i> partners; 0: otherwise
ENTCOOP	Dummy variable; 1: firms that have co-operation arrangements with <i>private partners</i> but <i>not</i> with <i>public organisations</i> ; 0 otherwise
UNICOOP	Dummy variable; 1: firms that have co-operation arrangements with <i>universities and other research institutions</i> ; 0: otherwise
InFEPT	Natural logarithm of innovation expenditures divided by sales
InINVPT	Natural logarithm of gross investment divided by sales
InHEPT	See Table 1a
GROUP	see Table 1a
FOREIGN	see Table 1a
SIZE_2; SIZE_3	see Table 1a
SECTOR_2 to	see Table A1a
SECTOR_7	

Table 2a: Multinomial probit model estimates for CO\_NAT\_INT (1: NATCOOP)  
(ref. cat.: no cooperation)

1: NATCOOP	BE	CH	GE	NO	PT
lnHEPT	0.042 (0.051)	0.230*** (0.067)	0.024 (0.027)	0.044* (0.023)	0.017 (0.027)
KCUS	-0.550** (0.255)	-0.270* (0.163)	-0.139 (0.128)	-0.024 (0.138)	-0.258 (0.212)
KSUP	-0.242 (0.247)	0.280 (0.218)	0.079 (0.116)	0.170 (0.123)	-0.085 (0.215)
KUNI	0.721*** (0.253)	0.405** (0.193)	0.793*** (0.122)	0.621*** (0.166)	1.176*** (0.260)
APPR	0.234 (0.287)	0.255 (0.169)	0.627*** (0.136)	0.004 (0.134)	0.265 (0.213)
OSKILL	0.034 (0.247)	0.060 (0.177)	-0.177 (0.114)	-0.278* (0.151)	-0.013 (0.204)
ORISK	-0.194 (0.276)	0.061 (0.176)	-0.010 (0.123)	0.049 (0.142)	0.077 (0.208)
OFIN	0.139 (0.255)	-0.015 (0.184)	0.186 (0.122)	-0.098 (0.155)	0.044 (0.210)
PUBFIN	0.938*** (0.263)	0.636** (0.312)	0.875*** (0.120)	1.113*** (0.146)	0.735*** (0.261)
GROUP	0.245 (0.298)	0.214 (0.157)	0.013 (0.133)	0.194 (0.137)	0.469* (0.241)
FOREIGN	-0.278 (0.313)	-0.447* (0.264)	-0.050 (0.216)	-0.755*** (0.195)	-1.054*** (0.367)
MARKET_2	-0.305 (0.358)	-0.027 (0.208)	-0.062 (0.159)	-0.083 (0.141)	0.132 (0.283)
MARKET_3	-0.445 (0.352)	-0.319 (0.219)	0.010 (0.172)	-0.356** (0.179)	0.462 (0.315)
SIZE_2	-0.005 (0.301)	0.083 (0.177)	0.194 (0.148)	0.048 (0.180)	0.271 (0.255)
SIZE_3	0.393 (0.329)	0.073 (0.228)	0.342** (0.162)	0.359** (0.145)	0.683** (0.272)
SECTOR_2	-2.034** (0.830)	0.141 (0.367)	-0.608 (0.451)	-1.151*** (0.307)	-1.305** (0.636)
SECTOR_3	-2.209*** (0.811)	-0.316 (0.325)	-0.256 (0.410)	-1.125*** (0.302)	-1.199* (0.623)
SECTOR_4	-2.005** (0.793)	-0.435 (0.315)	-0.445 (0.405)	-0.831*** (0.287)	-0.957 (0.611)
SECTOR_5	-1.729** (0.814)	-0.260 (0.330)	-0.268 (0.419)	-0.707** (0.295)	-0.549 (0.628)
SECTOR_6	-2.534*** (0.833)	-0.366 (0.346)	-0.035 (0.411)	-0.757*** (0.285)	-0.850 (0.626)
Constant	1.049 (1.195)	1.376 (0.973)	-1.564*** (0.584)	0.262 (0.459)	-1.082 (0.787)
N	490	1327	1496	1240	549
Wald chi2	145.477	216.851	355.867	357.194	145.18
Prob > chi2	0	0	0	0	0

Note: \*, \*\* and \*\*\* denote significances of coefficients at the 10%, 5% and 1% test-level; heteroscedasticity-robust standard errors (White procedure).

Table 2b: Multinomial probit model estimates for CO\_INT\_NAT (2: INTCOOP)  
(ref. cat.: no cooperation)

2: INTCOOP	BE	CH	GE	NO	PT
lnHEPT	0.075 (0.055)	0.078 (0.051)	-0.024 (0.040)	0.078*** (0.027)	0.033 (0.030)
KCUS	0.060 (0.208)	0.044 (0.137)	0.119 (0.151)	0.488*** (0.145)	0.117 (0.212)
KSUP	0.012 (0.202)	0.011 (0.207)	0.165 (0.133)	0.345*** (0.123)	0.549** (0.239)
KUNI	0.753*** (0.213)	0.490*** (0.151)	1.045*** (0.134)	0.895*** (0.155)	0.914*** (0.264)
APPR	0.437** (0.216)	0.318** (0.139)	1.059*** (0.192)	0.671*** (0.146)	0.696*** (0.218)
OSKILL	-0.001 (0.199)	0.169 (0.143)	-0.147 (0.134)	-0.098 (0.141)	0.073 (0.221)
ORISK	0.424* (0.221)	0.545*** (0.139)	0.091 (0.147)	0.043 (0.133)	0.382* (0.220)
OFIN	-0.166 (0.219)	0.105 (0.159)	0.268* (0.140)	0.062 (0.141)	-0.026 (0.214)
PUBFIN	0.912*** (0.201)	1.318*** (0.226)	0.821*** (0.136)	0.774*** (0.145)	0.522** (0.255)
GROUP	0.233 (0.244)	0.462*** (0.153)	0.180 (0.148)	0.670*** (0.152)	0.840*** (0.246)
FOREIGN	0.319 (0.236)	0.168 (0.174)	0.445** (0.207)	0.336** (0.159)	0.111 (0.307)
MARKET 2	0.008 (0.347)	0.398** (0.195)	0.326 (0.220)	0.253 (0.159)	0.125 (0.282)
MARKET 3	0.391 (0.335)	0.658*** (0.182)	0.821*** (0.228)	0.635*** (0.176)	0.413 (0.347)
SIZE 2	0.242 (0.237)	-0.126 (0.169)	0.378* (0.207)	-0.010 (0.183)	0.453 (0.289)
SIZE 3	0.714*** (0.256)	0.343* (0.194)	1.060*** (0.217)	0.266* (0.146)	0.871*** (0.289)
SECTOR 2	-1.940** (0.824)	0.501 (0.402)	-0.716* (0.418)	-0.391 (0.323)	-0.956 (0.843)
SECTOR 3	-1.903** (0.787)	0.476 (0.367)	-0.724** (0.367)	-0.423 (0.310)	-0.412 (0.822)
SECTOR 4	-2.096*** (0.794)	-0.017 (0.365)	-0.826** (0.359)	-0.286 (0.300)	-0.295 (0.825)
SECTOR 5	-2.245*** (0.804)	-0.263 (0.399)	-0.527 (0.392)	-0.290 (0.319)	-0.245 (0.821)
SECTOR 6	-2.103** (0.833)	-0.034 (0.387)	-0.350 (0.362)	-0.534* (0.306)	-0.351 (0.815)
Constant	0.518 (1.258)	-1.873** (0.824)	-3.976*** (0.698)	-1.521*** (0.518)	-2.772*** (0.993)
N	490	1327	1496	1240	549
Wald chi2	145.477	216.851	355.867	357.194	145.18
Prob > chi2	0	0	0	0	0

Note: \*, \*\* and \*\*\* denote significances at the 10%, 5% and 1% test-level; heteroscedasticity-robust standard errors (White procedure).

Table 3: Tobit estimates for LNEWS including NATCOOP and INTCOOP

	BE	CH	GE	NO	PT
NAT COOP	-0.677** (0.289)	-0.073 (0.148)	0.260*** (0.101)	0.035 (0.104)	0.006 (0.296)
INT COOP	0.315** (0.157)	0.058 (0.092)	0.721 (1.295)	0.337*** (0.091)	0.884*** (0.240)
lnINVPT	-0.008 (0.031)	0.078 (0.063)	-0.020 (0.031)	-0.022 (0.015)	-0.184*** (0.065)
lnFEPT	0.142*** (0.041)	0.145*** (0.030)	0.107*** (0.030)	0.036*** (0.010)	0.096 (0.066)
lnHEPT	0.034 (0.030)	0.071** (0.029)	0.060*** (0.020)	0.057*** (0.016)	0.034 (0.030)
FOREIGN	-0.056 (0.158)	0.067 (0.100)	-0.133 (0.140)	0.009 (0.108)	0.247 (0.258)
SIZE_2	0.456*** (0.170)	-0.185** (0.086)	-0.079 (0.135)	-0.176 (0.118)	0.377 (0.276)
SIZE_3	0.551*** (0.189)	-0.328*** (0.111)	0.160 (0.255)	-0.439*** (0.091)	0.111 (0.273)
SECTOR_2	0.851 (0.771)	1.135*** (0.289)	0.778* (0.409)	1.127*** (0.251)	0.887 (0.839)
SECTOR_3	1.012 (0.748)	0.781*** (0.285)	0.739* (0.385)	0.868*** (0.252)	0.845 (0.825)
SECTOR_4	1.583** (0.747)	1.151*** (0.276)	1.026*** (0.386)	1.657*** (0.243)	1.368* (0.822)
SECTOR_5	1.580** (0.759)	1.029*** (0.293)	0.569 (0.409)	1.013*** (0.258)	0.724 (0.857)
SECTOR_6	1.981*** (0.767)	0.795*** (0.306)	0.876** (0.379)	1.425*** (0.244)	1.098 (0.853)
Constant	1.173 (0.902)	3.969*** (0.490)	2.561*** (0.482)	2.158*** (0.339)	0.462 (0.990)
N	707	923	1615	1396	612
F-Test	7.843	7.269	101.622	16.117	3.972
Prob > chi	0	0	0.000	0	0
Pseudo R2	0.036	0.042	0.017	0.046	0.018
Left-censored	181	55	295	200	213

Note: Instrumented INTCOOP variable for GE (see TableA.5b in the appendix); \*, \*\* and \*\*\* denote coefficients significant at the 10%, 5% and 1% test-level; heteroscedasticity-robust standard errors (White procedure) in parantheses.

Table 4a: Multinomial probit model estimates for CO\_ENT\_UNI (1: ENTCOOP)  
(ref. cat.: no cooperation)

1: ENTCOOP	BE	CH	GE	NO	PT
lnHEPT	0.005 (0.044)	0.121** (0.053)	-0.018 (0.026)	0.059** (0.024)	0.017 (0.027)
KCUS	-0.183 (0.238)	0.050 (0.139)	-0.081 (0.145)	0.345** (0.138)	-0.192 (0.212)
KSUP	0.189 (0.233)	0.278 (0.193)	0.294** (0.137)	0.273** (0.121)	0.631*** (0.240)
KUNI	-0.473 (0.311)	-0.310* (0.185)	-0.432** (0.182)	-0.120 (0.182)	-0.118 (0.363)
APPR	0.553** (0.261)	0.218 (0.146)	0.579*** (0.151)	0.179 (0.132)	0.457** (0.211)
OSKILL	0.183 (0.246)	0.086 (0.149)	0.073 (0.134)	-0.178 (0.141)	0.072 (0.213)
ORISK	0.176 (0.265)	0.507*** (0.145)	-0.025 (0.144)	0.058 (0.135)	0.351* (0.210)
OFIN	0.017 (0.258)	-0.066 (0.165)	0.177 (0.140)	-0.189 (0.147)	-0.218 (0.211)
PUBFIN	0.388 (0.263)	0.553* (0.285)	0.304** (0.152)	0.488*** (0.150)	0.064 (0.306)
GROUP	0.326 (0.295)	0.204 (0.152)	-0.003 (0.158)	0.556*** (0.141)	0.387 (0.250)
FOREIGN	-0.207 (0.292)	0.166 (0.194)	0.352 (0.220)	-0.104 (0.164)	-0.098 (0.323)
MARKET_2	-0.473 (0.320)	0.091 (0.189)	-0.202 (0.173)	-0.066 (0.141)	-0.075 (0.266)
MARKET_3	-0.578* (0.331)	0.096 (0.184)	-0.119 (0.189)	-0.023 (0.168)	0.322 (0.328)
SIZE_2	0.075 (0.298)	-0.074 (0.158)	0.211 (0.169)	-0.086 (0.174)	0.215 (0.266)
SIZE_3	0.647** (0.325)	-0.048 (0.206)	0.319* (0.185)	0.007 (0.140)	0.645** (0.281)
SECTOR_2	-2.462*** (0.807)	0.221 (0.342)	-0.750 (0.511)	-0.793** (0.325)	-0.371 (0.308)
SECTOR_3	-2.045*** (0.762)	0.115 (0.301)	-0.362 (0.457)	-0.739** (0.315)	-0.204 (0.312)
SECTOR_4	-2.210*** (0.760)	-0.531* (0.305)	-0.424 (0.449)	-0.390 (0.301)	
SECTOR_5	-1.546** (0.767)	-0.500 (0.327)	-0.080 (0.454)	-0.304 (0.306)	0.552* (0.319)
SECTOR_6	-2.237*** (0.808)	-0.215 (0.326)	0.050 (0.449)	-0.502* (0.297)	0.372 (0.336)
Constant	0.112 (1.155)	-0.204 (0.823)	-2.306*** (0.619)	-0.249 (0.465)	-2.391*** (0.588)
N	490	1327	1496	1240	549
Wald chi2	172.203	252.545	428.477	391.538	152.787
Prob > chi2	0	0	0	0	0

Note: \*, \*\* and \*\*\* denote significances of coefficients at the 10%, 5% and 1% test-level; heteroscedasticity-robust standard errors (White procedure). Sector 4 was dropped for Portugal in order to ensure convergence of the model.

Table 4b: Multinomial probit model estimates for CO\_ENT\_UNI (2: UNICOOP)  
(ref. cat.: no cooperation)

2: UNICOOP	BE	CH	GE	NO	PT
lnHEPT	0.201*** (0.076)	0.138** (0.061)	0.126*** (0.046)	0.071*** (0.025)	0.059** (0.028)
KCUS	-0.120 (0.222)	-0.229 (0.152)	0.011 (0.143)	0.025 (0.146)	0.030 (0.226)
KSUP	-0.173 (0.216)	-0.154 (0.237)	-0.014 (0.124)	0.236* (0.127)	-0.227 (0.239)
KUNI	1.131*** (0.216)	1.082*** (0.167)	1.466*** (0.128)	1.355*** (0.155)	1.628*** (0.259)
APPR	0.315 (0.228)	0.404*** (0.156)	0.989*** (0.163)	0.471*** (0.147)	0.420* (0.232)
OSKILL	-0.092 (0.209)	0.189 (0.164)	-0.319** (0.126)	-0.200 (0.153)	-0.114 (0.236)
ORISK	0.311 (0.226)	0.213 (0.161)	0.101 (0.138)	0.079 (0.143)	0.183 (0.227)
OFIN	-0.154 (0.226)	0.271 (0.176)	0.230* (0.136)	0.118 (0.149)	0.331 (0.225)
PUBFIN	1.181*** (0.211)	1.465*** (0.235)	1.152*** (0.128)	1.292*** (0.143)	1.064*** (0.257)
GROUP	0.250 (0.261)	0.545*** (0.169)	0.124 (0.141)	0.098 (0.153)	0.894*** (0.255)
FOREIGN	0.293 (0.260)	-0.151 (0.196)	0.143 (0.210)	0.029 (0.169)	-0.424 (0.331)
MARKET_2	0.422 (0.416)	0.432** (0.220)	0.378* (0.201)	0.190 (0.160)	0.360 (0.337)
MARKET_3	0.793* (0.411)	0.690*** (0.206)	0.735*** (0.211)	0.419** (0.182)	0.584 (0.361)
SIZE_2	0.259 (0.255)	-0.024 (0.206)	0.285 (0.178)	0.238 (0.196)	0.623* (0.324)
SIZE_3	0.667** (0.274)	0.556** (0.221)	0.927*** (0.195)	0.745*** (0.153)	1.022*** (0.327)
SECTOR_2	-1.779** (0.864)	0.028 (0.426)	-0.510 (0.413)	-0.989*** (0.327)	-0.662* (0.354)
SECTOR_3	-1.999** (0.826)	-0.165 (0.384)	-0.456 (0.364)	-1.023*** (0.317)	-0.283 (0.271)
SECTOR_4	-2.085** (0.824)	-0.261 (0.377)	-0.745** (0.358)	-0.955*** (0.307)	
SECTOR_5	-2.667*** (0.859)	-0.275 (0.420)	-0.806** (0.387)	-1.006*** (0.325)	-0.682 (0.446)
SECTOR_6	-2.497*** (0.870)	-0.437 (0.422)	-0.386 (0.370)	-1.054*** (0.316)	-0.412 (0.386)
Constant	2.080 (1.435)	-1.110 (0.930)	-1.427* (0.751)	-0.493 (0.515)	-2.352*** (0.695)
N	490	1327	1496	1240	549
Wald chi2	172.203	252.545	428.477	391.538	152.787
Prob > chi2	0	0	0	0	0

Note: \*, \*\* and \*\*\* denote significances of coefficients at the 10%, 5% and 1% test-level; heteroscedasticity-robust standard errors (White procedure). Sector 4 was not included for Portugal to ensure convergence of the model.



Table 5: Tobit estimates for LNEWS including ENTCOOP and UNICOOP

	_BE	CH	GE	NO	PT
ENTCOOP	-0.126 (0.243)	-0.101 (0.116)	0.283** (0.142)	0.188* (0.096)	0.448 (0.339)
UNICOOP	0.141 (0.162)	0.135 (0.101)	0.416*** (0.098)	0.210** (0.097)	5.844** (2.537)
lnINVPT	-0.009 (0.031)	0.078 (0.062)	-0.022 (0.031)	-0.022 (0.015)	-0.216*** (0.078)
lnFEPT	0.152*** (0.042)	0.143*** (0.029)	0.098*** (0.029)	0.039*** (0.010)	0.170* (0.089)
lnHEPT	0.037 (0.030)	0.069** (0.029)	0.055*** (0.021)	0.058*** (0.016)	0.037 (0.031)
FOREIGN	0.006 (0.157)	0.076 (0.100)	-0.134 (0.139)	0.067 (0.106)	0.625** (0.271)
SIZE_2	0.452*** (0.171)	-0.190** (0.086)	-0.063 (0.117)	-0.173 (0.118)	-0.237 (0.424)
SIZE_3	0.590*** (0.191)	-0.348*** (0.112)	0.211* (0.111)	-0.436*** (0.092)	-0.947 (0.619)
SECTOR_2	0.902 (0.793)	1.145*** (0.289)	0.782* (0.403)	1.175*** (0.248)	0.210 (0.398)
SECTOR_3	1.077 (0.771)	0.792*** (0.285)	0.760** (0.377)	0.919*** (0.249)	-0.368 (0.298)
SECTOR_4	1.612** (0.771)	1.146*** (0.277)	1.054*** (0.374)	1.703*** (0.240)	
SECTOR_5	1.624** (0.780)	1.020*** (0.293)	0.575 (0.380)	1.047*** (0.255)	0.371 (0.563)
SECTOR_6	2.022** (0.789)	0.794*** (0.307)	0.899** (0.376)	1.445*** (0.242)	0.114 (0.355)
Constant	1.178 (0.924)	3.934*** (0.491)	2.436*** (0.482)	2.132*** (0.337)	1.373** (0.681)
N	707	923	1615	1396	480
F-Test	6.426	7.696	8.584	14.94	34.189
Prob > F	0	0	0	0	0.001
Pseudo R2	0.032	0.042	0.019	0.044	0.018
Left-censored	181	55	295	200	160

*Note:* Instrumented UNICOOP variable for Portugal (see Table A.8b in the appendix); \*, \*\* and \*\*\* denote coefficients significant at the 10%, 5% and 1% test-level; heteroscedasticity-robust standard errors (White procedure).

Table 6: Cooperation equations; summary results

	BE	CH	GE	NO	PT	BE	CH	GE	NO	PT
	National cooperation					International cooperation				
Absorptive capacity (InHEPT)	ns	+	Ns	+	ns	Ns	ns	ns	+	ns
Incoming spillovers (KUNI)	+	+	+	+	+	+	+	+	+	+
Appropriability (APPR))	ns	ns	+	ns	ns	+	+	+	+	+
Risk-sharing (ORISK)	ns	ns	Ns	ns	ns	+	+	ns	ns	+
Cost-sharing (OFIN)	ns	ns	Ns	ns	ns	Ns	ns	+	ns	ns
	Cooperation with enterprises					Cooperation with universities				
Absorptive capacity (InHEPT)	ns	+	Ns	+	ns	+	+	+	+	+
Incoming spillovers (KUNI)	ns	-	-	ns	ns	+	+	+	+	+
Incoming spillovers (KSUP)	ns	ns	+	+	+	Ns	ns	ns	+	ns
Appropriability (APPR))	+	ns	+	ns	+	Ns	+	+	+	+
Risk-sharing (ORISK)	ns	+	Ns	ns	+	Ns	ns	ns	ns	ns
Cost-sharing (OFIN)	ns	ns	Ns	ns	ns	Ns	ns	+	ns	ns

Note: + / -: positive /negative coefficient, statistically significant at least at the 10% test-level; ns: statistically insignificant at the 10% test level.

Table 7: Innovation equations; summary results

	BE	CH	GE	NO	PT
National cooperation	-	ns	+	ns	ns
International cooperation	+	ns	Ns	+	+
Cooperation with enterprises	ns	ns	+	+	ns
Cooperation with universities	ns	ns	+	+	+

Note: + / -: positive /negative coefficient, statistically significant at least at the 10% test-level; ns: statistically insignificant at the 10% test level.

## Appendix

Table A1a: Composition of the dataset by sector

Sector	BE		CH		GE		NO		PT	
	N	%	N	%	N	%	N	%	N	%
Industries										
mining, construction and energy	8	1.07	80	5.85	35	2.10	85	6.01	20	2.53
consumer	75	10.05	116	8.48	108	6.48	164	11.59	150	18.96
intermediate	192	25.74	280	20.47	353	21.19	246	17.39	191	24.15
investment	209	28.02	507	37.06	570	34.21	396	27.99	194	24.53
traditional services	123	16.49	217	15.86	235	14.11	176	12.44	120	15.17
knowledge-based services	139	18.63	168	12.28	365	21.91	348	24.59	116	14.66
Number of innovating firms	746	100.00	1368	100.00	1666	100.00	1415	100.00	791	100.00

*Note:* The sector definitions refer to the following 2-digit NACE codes: mining, construction, energy (10-14 and 40-41); consumer goods (SECTOR\_2; 15-19), intermediate goods (SECTOR\_3; 20-27); investment goods (SECTOR\_4; 28-37); traditional services (excluding hotels and restaurants) (SECTOR\_5; 50-52; 60-64); knowledge-based services (65-67; 72-74).

Table A1b: Composition of the dataset by firm size

Firm Size	BE		CH		GE		NO		PT	
	N	%	N	%	N	%	N	%	N	%
Small	312	41.82	543	39.69	522	31.33	602	42.54	265	33.50
Medium	252	33.78	567	41.45	548	32.89	274	19.36	252	31.86
Large	182	24.40	258	18.86	596	35.77	539	38.09	274	34.64
Number of innovating firms	746	100.00	1368	100.00	1666	100.00	1415	100.00	791	100.00

Table A1c: Composition of the sample by type of innovation cooperation

Type of Cooperation	BE		CH		GE		NO		PT	
	N	%	N	%	N	%	N	%	N	%
No coop	516	69.17	1091	79.75	1189	71.37	761	53.78	576	72.82
National coop	58	7.77	81	5.92	270	16.21	288	20.35	100	12.64
International coop	172	23.06	196	14.33	207	12.42	366	25.87	115	14.54
Total	746	100.00	1368	100.00	1666	100.00	1415	100.00	791	100.00

Table A1d: Composition of the sample by partner of innovation cooperation

Cooperation Partner	BE		CH		GE		NO		PT	
	N	%	N	%	N	%	N	%	N	%
No coop	516	69.17	1091	79.75	1189	71.37	761	53.78	576	72.82
Enterprise coop	73	9.79	132	9.65	142	8.52	304	21.48	93	11.76
University coop	157	21.05	145	10.60	335	20.11	350	24.73	122	15.42
Total	746	100.00	1368	100.00	1666	100.00	1415	100.00	791	100.00

Table A.2: Summary statistics

Country	Variable	N	Mean	Std. Dev	Min	Max
Belgium	NATCOOP	746	0.08	0.27	0.00	1.00
Switzerland	NATCOOP	1368	0.06	0.24	0.00	1.00
Germany	NATCOOP	1666	0.16	0.37	0.00	1.00
Norway	NATCOOP	1415	0.20	0.40	0.00	1.00
Portugal	NATCOOP	791	0.13	0.33	0.00	1.00
Belgium	INTCOOP	746	0.23	0.42	0.00	1.00
Switzerland	INTCOOP	1368	0.14	0.35	0.00	1.00
Germany	INTCOOP	1666	0.12	0.33	0.00	1.00
Norway	INTCOOP	1415	0.26	0.44	0.00	1.00
Portugal	INTCOOP	791	0.15	0.35	0.00	1.00
Belgium	ENTCOOP	746	0.10	0.30	0.00	1.00
Switzerland	ENTCOOP	1368	0.10	0.30	0.00	1.00
Germany	ENTCOOP	1666	0.09	0.28	0.00	1.00
Norway	ENTCOOP	1415	0.21	0.41	0.00	1.00
Portugal	ENTCOOP	791	0.12	0.32	0.00	1.00
Belgium	UNICOOP	746	0.21	0.41	0.00	1.00
Switzerland	UNICOOP	1368	0.11	0.31	0.00	1.00
Germany	UNICOOP	1666	0.20	0.40	0.00	1.00
Norway	UNICOOP	1415	0.25	0.43	0.00	1.00
Portugal	UNICOOP	791	0.15	0.36	0.00	1.00
Belgium	InHEPT	743	-14.50	2.88	-25.08	-10.31
Switzerland	InHEPT	1368	-9.79	1.63	-15.01	-5.84
Germany	InHEPT	1665	-14.29	2.55	-25.08	-8.41
Norway	InHEPT	1406	-14.16	2.99	-25.08	-5.18
Portugal	InHEPT	709	-15.28	3.89	-25.08	-9.68
Belgium	KCUS	729	0.62	0.49	0.00	1.00
Switzerland	KCUS	1368	0.51	0.50	0.00	1.00
Germany	KCUS	1596	0.69	0.46	0.00	1.00
Norway	KCUS	1413	0.71	0.45	0.00	1.00
Portugal	KCUS	782	0.52	0.50	0.00	1.00
Belgium	KSUP	729	0.65	0.48	0.00	1.00
Switzerland	KSUP	1368	0.13	0.33	0.00	1.00
Germany	KSUP	1596	0.51	0.50	0.00	1.00
Norway	KSUP	1413	0.58	0.49	0.00	1.00
Portugal	KSUP	782	0.68	0.47	0.00	1.00
Belgium	KUNI	729	0.24	0.43	0.00	1.00
Switzerland	KUNI	1368	0.22	0.41	0.00	1.00
Germany	KUNI	1596	0.28	0.45	0.00	1.00
Norway	KUNI	1413	0.19	0.39	0.00	1.00
Portugal	KUNI	782	0.15	0.35	0.00	1.00
Belgium	APPR	746	0.59	0.49	0.00	1.00
Switzerland	APPR	1368	0.41	0.48	0.00	1.00
Germany	APPR	1666	0.66	0.47	0.00	1.00
Norway	APPR	1415	0.66	0.47	0.00	1.00
Portugal	APPR	791	0.47	0.50	0.00	1.00
Belgium	OSKILL	504	0.45	0.50	0.00	1.00
Switzerland	OSKILL	1368	0.28	0.45	0.00	1.00
Germany	OSKILL	1541	0.55	0.50	0.00	1.00
Norway	OSKILL	1255	0.25	0.44	0.00	1.00
Portugal	OSKILL	622	0.46	0.50	0.00	1.00
Country	Variable	N	Mean	Std. Dev	Min	Max
Belgium	OFIN	506	0.32	0.47	0.00	1.00
Switzerland	OFIN	1368	0.24	0.43	0.00	1.00
Germany	OFIN	1542	0.47	0.50	0.00	1.00
Norway	OFIN	1255	0.34	0.47	0.00	1.00
Portugal	OFIN	621	0.50	0.50	0.00	1.00

Table A.2: Summary statistics (continued)

Belgium	ORISK	507	0.28	0.45	0.00	1.00
Switzerland	ORISK	1368	0.32	0.47	0.00	1.00
Germany	ORISK	1542	0.62	0.48	0.00	1.00
Norway	ORISK	1255	0.48	0.50	0.00	1.00
Portugal	ORISK	624	0.50	0.50	0.00	1.00
Belgium	PUBFIN	741	0.28	0.45	0.00	1.00
Switzerland	PUBFIN	1360	0.06	0.24	0.00	1.00
Germany	PUBFIN	1610	0.30	0.46	0.00	1.00
Norway	PUBFIN	1407	0.25	0.43	0.00	1.00
Portugal	PUBFIN	784	0.16	0.37	0.00	1.00
Belgium	GROUP	746	0.62	0.49	0.00	1.00
Switzerland	GROUP	1353	0.46	0.50	0.00	1.00
Germany	GROUP	1666	0.43	0.50	0.00	1.00
Norway	GROUP	1415	0.68	0.47	0.00	1.00
Portugal	GROUP	791	0.41	0.49	0.00	1.00
Belgium	FOREIGN	746	0.36	0.48	0.00	1.00
Switzerland	FOREIGN	1350	0.16	0.37	0.00	1.00
Germany	FOREIGN	1666	0.10	0.29	0.00	1.00
Norway	FOREIGN	1415	0.17	0.38	0.00	1.00
Portugal	FOREIGN	791	0.14	0.34	0.00	1.00
Belgium	lnLNEWS	746	2.06	1.45	0.00	4.61
Switzerland	lnLNEWS	1368	2.96	1.23	0.00	4.61
Germany	lnLNEWS	1665	2.47	1.42	0.00	4.61
Norway	lnLNEWS	1415	2.46	1.35	0.00	4.61
Portugal	lnLNEWS	789	1.90	1.63	0.00	4.61
Belgium	lnINVPT	738	-3.88	2.38	-13.83	1.44
Switzerland	lnINVPT	1294	-1.12	0.81	-6.62	2.38
Germany	lnINVPT	1660	-3.38	1.64	-13.83	1.87
Norway	lnINVPT	1403	-3.98	2.65	-13.83	6.21
Portugal	lnINVPT	706	-2.87	1.54	-13.83	1.52
Belgium	lnFEPT	7.14E+02	-4.18	2.52	-20.40	0.80
Switzerland	lnFEPT	983	-4.36	1.50	-10.95	-0.93
Germany	lnFEPT	1.62E+03	-3.93	2.07	-20.40	2.32
Norway	lnFEPT	1399	-4.80	4.75	-20.40	8.12
Portugal	lnFEPT	7.50E+02	-4.02	2.22	-20.40	0.98

Table A.3: Correlation matrix; cooperation equation

Pooled	lnHEPT	KCUS	KSUP	KUNI	APPR	OSKILL	ORISK	OFIN	PUBFIN	GROUP
lnHEPT	1.00									
KCUS	0.09	1.00								
KSUP	-0.05	0.10	1.00							
KUNI	0.13	0.09	0.04	1.00						
APPR	0.06	0.07	0.01	0.13	1.00					
OSKILL	-0.03	0.11	0.09	0.06	0.15	1				
ORISK	0.03	0.14	0.11	0.11	0.67	0.201	1			
OFIN	0.04	0.10	0.08	0.09	0.12	0.181	0.333	1.00		
PUBFIN	0.10	0.08	0.08	0.20	0.10	0.0311	0.1141	0.14	1.00	
GROUP	0.09	0.05	0.00	0.07	0.05	-0.023	-0.014	-0.13	0.00	1.00
FOREIGN	0.03	0.03	-0.04	0.03	0.04	-0.025	-0.061	-0.11	-0.05	0.40

Table A.3: Correlation matrix; cooperation equation (continued)

BE	InHEPT	KCUS	KSUP	KUNI	APPR	OSKILL	ORISK	OFIN	PUBFIN	GROUP
InHEPT	1.00									
KCUS	0.11	1.00								
KSUP	0.02	0.04	1.00							
KUNI	0.12	0.08	0.05	1.00						
APPR	0.20	0.17	0.03	0.20	1.00					
OSKILL	0.00	0.09	0.10	-0.06	0.02	1				
ORISK	-0.02	0.12	0.04	0.06	0.02	0.0954	1			
OFIN	0.03	0.11	0.05	0.08	0.10	0.1595	0.2753	1.00		
PUBFIN	0.08	0.01	0.08	0.27	0.16	-0.003	0.1047	0.03	1.00	
GROUP	0.09	0.03	0.01	0.02	0.16	-0.069	-0.024	-0.09	-0.05	1.00
FOREIGN	0.03	0.03	-0.08	0.01	0.05	-0.147	-0.024	-0.08	-0.12	0.58
CH	InHEPT	KCUS	KSUP	KUNI	APPR	OSKILL	ORISK	OFIN	PUBFIN	GROUP
InHEPT	1.00									
KCUS	0.07	1.00								
KSUP	-0.04	0.08	1.00							
KUNI	0.18	0.09	0.04	1.00						
APPR	0.09	0.09	-0.05	0.23	1.00					
OSKILL	0.07	0.15	0.03	0.11	0.09	1				
ORISK	0.08	0.13	0.00	0.17	0.12	0.1788	1			
OFIN	0.01	0.06	0.04	0.04	0.00	0.1641	0.1973	1.00		
PUBFIN	0.08	0.01	-0.04	0.13	0.10	0.018	0.0821	0.06	1.00	
GROUP	0.09	0.10	-0.04	0.11	0.12	0.0177	0.0508	-0.11	0.02	1.00
FOREIGN	0.05	0.09	-0.04	0.12	0.12	0.0074	0.0319	-0.09	0.02	0.34
GE	InHEPT	KCUS	KSUP	KUNI	APPR	OSKILL	ORISK	OFIN	PUBFIN	GROUP
InHEPT	1.00									
KCUS	0.08	1.00								
KSUP	-0.05	0.07	1.00							
KUNI	0.17	0.08	0.10	1.00						
APPR	0.14	0.20	0.03	0.18	1.00					
OSKILL	-0.01	0.11	0.05	0.01	0.06	1				
ORISK	0.06	0.11	0.10	0.11	0.06	0.1411	1			
OFIN	0.12	0.05	0.05	0.09	0.05	0.0639	0.2784	1.00		
PUBFIN	0.18	0.04	-0.02	0.21	0.10	-0.063	0.0585	0.13	1.00	
GROUP	0.00	0.00	-0.01	0.04	0.12	0.0722	0.0166	-0.16	-0.05	1.00
FOREIGN	0.00	0.01	-0.06	-0.01	0.05	0.0673	-0.03	-0.14	-0.07	0.37
NO	InHEPT	KCUS	KSUP	KUNI	APPR	OSKILL	ORISK	OFIN	PUBFIN	GROUP
InHEPT	1.00									
KCUS	0.10	1.00								
KSUP	-0.09	0.03	1.00							
KUNI	0.09	0.09	0.01	1.00						
APPR	0.11	0.20	-0.07	0.15	1.00					
OSKILL	-0.05	0.07	0.02	0.07	0.10	1				
ORISK	0.05	0.12	0.06	0.09	0.17	0.1966	1			
OFIN	0.06	0.14	-0.02	0.14	0.19	0.1885	0.4564	1.00		
PUBFIN	0.07	0.12	-0.02	0.20	0.18	0.0581	0.1239	0.22	1.00	
GROUP	0.11	0.02	-0.02	0.08	0.11	0.0383	-0.023	-0.04	-0.01	1.00
FOREIGN	0.05	0.00	-0.07	0.05	0.09	0.0092	-0.076	-0.06	-0.06	0.32
PT	InHEPT	KCUS	KSUP	KUNI	APPR	OSKILL	ORISK	OFIN	PUBFIN	GROUP
InHEPT	1.00									
KCUS	0.04	1.00								
KSUP	0.01	0.16	1.00							
KUNI	0.10	0.09	0.02	1.00						
APPR	0.14	0.13	-0.01	0.05	1.00					
OSKILL	-0.10	0.10	0.08	0.06	0.04	1				
ORISK	-0.06	0.11	0.10	0.02	-0.01	0.235	1			
OFIN	-0.03	0.11	0.07	0.04	0.00	0.2369	0.2882	1.00		
PUBFIN	0.00	0.04	0.09	0.17	0.05	0.0012	0.0387	0.02	1.00	
GROUP	0.17	0.00	-0.13	0.14	0.12	-0.168	-0.111	-0.17	0.02	1.00
FOREIGN	0.04	0.03	-0.12	-0.05	0.08	-0.109	-0.066	-0.12	-0.02	0.48

Table A.4: Correlation matrix; innovation equation

Pooled	NATCOOP	INTCOOP	ENTCOOP	UNICOOP	lnINVPT	lnFEPT	lnHEPT	PUBFIN
NATCOOP	1							
INTCOOP	-0.1814	1						
ENTCOOP	0.4068	0.3198	1					
UNICOOP	0.351	0.5509	-0.1797	1				
lnINVPT	-0.0427	-0.0142	-0.0264	-0.029	1			
lnFEPT	0.0119	0.1116	-0.0064	0.1253	0.1403	1		
lnHEPT	-0.0092	0.0394	-0.0056	0.0355	0.3135	0.1245	1	
PUBFIN	0.1632	0.1781	-0.0339	0.3466	-0.0194	0.1602	-0.0368	1
FOREIGN	-0.094	0.1602	0.0279	0.0514	-0.0714	-0.049	0.0203	-0.0512
BE	NATCOOP	INTCOOP	ENTCOOP	UNICOOP	lnINVPT	lnFEPT	lnHEPT	PUBFIN
NATCOOP	1							
INTCOOP	-0.1589	1						
ENTCOOP	0.3256	0.3339	1					
UNICOOP	0.2554	0.6855	-0.17	1				
lnINVPT	0.0228	0.0402	-0.0004	0.0569	1			
lnFEPT	-0.0187	0.1727	-0.0175	0.1792	0.1612	1		
lnHEPT	-0.0288	0.108	-0.0383	0.1207	0.0296	0.1787	1	
PUBFIN	0.0985	0.2205	-0.0645	0.3396	0.1244	0.1686	0.0756	1
FOREIGN	-0.0907	0.1373	-0.0003	0.0825	-0.1895	-0.1422	0.0319	-0.1211
CH	NATCOOP	INTCOOP	ENTCOOP	UNICOOP	lnINVPT	lnFEPT	lnHEPT	PUBFIN
NATCOOP	1							
INTCOOP	-0.1026	1						
ENTCOOP	0.453	0.4387	1					
UNICOOP	0.2155	0.6387	-0.1125	1				
lnINVPT	0.0023	-0.0079	-0.0085	0.001	1			
lnFEPT	-0.0098	0.1309	-0.0157	0.1547	0.0758	1		
lnHEPT	0.0754	0.0865	0.0439	0.1141	0.0212	0.2523	1	
PUBFIN	0.0485	0.2274	-0.0045	0.3007	0.0238	0.1167	0.0846	1
FOREIGN	-0.051	0.1076	0.0301	0.0551	-0.0192	0.0485	0.0475	0.0185
GE	NATCOOP	INTCOOP	ENTCOOP	UNICOOP	lnINVPT	lnFEPT	lnHEPT	PUBFIN
NATCOOP	1							
INTCOOP	-0.1657	1						
ENTCOOP	0.4491	0.1587	1					
UNICOOP	0.4702	0.5601	-0.1531	1				
lnINVPT	0.0423	0.0579	0.0181	0.074	1			
lnFEPT	0.0799	0.0893	-0.025	0.1644	0.2258	1		
lnHEPT	0.1104	0.0588	-0.0254	0.1676	0.1086	0.2037	1	
PUBFIN	0.1991	0.1421	-0.0373	0.3263	0.1619	0.2376	0.1809	1
FOREIGN	-0.0328	0.1181	0.0464	0.0347	-0.0455	-0.0127	0.0048	-0.0724
NO	NATCOOP	INTCOOP	ENTCOOP	UNICOOP	lnINVPT	lnFEPT	lnHEPT	PUBFIN
NATCOOP	1							
INTCOOP	-0.2986	1						
ENTCOOP	0.3894	0.2844	1					
UNICOOP	0.2594	0.4656	-0.2999	1				
lnINVPT	0.0008	0.0334	0.0163	0.0191	1			
lnFEPT	-0.0046	0.1683	0.0288	0.1395	0.1118	1		
lnHEPT	0.0601	0.0955	0.0653	0.0908	0.0846	0.2323	1	
PUBFIN	0.1383	0.1803	-0.0593	0.3685	0.039	0.1673	0.0743	1
FOREIGN	-0.1518	0.196	0.0117	0.0462	0.0152	-0.0486	0.0489	-0.0593
PT	NATCOOP	INTCOOP	ENTCOOP	UNICOOP	lnINVPT	lnFEPT	lnHEPT	PUBFIN
NATCOOP	1							
INTCOOP	-0.1569	1						
ENTCOOP	0.369	0.4062	1					
UNICOOP	0.4379	0.4693	-0.1559	1				
lnINVPT	0.0383	-0.0388	-0.0147	0.0105	1			
lnFEPT	0.0473	0.0255	0.0298	0.0419	0.3092	1		
lnHEPT	0.0772	0.0706	0.0311	0.1122	0.0715	-0.0565	1	
PUBFIN	0.1311	0.1506	-0.0233	0.2889	0.1379	0.0937	-0.0022	1
FOREIGN	-0.0848	0.1702	0.0606	0.0341	-0.1638	-0.0573	0.0353	-0.0163

Table A.5a: Instrument equations for NATCOOP; probit estimates

NAT COOP	BE	CH	GE	NO	PT
KCON(1)	-0.598*** (0.221)				-0.544*** (0.192)
OSKILL			-0.142* (0.078)		
OCOST(2)			0.173** (0.088)		
PUBFIN					0.436* (0.246)
I_DIFFKSUP(3)		-0.502* (0.279)	-0.412** (0.198)		
I_DIFFKCON(4)				-0.381** (0.177)	
Constant	-1.119*** (0.149)	0.102 (0.535)	-0.383 (0.303)	0.245 (0.339)	-0.800* (0.484)
N	300	921	1503	998	265
Wald chi2	7.341	21.091	9.954	19.929	18.65
Prob > chi2	0.007	0.007	0.019	0.011	0.028
Pseudo R2	0.047	0.042	0.007	0.021	0.063

*Note:* (1): KCON: a dummy variable that takes the value 1 if a firm reports the values 3 or 4 and the value 0 if a firm reports the values 1 or 2 on a four-point scale (1: 'not relevant'; 4: 'high importance') for assessing the importance of external knowledge from firms of the same group; Switzerland: the dummy takes the value 1 if a firm reports 4 or 5 and the value 0 if a firm reports 1, 2 or 3 on a five-point Likert scale (1; 'not important'; 5: very important'); (2): OCOST: dummy variable constructed as KCON referring to the importance of costs as an innovation obstacle; (3) I\_DIFFKSUP is the industry average of the dummy variable KSUP at 2-digit NACE level; (4): I\_DIFFKCON is the industry average of the dummy variable KCON on a 2-digit NACE level; All equations contain also 2 size dummies and 5 sectoral dummies (Belgium and Germany: without any dummies because none of them was statistically significant). \*, \*\* and \*\*\* denote coefficients significant at the 10%, 5% and 1% test-level; heteroscedasticity-robust standard errors (White procedure) in parentheses.



Table A.5b: Instrument equations for INTCOOP; probit estimates

	BE	CH	GE	NO	PT
INT COOP					
KGOV (1)		0.675*** (0.130)			
KCON				0.461*** (0.085)	0.333* (0.188)
OCOST					
ORISK	0.297* (0.179)				
EXPSHA (2)	0.005** (0.002)				
PUBFIN					0.761*** (0.229)
GROUP			0.193** (0.091)		
I_DIFFKSUP					
Constant	-0.817 (0.634)	-1.648*** (0.323)	-1.719*** (0.267)	-0.839*** (0.194)	-1.899*** (0.625)
N	300	921	1503	998	265
Wald chi2	31.58	56.154	99.621	51.457	32.422
Prob > chi2	0	0	0	0	0
Pseudo R2	0.087	0.064	0.093	0.042	0.118

*Note:* (1): KGOV: a dummy variable that takes the value 1 if a firm reports the values 3 or 4 and the value 0 if a firm reports the values 1 or 2 on a four-point scale (1: 'not relevant': 4: 'high importance') for assessing the importance of external knowledge from public or semi-private research institutions; Switzerland: the dummy takes the value 1 if a firm reports 4 or 5 and the value 0 if a firm reports 1, 2 or 3 on a five-point Likert scale (1; 'not important'; 5: very important'); (2); EXPSHA: export share of sales; All equations contain also 2 size dummies and 5 sectoral dummies. \*, \*\* and \*\*\* denote coefficients significant at the 10%, 5% and 1% test-level; heteroscedasticity-robust standard errors (White procedure) in parentheses.

Table A.6: Endogeneity tests for NATCOOP and INTCOOP; tobit estimates

LNEWS	BE	CH	GE	NO	PT	
RESID_NAT	3.416 (2.675)	1.696 (2.701)	0.763 (1.538)	0.822 (1.769)	-2.031 (1.679)	
RESID_INT	0.253 (1.512)	-0.258 (0.506)	-3.992** (1.804)	-0.129 (0.598)	1.290 (1.125)	
NATCOOP	-3.667 (2.664)	-1.761 (2.701)	-0.381 (1.540)	-0.715 (1.781)	1.937 (1.655)	
INTCOOP	-0.035 (1.476)	0.309 (0.489)	4.503** (1.808)	0.453 (0.596)	-0.694 (1.001)	
lnINVPT	0.002 (0.047)	0.085 (0.059)	-0.029 (0.028)	-0.026 (0.018)	-0.157 (0.128)	
lnFEPT	0.148*** (0.053)	0.141*** (0.028)	0.095*** (0.032)	0.037*** (0.012)	0.261** (0.102)	
lnHEPT	0.021 (0.070)	0.070** (0.029)	0.062*** (0.023)	0.084*** (0.024)	-0.016 (0.045)	
FOREIGN	-0.183 (0.223)	0.065 (0.099)	-0.151 (0.158)	-0.011 (0.113)	0.089 (0.294)	
SIZE_2	0.786*** (0.275)	-0.197** (0.088)	-0.325** (0.166)	-0.391** (0.168)	0.884* (0.473)	
SIZE_3	0.810** (0.388)	-0.387*** (0.143)	-0.757** (0.385)	-0.542*** (0.120)	1.027** (0.511)	
SECTOR_2	0.519 (0.940)	0.902* (0.478)	0.804* (0.418)	1.195*** (0.405)	1.239 (1.032)	
SECTOR_3	0.721 (0.859)	0.495 (0.548)	0.674* (0.387)	0.859* (0.510)	0.954 (0.990)	
SECTOR_4	1.562* (0.868)	0.869 (0.544)	0.921** (0.366)	1.685*** (0.453)	1.430 (1.019)	
SECTOR_5	1.543 (0.960)	0.897** (0.443)	0.688* (0.397)	1.068*** (0.406)	0.962 (1.059)	
SECTOR_6	1.587 (0.975)	0.660 (0.412)	0.866** (0.377)	1.440*** (0.393)	0.851 (1.044)	
Constant	1.346 (1.587)	3.955*** (0.727)	2.503*** (0.539)	2.730*** (0.739)	0.148 (1.358)	
N		300	921	1503	998	265
Prob > F		0	0	0	0	0.045
Pseudo R2		0.045	0.042	0.02	0.058	0.027
Leftcensored		76	54	283	141	69

Table A.7: Marginal effects of multinomial probit estimates for CO\_NAT\_INT (1: NATCOOP; 2: INTCOOP)

NATCOOP	BE	CH	GE	NO	PT
InHEPT	0.002	0.017	0.005	0.004	0.002
KCUS	-0.067	-0.022	-0.031	-0.041	-0.043
KSUP	-0.028	0.025	0.01	0.012	-0.029
KUNI	0.056	0.026	0.121	0.059	0.188
APPR	0.011	0.015	0.084	-0.048	0.019
OSKILL	0.004	0.002	-0.029	-0.052	-0.004
ORISK	-0.033	-0.004	-0.005	0.007	0
OFIN	0.021	-0.003	0.027	-0.026	0.008
PUBFIN	0.077	0.023	0.151	0.199	0.113
GROUP	0.018	0.01	-0.003	-0.005	0.045
FOREIGN	-0.039	-0.032	-0.026	-0.16	-0.114
MARKET_2	-0.032	-0.009	-0.023	-0.038	0.016
MARKET_3	-0.062	-0.034	-0.026	-0.12	0.062
SIZE_2	-0.009	0.009	0.025	0.011	0.028
SIZE_3	0.017	0	0.026	0.06	0.08
SECTOR_2	-0.085	0.002	-0.082	-0.17	-0.128
SECTOR_3	-0.12	-0.029	-0.029	-0.174	-0.134
SECTOR_4	-0.111	-0.032	-0.059	-0.146	-0.114
SECTOR_5	-0.079	-0.015	-0.035	-0.115	-0.065
SECTOR_6	-0.12	-0.024	0.003	-0.116	-0.093
INTCOOP	BE	CH	GE	NO	PT
InHEPT	0.015	0.007	-0.004	0.015	0.004
KCUS	0.033	0.01	0.018	0.11	0.024
KSUP	0.011	-0.004	0.017	0.068	0.074
KUNI	0.147	0.064	0.114	0.174	0.098
APPR	0.085	0.039	0.09	0.148	0.092
OSKILL	-0.001	0.022	-0.012	-0.003	0.011
ORISK	0.104	0.077	0.011	0.006	0.052
OFIN	-0.04	0.014	0.026	0.022	-0.005
PUBFIN	0.174	0.247	0.073	0.085	0.052
GROUP	0.042	0.058	0.021	0.134	0.111
FOREIGN	0.081	0.03	0.065	0.136	0.041
MARKET_2	0.012	0.058	0.042	0.067	0.014
MARKET_3	0.1	0.097	0.106	0.188	0.046
SIZE_2	0.054	-0.018	0.04	-0.006	0.059
SIZE_3	0.154	0.048	0.135	0.035	0.111
SECTOR_2	-0.227	0.076	-0.051	-0.026	-0.083
SECTOR_3	-0.265	0.076	-0.063	-0.031	-0.027
SECTOR_4	-0.304	0.004	-0.075	-0.01	-0.016
SECTOR_5	-0.262	-0.028	-0.045	-0.022	-0.019
SECTOR_6	-0.267	0.001	-0.036	-0.07	-0.027

Table A.8a: Instrument equations for ENTCOOP; probit estimates

ENTCOOP	BE	CH	GE	NO	PT
EXPSHA	-0.005** (0.002)				0.005*** (0.002)
ORISK		0.246** (0.109)			
I_DIFFKCON <sup>(1)</sup>				0.296* (0.173)	
I_DIFFOORG <sup>(2)</sup>			0.570** (0.231)		
Constant	0.093 (0.562)	-0.780*** (0.247)	-2.000*** (0.273)	-0.888*** (0.337)	-1.836*** (0.209)
N	480	923	1503	998	480
Wald chi2	19.255	24.14	6.095	13.572	27.793
Prob > chi2	0.014	0.002	0.014	0.094	0
Pseudo R2	0.054	0.036	0.006	0.012	0.081

*Note:* (1): ORISK: a dummy variable that takes the value 1 if a firm reports the values 3 or 4 and the value 0 if a firm reports the values 1 or 2 on a four-point scale (1: 'not relevant'; 4: 'high importance') for assessing the importance of risks as an innovation obstacle; Switzerland: the dummy takes the value 1 if a firm reports 4 or 5 and the value 0 if a firm reports 1, 2 or 3 on a five-point Likert scale (1; 'not important'; 5: very important'); (2): I\_DIFFOORG<sup>(1)</sup>: I\_DIFFOORG is the industry average of the dummy variable OORG at 2 digit NACE level where OORG is a dummy variable that is constructed as ORISK referring to the importance of organisation as an innovation obstacle; All equations contain also 2 size dummies and 5 sectoral dummies (Germany: without any dummies because none of them was statistically significant; Portugal: no dummy for Sector 4 because not used in first stage regression). \*, \*\* and \*\*\* denote coefficients significant at the 10%, 5% and 1% test-level; heteroscedasticity-robust standard errors (White procedure) in parantheseses.

Table A.8b: Instrument equations for UNICOOP; probit estimates

UNICOOP	BE	CH	GE	NO	PT
KGOV		0.801*** (0.133)			
KCON				0.178** (0.088)	
OCOST					
OORG	-0.407** (0.176)				
ORISK			0.210*** (0.079)		
OFIN					0.239* (0.144)
Constant	-1.168* (0.625)	-1.781*** (0.334)	-1.196*** (0.241)	-0.643*** (0.186)	-1.565*** (0.215)
N	480	923	1503	998	480
Wald chi2	42.959	69.716	82.73	54.093	35.596
Prob > chi	0	0	0	0	0
Pseudo R2	0.078	0.094	0.056	0.05	0.087

*Note:* All equations contain also 2 size dummies and 5 sectoral dummies (Portugal: no dummy for Sector 4 because not used in first stage regression). \*, \*\* and \*\*\* denote coefficients significant at the 10%, 5% and 1% test-level; heteroscedasticity-robust standard errors (White procedure) in parentheseses.

Table A.9: Endogeneity tests for ENTCOOP and UNICOOP; tobit destimates

LNEWS	BE	CH	GE	NO	PT	
RESID ENT	-0.235 (3.040)	1.760 (1.511)	-2.566 (2.916)	-1.678 (2.099)	1.989 (2.848)	
RESID UNI	-0.906 (1.750)	-0.230 (0.473)	-2.188 (1.409)	-0.398 (1.630)	-4.918* (2.818)	
ENTCOOP	0.209 (3.049)	-1.848 (1.509)	2.885 (2.932)	1.864 (2.091)	-1.358 (2.766)	
UNICOOP	1.067 (1.744)	0.366 (0.450)	2.674* (1.399)	0.690 (1.620)	5.567** (2.824)	
lnINVPT	-0.007 (0.040)	0.077 (0.068)	-0.026 (0.033)	-0.026* (0.015)	-0.206*** (0.078)	
lnFEPT	0.139*** (0.045)	0.144*** (0.030)	0.096*** (0.033)	0.038*** (0.013)	0.164* (0.085)	
lnHEPT	0.023 (0.036)	0.070*** (0.026)	0.060*** (0.022)	0.083*** (0.026)	0.030 (0.036)	
FOREIGN	-0.206 (0.202)	0.076 (0.099)	-0.041 (0.128)	0.017 (0.114)	0.641** (0.286)	
SIZE_2	0.690*** (0.247)	-0.225** (0.097)	-0.205 (0.144)	-0.263 (0.204)	-0.102 (0.469)	
SIZE_3	0.449 (0.550)	-0.466*** (0.174)	-0.350 (0.300)	-0.544* (0.293)	-0.713 (0.719)	
SECTOR_2	1.022 (1.610)	1.111*** (0.281)	0.885** (0.429)	1.520*** (0.371)	0.200 (0.396)	
SECTOR_3	1.195 (1.552)	0.726** (0.295)	0.704* (0.379)	1.297*** (0.383)	-0.420 (0.309)	
SECTOR_4	1.844 (1.552)	0.898*** (0.316)	0.946** (0.391)	2.026*** (0.313)		
SECTOR_5	2.094 (1.401)	0.824*** (0.318)	0.793* (0.444)	1.304*** (0.441)	0.613 (0.687)	
SECTOR_6	2.264 (1.562)	0.672** (0.314)	0.835** (0.376)	1.734*** (0.395)	0.303 (0.475)	
Constant	0.439 (1.890)	4.018*** (0.501)	1.978*** (0.527)	1.749* (0.981)	1.371* (0.823)	
N		480	923	1503	998	480
Prob > F		0	0	0	0	0
Pseudo R2		0.038	0.043	0.02	0.057	0.021
left-censo~		122	55	283	141	160

Table A.10: Marginal effects of multinomial probit estimates for CO\_ENT\_UNI (1: ENTCOOP; 2: UNICOOP)

ENTCOOP	BE	CH	GE	NO	PT
InHEPT	-0.006	0.013	-0.006	0.008	0.001
KCUS	-0.018	0.010	-0.011	0.076	-0.029
KSUP	0.027	0.041	0.037	0.045	0.090
KUNI	-0.079	-0.054	-0.086	-0.139	-0.070
APPR	0.052	0.021	0.044	0.007	0.057
OSKILL	0.025	0.008	0.018	-0.026	0.014
ORISK	0.011	0.064	-0.006	0.007	0.047
OFIN	0.007	-0.013	0.016	-0.052	-0.041
PUBFIN	0.003	0.030	0.000	-0.006	-0.027
GROUP	0.030	0.016	-0.004	0.116	0.032
FOREIGN	-0.033	0.024	0.046	-0.026	-0.005
MARKET_2	-0.064	0.004	-0.035	-0.030	-0.020
MARKET_3	-0.094	0.000	-0.035	-0.039	0.032
SIZE_2	0.000	-0.009	0.019	-0.038	0.014
SIZE_3	0.060	-0.016	0.011	-0.058	0.068
SECTOR_2	-0.107	0.029	-0.061	-0.108	-0.037
SECTOR_3	-0.126	0.017	-0.031	-0.097	-0.022
SECTOR_4	-0.143	-0.058	-0.032	-0.026	
SECTOR_5	-0.081	-0.049	0.008	-0.011	0.113
SECTOR_6	-0.119	-0.019	0.017	-0.046	0.072
UNICOOP	BE	CH	GE	NO	PT
InHEPT	0.038	0.010	0.020	0.011	0.007
KCUS	-0.017	-0.020	0.004	-0.020	0.009
KSUP	-0.039	-0.016	-0.010	0.032	-0.045
KUNI	0.262	0.139	0.299	0.369	0.321
APPR	0.042	0.032	0.122	0.088	0.040
OSKILL	-0.023	0.015	-0.053	-0.031	-0.016
ORISK	0.055	0.010	0.016	0.013	0.013
OFIN	-0.029	0.026	0.031	0.041	0.047
PUBFIN	0.238	0.215	0.203	0.282	0.179
GROUP	0.036	0.044	0.020	-0.018	0.109
FOREIGN	0.064	-0.015	0.012	0.015	-0.043
MARKET_2	0.097	0.041	0.067	0.048	0.046
MARKET_3	0.164	0.063	0.126	0.101	0.071
SIZE_2	0.048	-0.001	0.040	0.063	0.079
SIZE_3	0.112	0.059	0.152	0.174	0.125
SECTOR_2	-0.172	-0.001	-0.053	-0.137	-0.061
SECTOR_3	-0.230	-0.015	-0.056	-0.149	-0.028
SECTOR_4	-0.247	-0.014	-0.096	-0.164	
SECTOR_5	-0.232	-0.015	-0.095	-0.160	-0.075
SECTOR_6	-0.249	-0.028	-0.056	-0.170	-0.052