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Journal Article**Author(s):**

Arvanitis, Spyros; [Bolli, Thomas](#) 

Publication date:

2013-11

Permanent link:

<https://doi.org/10.3929/ethz-b-000073453>

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Originally published in:

Review of Industrial Organization 43(3), <https://doi.org/10.1007/s11151-012-9348-6>

A Comparison of National and International Innovation Cooperation in Five European Countries

Spyros Arvanitis · Thomas Bolli

Published online: 15 March 2012
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Abstract This paper analyses the differences between national and international innovation cooperation in five European countries: Belgium, Germany, Norway, Portugal and Switzerland. We find that absorptive capacity, incoming spillovers, appropriability and risk-sharing are more important in an international context. Furthermore innovation performance is positively influenced by international cooperation, but remains unaffected by national cooperation. Despite the heterogeneity of the investigated countries, we find similar determinants and impacts of innovation cooperation.

Keywords National innovation cooperation · International innovation cooperation · Innovation performance

JEL Classification O30

1 Introduction

This paper analyses the differences between national and international innovation cooperation¹ with respect to their determinants and their impact on innovation performance. The interest in the cooperation behaviour of firms stems from the growing importance of innovation networks and the increasing openness of firm boundaries in the innovation process.

¹ In the text below ‘cooperation’ denotes always ‘innovation cooperation’.

S. Arvanitis (✉)
KOF Swiss Economic Institute, ETH Zurich, 8092 Zurich, Switzerland
e-mail: arvanitis@kof.ethz.ch

T. Bolli
Economics Department, Lancaster University, Lancaster LA1 4YX, UK
e-mail: bolli@alumni.ethz.ch

In order to keep up with the pace of the markets and to remain competitive, it is often no longer sufficient to rely only on in-house innovation, but becomes increasingly important to make the borders of the firms permeable. In particular, the relevance of cooperation with partners from other countries is increasing due to the ongoing globalisation of production and development processes. But while the promotion of international cooperation constitutes an important goal of technology policy especially of the European Union [see, e.g., Vonortas (2000) and Hagedoorn et al. (2000); see also Boardman and Gray (2010)], our understanding of the differences between national and international cooperation agreements with respect to their determinants and their impacts remains incomplete.

This paper attempts to investigate the differences between national and international cooperation. To this end, we analyse the cooperation behaviour of innovative firms in five European countries: Belgium, Germany, Norway, Portugal and Switzerland. This heterogeneous sample of countries varies with respect to size, degree of openness, innovation performance and cultural background. The database consists of Community Innovation Survey (CIS3) data for the EU member states and Norway. For Switzerland the data were collected through a comparable survey.

We investigate cooperation agreements along the dimension of national versus international cooperation. More concretely, in a first step, we analyse the determinants of national and international cooperation by estimating two probit models that use dummy variables that indicate national and international cooperation, respectively. In the second step, we estimate a tobit model that uses the share of sales that are generated by innovative products as dependent variable. The independent variables include dummy variables for exclusive national cooperation and for international cooperation. We address endogeneity using an instrumental variable approach.

The paper extends the existing empirical work concerning innovation cooperation in two ways: First, we complement existing research by specifying separate equations for the determinants of national and international cooperation and their impact on innovation performance. We also account for potential endogeneity of cooperative agreements in the innovation equation. Second, our analysis comprises five European countries, thereby allowing an assessment of the validity of our findings across countries and an analysis of differences between countries.

The set-up of the paper is as follows: In Sect. 2 of the paper the conceptual framework and related empirical literature is presented. The data and some country characteristics are briefly described in Sect. 3. Section 5 presents the model specification and the estimation procedure. In Sect. 5 the empirical results are discussed and Sect. 6 concludes the paper.

2 Conceptual Framework and Literature Review

2.1 Preliminary Remarks

The following discussion of the conceptual framework concerning the determinants of innovation cooperation is based on three literature strands. The industrial organisation

(IO) literature analyses the incentives that are created by incoming and outgoing spillovers [see Kaiser (2002) and De Bondt (1996) for reviews]. The second strand originates from the management literature and discusses potential motives for innovation cooperation [see Caloghirou et al. (2003) for a review]. Third, the regional innovation systems literature focuses on the characteristics of spillovers [Simmie (2004) provides a review]. The final paragraphs of the section discuss the existing literature on the impact of cooperation on innovation output and present our hypotheses.

2.2 Absorptive Capacity and Knowledge Spillovers

An important strand of the IO literature is concerned with endogenous *absorptive capacity*, which is the ability to exploit externally generated knowledge: knowledge that is generated by competitors, suppliers, customers, and/or public research institutions and universities (Cohen and Levinthal 1989, 1990). Firms with well-educated staff and permanent research activities are supposed to have higher absorptive capacity than do firms that lack such characteristics.

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 exploitable external knowledge that flows into the firm. The type of cooperation partner is an important characteristic that can affect the extent of such spillover effects in a cooperative project. In cooperative agreements 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 are also interested in minimizing outgoing spillovers.

Outgoing spillovers measure the amount of a firm’s knowledge that seeps out of the firm and can be utilised by other firms. While incoming spillovers may motivate a firm to seek Research and Development (R&D) cooperation, outgoing spillovers exert the opposite influence: 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., by ensuring property rights through patents) and informal (e.g., secrecy, lead time over competitors, complexity of developed products) *appropriability mechanisms*.

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: to ensure knowledge flows to the firm (incoming spillovers). But the firm also protects its own knowledge base from being exploited by other firms or institutions without paying for it, thus controlling outgoing spillovers, e.g., through various protection mechanisms.

Innovation cooperation, particularly in the form of 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.

[Kamien et al. \(1992\)](#) generalize the framework of [D'Aspremont and Jacquemin \(1988\)](#). Relevant key findings of this paper are that: (a) An increase in spillovers tends to reduce incentives to collaborate in R&D; (b) An increase in market demand leads to an increase of research efforts; (c) An increase of market demand fosters R&D cooperation; and (d) Increased research productivity leads to increased incentives to invest in R&D and also to cooperate.

Using data from the Community Innovation Survey (CIS) for different European countries, [Cassiman and Veugelers \(2002\)](#), [Belderbos et al. \(2004a\)](#), [Bönte and Keilbach \(2005\)](#), [Schmidt \(2005\)](#), [Miotti and Sachwald \(2003\)](#) and [Abramovsky et al. \(2009\)](#) provide empirical evidence that supports the notion that absorptive capacity and the extent of incoming and extent of outgoing spillovers have the expected effects on the likelihood of innovation cooperation. Moreover, analyzing national and international cooperation separately [Faria and Schmidt \(2007\)](#) find little evidence for differences between national and international cooperation with respect to these variables.

2.3 Cost- and Risk-Sharing Motives

The second branch of literature to be taken into consideration is research on the motives of international firm alliances in management economics (see, e.g., [Glaister and Buckley 1996](#)). The most relevant motive in this context is the realisation of synergies by transferring complementary technology. Another motive is to share innovation risks.

However, while [Belderbos et al. \(2004a\)](#) find a positive significant coefficient for a variable that measures innovation risk, the risk-sharing motive appears to be of no relevance in [Cassiman and Veugelers \(2002\)](#), [Bönte and Keilbach \(2005\)](#), [Schmidt \(2005\)](#) and [Miotti and Sachwald \(2003\)](#). A potential explanation could be that the positive effect for international cooperation is disguised by the insignificant effect for national cooperation in empirical estimates that do not distinguish between these two types of cooperation.

Furthermore, [Glaister and Buckley \(1996\)](#) argue that firms might cooperate to share costs and thereby realise economies of scale. The empirical results of [Cassiman and Veugelers \(2002\)](#), [Bönte and Keilbach \(2005\)](#), and [Schmidt \(2005\)](#) support this hypothesis. [Miotti and Sachwald \(2003\)](#) augment the hypothesis arguing that the cost-sharing motive is more important for national than for international cooperation.

Firms might enter innovation cooperation in order to attract governmental funding. Since the acquisition of funding by foreign governments requires specific knowledge about local funding schemes, international cooperation reduces information costs.

Furthermore, there are many funding schemes that require firms to enter an international cooperation agreement (see, e.g., [Czarnitzki and Fier 2003](#)).

A further motive for international cooperation that is discussed in the management economics literature is that spillovers and synergies might be larger in the international context. Potential reasons for larger spillovers could be the likelihood that international partners might be closer to the technological frontier than are national partners ([Miotti and Sachwald 2003](#)) and the necessity of applying location-specific technology (see, e.g., [Li and Zhong 2003](#)).

2.4 The Role of the Regional Dimension

The third literature strand—the economics of regional innovation systems—investigates geographic innovation clusters and the role of technological spillovers in this context (see, e.g., [Leamer and Storper 2001](#); [Sonn and Storper 2008](#)).

An early explanation for the formation of such clusters is that innovation activities require flexible inputs and a high degree of communication that can be achieved only in urban areas ([Vernon 1966](#)). The existence of local spillovers provides an alternative explanation: The transfer of uncodifiable and complex knowledge requires trust and understanding among cooperation partners that can be developed more effectively through face-to-face contacts ([Simmie 2004](#); [Storper and Venables 2004](#)).

The findings of [Lindelöf and Löfsten \(2004\)](#) support the relevance of informal contacts for university–industry linkages. Furthermore, [Aldieri and Cincera \(2009\)](#) as well as [Bottanzi and Peri \(2003\)](#) provide empirical evidence for the local nature of spillovers: Regional but not interregional spillovers show a positive impact on productivity growth.

The general impression from this literature is that incoming spillovers are more important for intra-regional (national) than inter-regional (international) cooperation. The implications with respect to outgoing spillovers and hence appropriability are ambiguous: While outgoing spillovers appear to be larger in the national context, trust might provide an alternative mechanism to secrecy and/or legal protection thus raising knowledge appropriability for a given level of outgoing spillovers. Since trust is harder to achieve in the international context, appropriability that is based on legal protection and/or secrecy might be more important in the international context despite the smaller magnitude of outgoing spillovers.

However, [Waxell and Malmberg \(2007\)](#) observe that while the Uppsala biotech cluster is locally anchored, it has strong links to the world as well. [Bathelt et al. \(2003\)](#) see these interregional connections as network pipelines that mitigate the lock-in effect that may be created by high levels of geographic concentration (see, e.g., [Boschma 2005](#)). Such pipelines work through functional proximity rather than geographic proximity ([Cooke 2006](#)). Similarly, [Morgan \(1997\)](#), [Hart and Simmie \(1997\)](#), and [Wolfe and Gertler \(2004\)](#) stress the relevance of interregional and international pipelines for innovation.

[Maskell et al. \(2006\)](#) add a further aspect to this perspective by pointing out the relevance of temporary clusters—for example, international professional gatherings—for

the creation of trust that is needed to complement the functional proximity. On the whole, this part of the regional innovation systems literature emphasises in accordance with the management economics literature the relevance of spillovers (and synergies) in the international context.

2.5 The Impact of Cooperation on Innovation Performance

In sum, existing literature seems to provide conflicting views as to the role of spillovers in the national and international context with respect to both the effect on the likelihood of cooperation and the impact on innovation output and productivity.

Empirical evidence is also mixed.² A number of empirical studies have found a positive impact of engaging in innovation cooperation on innovation performance, which is usually measured by the sales share of innovative products [see, e.g., Klomp and van Leeuwen (2001), Lööf and Heshmati (2002); and Belderbos et al. (2004b)]. However, other studies find little evidence for a significant correlation between innovation cooperation and innovation performance (e.g., Kemp et al. 2003; Janz et al. 2003).

Moreover, the existing evidence with respect to the differences between national and international innovation cooperation remains inconclusive as well. Namely, Miotti and Sachwald (2003) show that in France innovation performance is not affected by innovation cooperation agreements with national partners but is positively influenced by cooperation with foreign partners. Similarly, Lööf (2009) finds that the presence of foreign cooperation partners in the network has a positive effect on innovation performance. However, Lööf and Heshmati (2002) find positive effects on innovation for both partner types and Jaklic et al. (2008) find positive effects of national but not of international innovation cooperation for Slovenian firms.

2.6 Research Hypotheses

Based on the literature discussed above, we formulate the following hypotheses:

Hypothesis 1 Absorptive capacity exerts a positive influence on the likelihood of cooperation.

Hypothesis 2 Incoming spillovers exert a positive influence on the likelihood of cooperation.

Hypothesis 3 Appropriability exerts a positive influence on the likelihood of cooperation.

Given the existing theoretical and empirical literature we have no specific a priori expectations as to the effects of absorptive capacity and incoming and outgoing

² Nevertheless, subjective measures of cooperation performance obtained from a broad survey of European countries (Caloghirou and Vonortas 2000) showed a wide spectrum of expected benefits, primarily from international research joint ventures: acquisition and/or creation of new knowledge, development of new products, improvement of the technological capabilities of participating firm, etc. (see also Caloghirou et al. 2003).

Table 1 Population size, sample size and response rate by country

Country	Firms in population	Firms in sample	Response rate in %	Observations used in estimations
Belgium	13,827	4,482	47	428
Switzerland	56,722	6,000	40	980
Germany	117,979	13,642	21	1,314
Norway	9,316	3,796	96	1,068
Portugal	23,816	4,097	<i>na</i>	460

Source: Lucking (2004)

spillovers *separately* for national and international cooperation. It is expected that the empirical comparative analysis would cast more light on this issue.

Hypothesis 4 Innovation risks exert a positive influence on the likelihood of cooperation.

Hypothesis 4a Innovation risks as a determinant of the likelihood of cooperation are more important for international than for national cooperation.

Hypothesis 5 Financial constraints exert a positive influence on the likelihood of cooperation

Hypothesis 5a Financial constraints as a determinant of the likelihood of cooperation are more important for national than international cooperation

According to the theoretical arguments and existing empirical evidence the effect of innovation cooperation on innovation performance is not a priori clear.

3 Data Description

The data for Belgium, Germany, Norway, and Portugal were collected in the course of the Third Community Innovation Survey (CIS3), which covered the period 1998–2000 and were available as micro-aggregated data in the form that is usually provided by Eurostat. The questionnaire that was used was based on the Oslo manual (OECD 1997). Sample reliability of the CIS data is ensured by the sampling procedure that is described in Eurostat (2001). The Swiss data are from the Swiss Innovation Survey 2002, which covered the period 2000–2002 and referred to R&D-active firms. The underlying questionnaire was also based on the Oslo manual [see Arvanitis and Hollenstein (2004) for the sample construction].³

Table 1 provides information on the number of firms in the population and the sample as well as the response rates and the number of observations without missing values due to item-non-response for each country. Response rates vary between

³ 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.

Table 2 Composition of the sample by sector, firm size and type of innovation cooperation

	BE		CH		DE		NO		PT	
	N	%	N	%	N	%	N	%	N	%
By sector:										
Mining, construction and energy	5	1	61	6	30	2	60	6	10	2
Consumer goods	42	10	63	6	94	7	139	13	91	20
Intermediate goods	111	26	193	20	299	23	199	19	123	27
Investment goods	129	30	415	42	503	38	333	31	134	29
Traditional services	61	14	130	13	190	14	132	12	62	13
Knowledge-based services	80	19	118	12	198	15	205	19	40	9
By firm size in employees:										
Small (10–49)	180	42	386	39	431	33	469	44	152	33
Medium (50–249)	148	35	415	42	458	35	195	18	145	32
Large (250 and more)	100	23	179	18	425	32	404	38	163	35
By type of innovation cooperation:										
No cooperation	297	69	789	81	906	69	589	55	343	75
National cooperation	39	9	62	6	227	17	223	21	66	14
National and international cooperation	92	21	129	13	181	14	256	24	51	11
Total	428	100	980	100	1,314	100	1,068	100	460	100

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 (SECTOR_6; 72–74)

21 % for Germany and 96 % for Norway. For all countries we restrict the sample to firms with 10 and more employees. Furthermore, the data sets contain only innovating firms. Therefore, our inferences refer only to innovating firms. In addition, we eliminate financial intermediaries from our sample as well as observations that indicate an R&D or investment intensity above one. Finally, we drop observations of firms that conduct international but not national innovation cooperation to facilitate the interpretation of our cooperation variables. Table 2 shows the composition of the data sets that are used in this study for all five countries by sector, firm size class and type of innovation cooperation.

Table 3 provide the definitions of the variables that are used in this study. Table 4 contains descriptive statistics of the used variables; and Table 5 shows the correlations between the model variables. Country-specific descriptive statistics and cross-correlations are available upon request.

4 Model Specification and Estimation Procedure

4.1 Specification of the Cooperation Equations

The fact that many firms are engaged at the same time in both types of cooperation leads to the problem of interdependence between national and international cooperation,

Table 3 Definition of the variables of the cooperation equation

Variables	Description
<i>Dependent variables</i>	
<i>First equation</i>	
COOP_NAT_INT	0: no cooperation; 1: <i>only</i> national cooperation; 2: <i>also</i> international cooperation
<i>Second equation</i>	
NEWS	Sales share of new or significantly improved products in %
<i>Independent variables</i>	
<i>Absorptive capacity</i>	
FEPT	Innovation expenditures divided by sales (Switzerland: R&D expenditures)
OSKILL	Dummy variable ^a ; 1: lack of qualified personnel is an important innovation obstacle; 0: otherwise
<i>Incoming spillovers</i>	
SPILLIN	Dummy variable ^b ; 1: high relevance of customers, suppliers of materials and capital goods and universities reflects as innovation-relevant external knowledge resource; 0: otherwise
<i>Appropriability</i>	
APPR	Dummy variable ^c ; 1: any of the following means to protect inventions or innovations were used: patents; design patterns; trademarks; copyright; 0: otherwise
<i>Proxies for risk- and cost sharing</i>	
ORISK	Dummy variable ^a ; 1: risks of innovation projects are an important innovation obstacle; 0: otherwise
OFIN	Dummy variable ^a ; 1: difficulty to access to financial sources is an important innovation obstacle; 0: otherwise
<i>Cooperation variables (for second equation)</i>	
NATCOOP	Dummy variable; 1: firms that have co-operation arrangements with other firms or organisations (only <i>national</i> partners); 0 otherwise
INTCOOP	Dummy variable; 1: firms that have co-operation arrangements with other firms or organisations (also <i>international</i> partners); 0: otherwise
<i>Control variables</i>	
INVPT	Gross investment divided by sales
PUBFIN	Dummy variable for public financial support in the respective reference period
GROUP	Dummy variable; 1: firm is part of an enterprise group; 0: firm is independent
FOREIGN	Dummy variable ^d ; 1: firm with foreign headquarter; 0: otherwise
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
SIZE_2; SIZE_3	Dummy variables; 1: 50 to 249 employees; 0: otherwise and 1: 250 employees and more; 0: otherwise, respectively; reference group: firms with 10–49 employees

which can be addressed econometrically by estimating a multinomial probit model that is based on a dependent variable referring to exclusive groups of firms. To this end, we constructed the nominal variable COOP_NAT_INT (0: no cooperation; 1:

Table 3 continued

Variables	Description
SECTOR_2-SECTOR_7	7 sectoral dummies; see Table 2 for the definitions; reference group: mining, construction, energy

^a 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 Likert 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'); ^b the dummy variable takes the value 1 if the average score of the relevance of customers, suppliers of materials and capital goods and universities as sources of innovation-relevant information is higher than 4; the importance of each single source is measured on four(five)-point Likert scale; ^c for Switzerland, the dummy variable takes the value 1 if a firm reports that the relevance of innovation protection measures takes the value 4 or 5 and 0 otherwise; ^d for Switzerland the dummy variable takes the value 1 if the firm is foreign-owned

Table 4 Summary statistics

Variable	N	Mean	SD	Min	Max
NATCOOP	4,250	0.1451765	0.3523201	0	1
INTCOOP	4,250	0.1668235	0.3728621	0	1
NEWS (%)	4,250	24.54781	25.17792	0	100
FEPT	4,250	0.05945	0.1170298	0	0.989
OSKILL	4,250	0.4011765	0.4901943	0	1
SPILLIN	4,250	0.4136471	0.4925447	0	1
APPR	4,250	0.5990588	0.4901468	0	1
ORISK	4,250	0.4738824	0.4993762	0	1
OFIN	4,250	0.3903529	0.4878868	0	1
INVPT	4,250	0.1446866	0.1903109	0	0.999
PUBFIN	4,250	0.2371765	0.4254014	0	1
GROUP	4,250	0.5124706	0.4999033	0	1
FOREIGN	4,250	0.1517647	0.3588349	0	1
MARKET_2	4,250	0.3682353	0.4823824	0	1
MARKET_3	4,250	0.3783529	0.4850333	0	1

only national cooperation; 2: also international cooperation) that serves as dependent variable for the cooperation equation.

Our model contains variables that measure a firm's knowledge absorptive capacity, the availability of qualified personnel, incoming spillovers, appropriability, the extent of innovation risks, the extent of financial constraints, a series of control variables with respect to capital intensity, public promotion of innovation, affiliation to a group of enterprises, type of market in which a firm operates, firm size and sector affiliation.

We measure absorptive capacity (FEPT) by the innovation expenditures intensity: the ratio of innovation expenditures to sales (for Switzerland: R&D expenditures/sales). Based on hypothesis 1, we expect a positive effect of this variable. We use a variable for lack of qualified personnel (variable OSKILL) as an additional measure that reflects absorptive capacity. For this variable we expect a negative effect.

Table 5 Correlation matrix; cooperation equation

	NATCOOP	INTCOOP	LNEWS	FPT	OSKILL	SPILLIN	APPR	ORISK	OFIN	INVPT	PUBFIN	GROUP	FOREIGN	MARKET2
NATCOOP	1.00													
INTCOOP	-0.18	1.00												
LNEWS	-0.02	0.08	1.00											
FPT	0.05	0.16	0.16	1.00										
OSKILL	-0.02	0.02	0.01	0.01	1.00									
SPILLIN	0.06	0.22	0.05	0.12	0.13	1.00								
APPR	0.06	0.22	0.12	0.15	0.08	0.23	1.00							
ORISK	0.04	0.09	0.02	0.09	0.19	0.18	0.11	1.00						
OFIN	0.04	0.03	0.04	0.13	0.19	0.13	0.08	0.34	1.00					
INVPT	-0.09	-0.02	0.11	0.03	-0.11	-0.18	-0.13	-0.11	-0.10	1.00				
PUBFIN	0.18	0.20	0.03	0.21	0.04	0.18	0.16	0.11	0.13	-0.11	1.00			
GROUP	0.01	0.21	-0.02	-0.03	-0.02	0.09	0.15	-0.01	-0.12	-0.06	0.01	1.00		
FOREIGN	-0.09	0.12	0.00	-0.02	-0.02	0.02	0.08	-0.07	-0.12	-0.01	-0.05	0.38	1.00	
MARKET_2	0.03	-0.06	-0.05	0.00	0.01	0.00	-0.02	0.03	0.05	-0.13	0.04	-0.07	-0.06	1.00
MARKET_3	-0.05	0.19	0.09	0.04	0.07	0.13	0.21	0.04	0.00	0.03	0.07	0.17	0.16	-0.60

The variable serving as a proxy for incoming spillovers (SPILLIN) is based on the average score (on a four-point Likert scale for all countries with the exception of Switzerland, where a five-point scale is used) of the innovation relevance of knowledge from customers, suppliers of material and capital goods and universities (on the whole: four different sources). Following hypothesis 2, we expect a positive effect from this variable, but remain agnostic with respect to the relative effects as to national and international cooperation.

Outgoing spillovers (APPR) are proxied by a dummy variable that is constructed on the basis of information on the availability and use of several legal means (patents, design patterns, trademarks, and copyright) to protect innovation returns. For firms that use such means extensively, we assume that the firms need them in order to protect their knowledge from imitation and improve the appropriability of their innovation revenues. But this kind of measure does not denote in itself much about the effectiveness of these protection means. Unfortunately, measures of the effectiveness of protection are not available in our dataset. If protection is effective, appropriability is warranted and cooperation could not be harmful. If protection is ineffective, low appropriability would be a problem for the firm and cooperation would be avoided. In accordance with hypothesis 3, a positive sign of the variable would be interpreted as support for the validity of the assumption that high appropriability (low level of outgoing spillovers) is present, a negative sign would be a confirmation of the low appropriability assumption (high level of outgoing spillovers).

Further, the management literature considers two additional motives for innovation (R&D) cooperation: sharing of innovation risks, and sharing of innovation investment. As proxies for these two motives we use the variables ORISK, which refers to the importance of innovation risks as an innovation obstacle and OFIN controlling for lack of funds for innovation, respectively. Based on hypotheses 4 and 4a, we expect that high innovation risks are a motivation for cooperation and that this effect is stronger for international than for national cooperation. Furthermore, we expect lack of funds for innovation to be an incentive rather for national than international cooperation as described in the hypotheses 5 and 5a.

Several additional firm characteristics are also taken into account as control variables: the intensity of physical capital (INVPT), measured by the ratio of investment expenditures to sales; 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 would 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, dummy variables for market orientation (local, domestic, international), firm size (10–49, 50–249, 250 and more employees) and sector affiliation are included in the cooperation equations.

Hence, a formal expression of the probability that firm i cooperates with national / international partners is as follows:

$$COOP_NAT_INT_{ij} = \alpha_{0,j} + \alpha_{1,j}FEPT_i + \alpha_{2,j}OSKILL_i + \alpha_{3,j}SPILLIN_i$$

$$\begin{aligned}
& + \alpha_{4,j} APPR_i + \alpha_{5,j} ORISK_i + \alpha_{6,j} OFIN_i \\
& + \alpha_{7,j} INVPT_i + \alpha_{8,j} PUBFIN_i + \alpha_{9,j} GROUP_i \\
& + \alpha_{10,j} FOREIGN_i + controlvariables \\
& + u_{i,j}; (j=1 : onlynational; j=2 : alsointernational).
\end{aligned} \tag{1}$$

4.2 Specification of the Innovation Equation

Our innovation equation is specified on the basis of the resource-based firm concept [see, e.g., Teece (1982) and Teece et al. (1997)]. Innovation performance (NEWS) is measured by the sales share of new and considerably modified products (see Table 3). As independent variables we use proxies for the intensity of innovation expenditures (FEPT), investment intensity (INVPT), and a series of control variables for foreign ownership, firm size and sector affiliation. Finally, we include also the cooperation dummy variables (NATCOOP; INTCOOP).

We expect a positive effect of the two 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 this equation for a firm i is as follows:

$$\begin{aligned}
NEWS_i = & \beta_0 + \beta_1 NATCOOP_i + \beta_2 INTCOOP_i + \beta_3 FEPT_i \\
& + \beta_4 INVPT_i + \beta_5 FOREIGN_i + control\ variables + v_i.
\end{aligned} \tag{2}$$

In this second step, we estimate tobit models for Eq. (2), since NEWS, the dependent variable, was downward censored at 0. Reported standard errors are heteroscedasticity-robust standard errors.

4.3 Endogeneity

Being involved in cooperation activities might not be exogenous to innovation activities. Following Cassiman and Veugelers (2002), we tested the endogeneity of three variables in the cooperation equations (FEPT, SPILLIN, APPR) and the two cooperation variables in the innovation equation (NATCOOP, INTCOOP) according to the following procedure (Rivers and Vuong 1988): Instrument equations were estimated separately for each cooperation variable and each sample. Instrument choice was based on a significant correlation with the endogenous variable and an insignificant coefficient in a regression that includes both endogenous and instrumental variables. The residuals of the first stage equations were inserted in the cooperation equations and in the innovation equations respectively 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. Tables with the estimates of the instrumental equations, the results of the endogeneity tests, and the reduced form estimates are available upon request.

The endogeneity tests for FEPT, SPILLIN, and APPR show that the null hypothesis of exogeneity cannot be rejected. Endogeneity tests for NATCOOP and INTOOP reveal endogeneity for NATCOOP in Germany and Norway, while INTOOP is endogenous in all equations except for Belgium and Portugal. Therefore, we report results based on instrumented variables in these cases. As instruments we used (a) the 2-digit industry means of four variables that measure the importance of the following sources of external knowledge: suppliers (manufacturing; CH; DE); firms belonging to the same group (CH); universities (pooled; manufacturing; services sector); and public research institutions (pooled; NO); (b) the 2-digit industry means of two variables that measure the importance of the following obstacles of innovation: costs of innovation (DE); and lack of market information (services sector); and (c) the 2-digit industry means of the export shares of turnover (NO). All instrument variables fulfilled the conditions for appropriate instruments that are mentioned in the first paragraph of this section.

5 Empirical Results

5.1 Cooperation Propensity

Table 6 summarizes the main results, and Tables 7 and 8 show the estimates of the multinomial probit model for the exclusive categories ‘*only national*’ and ‘*also international*’ innovation cooperation with respect to the reference category (consisting of firms that are *not* engaged in innovation cooperation). In addition to country results, Tables 7 and 8 contain estimates of pooled regressions. Further, we report separate estimates for the pooled manufacturing and the pooled service sector. The estimates at country level are justified by the Chow-type likelihood ratio test, which rejects the pooled model with a p value of 0.001. A further test rejected pooling sectors with a p value of 0.02.

Supporting hypothesis 1, we find that absorptive capacity as measured by intensity of innovation expenditures (FEPT) increases the likelihood of national cooperation except for Portugal (no effect) and Belgium (negative effect). The insignificant marginal effect for pooled manufacturing indicates that the overall positive effect can be traced back mainly to the services sector. The marginal effects become positively significant in all equations that analyse international innovation cooperation with the exception of Portugal. Furthermore, the effect is larger for international than for national cooperation.

The measure for absorptive capacity that is related to human capital (OSKILL) shows the expected negative sign in the regressions of national cooperation, but it is statistically significant only at the more aggregate for the service sector and at the country level only for Norway. Also in this case the expected negative effect is found primarily in the pooled service sector. We found no effect for international cooperation.

Table 6 Cooperation equations; summary results

	NAT										INT									
	Pool	Man	Serv	BE	CH	GE	NO	PT	Pool	Ind	Serv	BE	CH	GE	NO	PT				
	Abs. capacity (FEPT)	+++	ns	+++	---	+++	+	+++	ns	+++	+++	+++	+++	+++	+++	+++	ns			
Incoming spill. (SPILLIN)	+++	+++	ns	ns	ns	+++	-*	ns	+++	+++	+++	+++	+++	+++	+++	+++				
Appropriability (APPR)	+++	+++	ns	ns	ns	+++	ns	ns	+++	+++	+++	+	+++	+++	+++	+++				
Risk-sharing (ORISK)	ns	ns	ns	ns	ns	ns	ns	ns	+++	+++	ns	ns	+++	ns	ns	ns				
Cost-sharing (OFIN)	ns	ns	+++	ns	ns	+	ns	ns	ns	ns	+++	ns	ns	ns	ns	ns				

+/-: positive/negative coefficient, *, **, and *** denote statistically significance at the 10, 5 and 1 % test-level; ns: statistically insignificant at the 10 % test level

Table 7 Multinomial probit model estimates for COOP_NAT_INT = 1 (only national cooperation; ref. cat.: no cooperation)

	Pooled	Manufacturing	Service	BE	CH	GE	NO	PT
FEPT	0.025** (0.046)	-0.037 (0.077)	0.086** (0.062)	-0.677** (0.286)	0.298** (0.178)	0.114* (0.103)	0.091** (0.084)	0.143 (0.177)
OSKILL	-0.023** (0.011)	-0.016 (0.013)	-0.040* (0.022)	-0.014 (0.028)	-0.002 (0.017)	-0.030 (0.020)	-0.047* (0.028)	-0.014 (0.034)
SPILLIN	0.007*** (0.011)	0.012*** (0.013)	-0.009 (0.022)	-0.010 (0.028)	0.006 (0.020)	0.019** (0.021)	-0.012* (0.024)	0.011 (0.032)
APPR	0.017*** (0.012)	0.021*** (0.014)	0.014 (0.022)	0.022 (0.032)	0.012 (0.016)	0.082*** (0.026)	-0.046 (0.026)	0.018 (0.032)
ORISK	-0.004 (0.011)	0.002 (0.013)	-0.024 (0.022)	-0.044 (0.031)	0.005 (0.017)	-0.007 (0.022)	0.015 (0.028)	0.003 (0.033)
OFIN	0.007 (0.012)	-0.004 (0.013)	0.040** (0.022)	0.031 (0.028)	-0.003 (0.018)	0.036* (0.022)	-0.015 (0.029)	-0.012 (0.033)
INVPT	-0.052 (0.040)	-0.034 (0.049)	-0.076 (0.072)	0.037 (0.165)	0.022 (0.034)	-0.013 (0.101)	-0.277** (0.119)	-0.192 (0.117)
PUBFIN	0.118*** (0.011)	0.108*** (0.013)	0.140*** (0.023)	0.097*** (0.028)	0.026 (0.030)	0.126*** (0.020)	0.187*** (0.026)	0.110*** (0.036)
GROUP	0.011*** (0.012)	0.003** (0.014)	0.034* (0.022)	0.001 (0.033)	0.022* (0.015)	0.002 (0.024)	-0.003* (0.027)	0.073*** (0.034)
FOREIGN	-0.085*** (0.018)	-0.077*** (0.021)	-0.113*** (0.034)	-0.036 (0.034)	-0.031 (0.025)	-0.040 (0.040)	-0.144*** (0.038)	-0.207*** (0.065)
MARKET_2	-0.023 (0.014)	-0.007 (0.018)	-0.033 (0.022)	-0.036 (0.038)	-0.031 (0.022)	-0.014 (0.030)	-0.039 (0.028)	0.017 (0.044)
MARKET_3	-0.038 (0.015)	-0.010 (0.019)	-0.118*** (0.030)	-0.060 (0.038)	-0.045* (0.021)	-0.029 (0.031)	-0.093 (0.034)	0.098** (0.049)

Table 7 Continued

	Pooled	Manufacturing	Service	BE	CH	GE	NO	PT
SIZE_2	0.019 (0.014)	0.021 (0.017)	0.007 (0.025)	0.016 (0.033)	0.002 (0.017)	0.020 (0.027)	-0.018 (0.036)	0.054 (0.043)
SIZE_3	0.034*** (0.014)	0.027*** (0.017)	0.039*** (0.026)	0.045* (0.039)	-0.009 (0.022)	0.016*** (0.029)	0.055*** (0.029)	0.086*** (0.043)
SECTOR_2	-0.126*** (0.028)	-0.130*** (0.028)		-0.154** (0.092)	-0.020 (0.036)	-0.106* (0.077)	-0.238*** (0.056)	-0.119 (0.101)
SECTOR_3	-0.118*** (0.026)	-0.122*** (0.026)		-0.185** (0.088)	-0.065* (0.031)	-0.048 (0.070)	-0.231*** (0.057)	-0.119 (0.098)
SECTOR_4	-0.108*** (0.025)	-0.115*** (0.026)		-0.137* (0.089)	-0.062** (0.029)	-0.066 (0.068)	-0.204*** (0.054)	-0.090 (0.096)
SECTOR_5	-0.090*** (0.027)		-0.007 (0.022)	-0.146* (0.090)	-0.060* (0.032)	-0.047 (0.071)	-0.145*** (0.056)	-0.007 (0.100)
SECTOR_6	-0.080*** (0.027)			-0.153* (0.093)	-0.019 (0.031)	-0.036 (0.072)	-0.184*** (0.056)	-0.078 (0.107)
COUN_BE	0.009 (0.027)	0.027 (0.032)	-0.021 (0.051)					
COUN_DE	0.073** (0.021)	0.082* (0.024)	0.052 (0.039)					
COUN_NO	0.102*** (0.021)	0.114*** (0.025)	0.084** (0.040)					
COUN_PT	0.074** (0.023)	0.080** (0.027)	0.060 (0.048)					
Constant	-1.510*** (0.210)	-1.641*** (0.242)	-1.886*** (0.262)	-0.061 (0.886)	-1.774*** (0.351)	-1.967*** (0.423)	-0.124 (0.314)	-1.863*** (0.695)

Table 8 Multinomial probit model estimates for COOP_NAT_INT = 2 (also international cooperation; ref. cat.: no cooperation)

	Pooled	Manufacturing	Service	BE	CH	GE	NO	PT
FEPT	0.269*** (0.042)	0.331*** (0.069)	0.194*** (0.047)	0.537*** (0.146)	0.987*** (0.231)	0.236*** (0.077)	0.308*** (0.081)	-0.102 (0.155)
OSKILL	0.004 (0.011)	0.001 (0.013)	0.013 (0.019)	-0.008 (0.036)	0.033* (0.020)	-0.006 (0.017)	-0.004 (0.025)	-0.008 (0.029)
SPILLIN	0.091*** (0.011)	0.101*** (0.013)	0.074*** (0.018)	0.097*** (0.036)	0.063*** (0.021)	0.070*** (0.018)	0.144*** (0.023)	0.073*** (0.028)
APPR	0.087*** (0.012)	0.098*** (0.015)	0.055*** (0.020)	0.065* (0.041)	0.044** (0.019)	0.085*** (0.026)	0.151*** (0.029)	0.068** (0.030)
ORISK	0.028** (0.011)	0.042*** (0.014)	-0.008 (0.019)	0.047 (0.039)	0.057*** (0.019)	0.008 (0.020)	-0.002 (0.026)	0.034 (0.028)
OFIN	0.009 (0.012)	-0.004 (0.014)	0.035** (0.020)	-0.052 (0.040)	0.029 (0.023)	0.009 (0.019)	0.037 (0.027)	0.005 (0.028)
INVPT	0.035 (0.040)	0.027 (0.051)	0.018 (0.062)	-0.746*** (0.277)	0.022 (0.052)	0.147* (0.079)	-0.049 (0.104)	0.183 (0.104)
PUBFIN	0.094*** (0.011)	0.093*** (0.013)	0.094*** (0.020)	0.147*** (0.033)	0.140*** (0.031)	0.068*** (0.017)	0.070*** (0.025)	0.082*** (0.030)
GROUP	0.078*** (0.012)	0.107*** (0.015)	0.012 (0.020)	0.059 (0.046)	0.057*** (0.022)	0.043** (0.020)	0.130*** (0.029)	0.113*** (0.030)
FOREIGN	0.040 (0.014)	0.051* (0.017)	0.022 (0.026)	0.041 (0.043)	0.008 (0.026)	0.054 (0.027)	0.097* (0.031)	-0.015 (0.040)
MARKET_2	0.050*** (0.016)	0.032 (0.021)	0.065*** (0.022)	0.052 (0.060)	0.021 (0.029)	0.068** (0.032)	0.065* (0.031)	0.013 (0.039)
MARKET_3	0.100*** (0.016)	0.080*** (0.020)	0.126*** (0.024)	0.092 (0.058)	0.061* (0.026)	0.127*** (0.032)	0.131*** (0.032)	0.015 (0.045)

Table 8 continued

	Pooled	Manufacturing	Service	BE	CH	GE	NO	PT
SIZE_2	0.008 (0.014)	-0.011 (0.018)	0.055*** (0.022)	0.025 (0.044)	0.000 (0.024)	0.041* (0.028)	0.017 (0.036)	0.027 (0.040)
SIZE_3	0.083*** (0.014)	0.066*** (0.017)	0.109*** (0.022)	0.091** (0.046)	0.073*** (0.027)	0.147*** (0.029)	0.045*** (0.029)	0.044* (0.040)
SECTOR_2	-0.030** (0.031)	-0.026** (0.032)		-0.160 (0.150)	0.043 (0.059)	-0.063 (0.058)	-0.025* (0.061)	-0.071 (0.089)
SECTOR_3	-0.034** (0.029)	-0.032** (0.030)		-0.149 (0.144)	0.042 (0.052)	-0.097** (0.052)	-0.047** (0.061)	-0.029 (0.085)
SECTOR_4	-0.042*** (0.028)	-0.039** (0.029)		-0.197 (0.146)	0.004 (0.050)	-0.095*** (0.051)	-0.033* (0.058)	-0.020 (0.084)
SECTOR_5	-0.018 (0.030)		0.021 (0.019)	-0.164 (0.148)	-0.015 (0.057)	-0.049 (0.054)	-0.026 (0.062)	-0.030 (0.089)
SECTOR_6	-0.044** (0.030)			-0.159 (0.150)	-0.007 (0.054)	-0.025 (0.054)	-0.124*** (0.064)	-0.058 (0.090)
COUN_BE	-0.046* (0.024)	-0.067** (0.030)	-0.006 (0.041)					
COUN_DE	-0.111*** (0.021)	-0.130*** (0.026)	-0.069 (0.037)					
COUN_NO	-0.022 (0.021)	-0.031 (0.026)	0.003 (0.035)					
COUN_PT	-0.084*** (0.025)	-0.086** (0.030)	-0.073 (0.044)					

Table 8 continued

	Pooled	Manufacturing	Service	BE	CH	GE	NO	PT
Constant	-2.757*** (0.239)	-2.747*** (0.266)	-3.179*** (0.299)	-1.532* (0.925)	-3.363*** (0.443)	-3.727*** (0.465)	-2.607*** (0.405)	-3.189*** (0.824)
N	4,250	3,034	1,216	428	980	1,314	1,068	460
Wald chi2	935.595	717.528	291.739	126.445	158.214	273.265	310.454	114.999
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

** and *** denote significances of marginal effects at the 10, 5 and 1 % test-level; Table reports marginal effects and heteroscedasticity-robust standard errors (White procedure). Testing whether sector/country dummies are jointly significant yields p values below 1 %. A Chow-type likelihood ratio test rejects the pooling of countries and sectors with p values of 0.001 and 0.02, respectively

Thus, there is little support for hypothesis 1 coming from this variable, presumably because of the nature of the proxy used that does not allow a direct measurement of human capital endowment.

These results coincide with the findings of [Woerter \(2011\)](#) 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 hypothesis 2, we find a significantly positive effect of incoming spillovers (SPILLIN) for both national (only pooled manufacturing) and international cooperation (both pooled sectors). At the county level, the effect for national cooperation is significantly positive only for Germany and is negative for Norway, though only marginally significant. For international cooperation, the effect is significantly positive in all equations. Furthermore, the marginal effect is substantially larger for international cooperation, which suggests that incoming spillovers are larger in the international context.

[Faria and Schmidt \(2007\)](#) found no significant effect for their variable that measured overall incoming spillovers for Germany and Portugal. [Abramovsky et al. \(2009\)](#) obtained a positive effect of incoming spillovers (also measured by an overall variable) for Germany after taking into account the endogeneity of this variable.

In accordance with hypothesis 3 and the existing empirical evidence, the variable for appropriability (APPR) generally shows a positive effect on cooperation. However, in the case of national cooperation the variable for appropriability is statistically significant only for the pooled manufacturing sector, for which intellectual property rights are in general more important than for the service sector. At the country level, only the marginal effect for Germany is significantly positive. By contrast, the marginal effects of the appropriability variable for international cooperation are throughout positive and statistically significant.

We interpret the positive sign of this variable as evidence in favour of the assumption of high appropriability (low level of outgoing spillovers) influencing positively the cooperation propensity. This finding is also in accordance with the theoretical expectation that appropriability that is based on legal protection or secrecy etc. is more important for international than national cooperation (see Sect. 2).

The results for Germany and Portugal are in line with the findings of [Faria and Schmidt \(2007\)](#) and those for Germany are also in accordance with [Abramovsky et al. \(2009\)](#). The positive significant effect on national cooperation in Germany might reflect the large size of the domestic economy, which provides firms with more possible sources of innovation-relevant information cooperation partners than do small countries' economies.

As expressed in hypotheses 4 and 4a, 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 the perspective of risk-sharing increases the cooperation propensity of firms, especially for international cooperation. In line with the higher uncertainty in an international environment, we find partial evidence for the presence of this positive effect in the context of international cooperation agreements, as the variable ORISK is significant for manufacturing and for Switzerland.

Miotti and Sachwald (2003), who use a similar variable in their study do not find a strong relationship for France.

Obstacles with respect to the availability of financing (OFIN) serve as a proxy for the cost-sharing motive for cooperation. It does not affect the decision to cooperate significantly. However, we found a significantly positive effect for the pooled service sector both for national and international cooperation. At the country level, only the effect on national cooperation for Germany is significant. Hence, there is no confirmation for hypotheses 5 and 5a.

The positive effect of public finance support (variable PUBFIN) on the propensity to cooperate both nationally and internationally for all countries reflects, even if it cannot be causally interpreted, the common goal of technology policy in most countries to foster cooperation by providing subsidies under the condition of cooperation either with universities or other firms.

In the group of variables that capture the market environment, operating in regional, national or international markets does not make a difference for national cooperation at country level with the exceptions of Switzerland, where firms that operate in international markets show a lower propensity for national cooperation than firms operating in regional markets and Portugal, where the marginal effect is positive. At more aggregate level, we found that service firms with international orientation of their activities in general tend to cooperate less at the national level than other firms. On the contrary, firms operating in international markets show not astonishingly a significantly higher inclination for international cooperation than firms with regional or national action radius.

Furthermore, being a member of an enterprise group (variable GROUP) increases the likelihood of cooperation, both at the national and international level. This effect is stronger for international cooperation. In the regressions for the pooled, the manufacturing and services sample as well as in Norway and Portugal the variable FOREIGN has a significantly negative sign, implying that the propensity to cooperate only at a national level is lower for foreign firms. In Belgium, Switzerland, and Germany there appears to be no difference between domestic and foreign firms with respect to cooperative behaviour. Foreign firms show a higher propensity for international cooperation than do domestic firms. This effect could be found for pooled manufacturing and for Norway at the country level.

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

5.2 Innovation Output

In a second step we analyse the impact of innovation cooperation (instrumented, when appropriate) on the innovation performance of firms by estimating a Tobit model, where the dependent variable is the share of sales that are generated by innovative (new and considerably modified) products. Also in this case a Chow-type likelihood ratio test rejects pooling countries and sectors with p values of 0.000 and 0.008,

Table 9 Innovation equations; summary results

	Pooled	Manuf	Service	BE	CH	GE	NO	PT
National cooperation	ns	ns	ns	ns	ns	ns	ns	ns
International cooperation	+***	+***	+***	ns	+***	+**	+***	+***

Instrumented NATCOOP variable for DE and NO and instrumented ITCOOP variable in all equations except BE and PT; +/−: positive /negative coefficient, *, ** and *** denote statistical significance at the 10, 5 and 1 % test-level; ns: statistically insignificant at the 10 % test level

respectively. The results are summarised in Table 9, and the detailed results are found in Table 10.

The results exhibit no evidence for an effect of the dummy variable for national cooperation (NATCOOP) on innovation performance. International cooperation (INTCOOP), on the other hand, is clearly positively correlated to innovation performance. The coefficients are significantly positive in all regressions with the exception of that for Belgium. There are no discernible differences between the manufacturing and the sector service.

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 is positively affected by 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.

A possible explanation for this difference between national and international cooperation may be given by different motives behind the two types of cooperation. More knowledge-oriented motives (e.g., utilization of technological synergies; access to specialized technology) could be expected to be primarily drivers of international cooperation because the likelihood to find such partners internationally is higher than inside a single country, especially inside a small single country ([Miotti and Sachwald 2003](#)). Moreover, such motives seem to enhance stronger innovation performance than more cost-oriented motives (e.g., saving of R&D costs) that tend to improve overall firm efficiency ([Arvanitis 2008](#)). If knowledge-oriented motives are predominant in international cooperation, then it is not astonishing that the impact of international cooperation on innovation shows to be significantly larger than that of national cooperation.

In accordance with our expectations, the intensity of innovation or R&D expenditures (FEPT) is positively correlated with the share of innovative products. Exceptions are Belgium and Germany, where the coefficient is positive but insignificant.

As to the control variables, we find a counterintuitive negative effect for investment intensity (INVPT) in the regressions for Norway and Portugal that render the effect in the pooled and manufacturing equations negative as well. The variable remains insignificant in the other regressions. This finding might reflect the specific industry structure of Portugal and Norway, where oil refineries, cement production and paper manufacturing are among the major industries; these are industries that are not particularly innovative industries but quite investment-intensive. In four of the five countries (except Germany) foreign firms are as innovative as are domestic firms.

Table 10 Tobit estimates for NEWS including NATCOOP and INTCOOP

DEP: NEWS	Pooled	Manufacturing	Services	BE	CH	GE	NO	PT
NATCOOP	-0.364 (1.148)	0.369 (1.525)	-1.562 (2.145)	-6.088 (3.986)	-2.596 (3.512)	2.814 (2.028)	-0.640 (1.766)	-0.756 (4.830)
INTCOOP	26.001*** (3.442)	28.245*** (3.332)	25.773*** (6.377)	3.035 (2.833)	24.693*** (7.732)	42.663*** (8.369)	22.346*** (4.789)	20.425*** (4.843)
FEPT	23.055*** (5.301)	12.115* (6.840)	29.542*** (7.635)	16.369 (11.448)	67.115*** (29.387)	18.647 (11.431)	24.410*** (7.835)	33.291* (19.242)
INVPT	-7.057** (2.964)	-9.929*** (4.497)	2.136 (5.399)	-2.614 (12.272)	1.002 (4.269)	1.515 (9.304)	-16.574*** (6.922)	-42.144*** (13.925)
FOREIGN	-0.747 (1.192)	-1.421 (1.482)	-0.681 (2.409)	-0.823 (2.949)	3.477 (2.218)	-6.076** (2.778)	-2.509 (2.165)	3.863 (4.863)
SIZE_2	-2.704** (1.135)	-1.826 (1.336)	-5.804*** (2.069)	7.848*** (2.753)	-6.974*** (1.959)	-3.833* (2.037)	-3.517 (2.542)	3.760 (4.396)
SIZE_3	-6.913*** (1.277)	-6.440*** (1.379)	-9.603*** (2.333)	3.588 (3.544)	-11.168*** (2.966)	-9.674*** (2.883)	-7.143*** (1.907)	-0.838 (4.530)
SECTOR_2	6.017** (2.613)	6.219** (2.651)		10.357 (7.506)	6.869 (4.659)	9.290 (6.184)	5.105 (3.754)	-2.834 (17.253)
SECTOR_3	5.460** (2.501)	5.646** (2.478)		16.940** (7.363)	0.357 (4.489)	10.245* (5.702)	3.090 (3.714)	-3.918 (17.254)
SECTOR_4	15.307*** (2.557)	15.397*** (2.450)		25.613*** (7.248)	13.094*** (4.006)	15.795*** (5.663)	15.872*** (3.720)	4.662 (17.047)
SECTOR_5	7.274*** (2.546)			19.036** (7.438)	5.190 (4.253)	6.881 (5.646)	8.762** (3.473)	-4.418 (17.523)

Table 10 Continued

DEP: NEWS	Pooled	Manufacturing	Services	BE	CH	GE	NO	PT
SECTOR_6	16.716*** (2.764)			32.712*** (8.127)	8.184* (4.601)	15.039** (6.008)	20.478*** (4.173)	9.314 (18.045)
COUN_BE	-23.094*** (1.795)	-25.118*** (2.413)	-17.367*** (3.088)					
COUN_DE	-12.342*** (1.410)	-12.702*** (2.058)	-10.259*** (2.735)					
COUN_NO	-14.737*** (1.601)	-17.149*** (2.192)	-8.339*** (2.849)					
COUN_PT	-16.977*** (1.932)	-17.982*** (2.522)	-12.883*** (4.526)					
Constant	21.320*** (2.737)	22.354*** (3.419)	33.686*** (3.022)	-12.789* (7.465)	22.765*** (4.201)	6.226 (5.806)	8.156** (3.829)	11.652 (16.810)
N	4,250	3,034	1,216	428	980	1,314	1,068	460
Wald chi2	539.019	421.772	168.879		131.063	108.301	225.239	
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Left-censored	657	475	182	94	72	236	110	145

Instrumented NATCOOP variable for DE and NO and instrumented INTCOOP variable in all equations except BE and PT; *, **, and *** denote significance at the 10, 5 and 1 % test-level; Table reports marginal effects on the latent variable and bootstrapped standard errors in parentheses. Testing whether sector/country dummies are jointly significant yields *p* values below 1 %. A Chow-type Likelihood ratio test rejects pooling countries and sectors with *p* values of 0.000 and 0.008, respectively

The effect of size is ambiguous, as it is positive in Belgium and negative in Switzerland, Germany and Norway.

6 Summary and Conclusions

Fostering innovation cooperation constitutes an important element of innovation policy around the globe but especially in Europe. In order to select the optimal policy instruments, politicians require information on both the determinants and the impact of different cooperation forms. This paper adds to the literature by providing information about determinants and impact of two major categories of innovation cooperation: national and international cooperation, across 5 European countries. Tables 6 and 9 summarize the results.

With respect to the determinants of innovation cooperation, we find that absorptive capacity, incoming spillovers, and high appropriability foster both national and international cooperation, but the effect is more pronounced for international cooperation. Risk-sharing as a motive of cooperation appears to be weak and primarily for international cooperation. Cost-sharing has no relevance as a cooperation motive. Finally, we find evidence that public support fosters cooperative behaviour, thereby supporting the potential effectiveness of public policy instruments in this respect.

On the whole, despite the structural heterogeneity of the investigated countries, we find similar determinants and impacts of innovation cooperation, although Chow-like likelihood ratio tests indicated that the countries ought not to be pooled for analysis. Greater differences are detected between the pooled manufacturing and the pooled service sector, presumably due to sectoral differences in the nature of innovations.

Our analysis of the impact of innovation cooperation shows that international cooperation exerts a significantly positive effect on innovation performance, while national cooperation remains insignificant. If knowledge-oriented motives are predominant in international cooperation because of the higher likelihood to find technologically high-qualified partners internationally, then it is not astonishing that the impact of international cooperation on innovation shows to be significantly larger than that of national cooperation.

Our results have two main policy implications. First, the engagement in some cooperation projects appears to exert a positive influence on firm innovation output; thus policy instruments that promote innovation cooperation may contribute to an increase of innovation output. Second, the choice of cooperation partner—national or international—matters. Notably, while the effectiveness of policy instruments fostering national cooperation agreements is questionable, instruments that facilitate international cooperation clearly increase innovation output. Potential instruments include fiscal facilitation and/or subsidies that encourage involvement in such projects (see, e.g., [Audretsch et al. 2002](#)).

Acknowledgments This study was financed by the Swiss National Science Foundation SNSF. Comments and suggestions of the participants of the Conference on Neo-Schumpeterian Economics 09, Trest, Czech, June 2009, the General Editor of this Journal and two anonymous referees are gratefully acknowledged.

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