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FOREIGN DIRECT INVESTMENT AND SCIENCE AND TECHNOLOGY INFRASTRUCTURE IN SMALL COUNTRIES: EVIDENCE FROM FINLAND AND THE NETHERLANDS

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Abstract: This study investigates the links between foreign firms and the public Science and Technology (S&T) institutions in Finland and the Netherlands. By estimating models on data from Community Innovation Surveys, we find for the Netherlands that foreign firms reveal a significantly lower probability to co-operate with domestic S&T institutions than domestic firms, which can be expected a priori. In Finland this negative bias is not present due to Finnish innovation policies in which R&D collaboration is an explicit requirement.

If innovating foreign firms in the Netherlands produce innovations based on ideas originating in the firm, they do not co-operate with domestic S&T institutions while in Finland these co-operation schemes do exist. Finnish S&T institutions fit in the R&D strategies of MNEs while S&T institutions in the Netherlands do not.

Key words: Multinational Enterprises, Innovation, R&D collaboration, Science and Technology Institutions
JEL-code: O32

Tiivistelmä: Estimoimme ulkomaisten yritysten ja julkisten tiede- ja teknologiatutkimuslaitosten välisiä yhteyksiä Suomessa ja Hollannissa Euroopan yhteisön innovaatiotutkimus (Community Innovation Survey) -aineistolla. Kuten odotettavissa on, verrattuna kotimaisiin yrityksiin Hollannissa, ulkomaiset yritykset Hollannissa osoittavat selvästi alhaisempaa todennäköisyyttä yhteistyöhön kotimaisten julkisten tiede- ja teknologiatutkimuslaitosten kanssa. Suomessa sitä vastoin tällaista negatiivista vinoumaa ei ole havaittavissa. Löytö viittaa siihen, että Tekesin yhteistyötä edellyttävä tukipolitiikka on selkeästi edesauttanut yhteistyön syntymistä erilaisten toimijoiden välillä.

Yritysten sisäisten yhteyksien toimiessa pääasiallisena idealähteenä innovaatioille Hollannissa toimivien ulkomaisten yritysten innovaatiotoiminnassa, kyseiset yritykset harjoittavat epätodennäköisemmin yhteistyötä paikallisten julkisten tiede- ja teknologiainstituutioiden kanssa. Suomessa, sitä vastoin, tällaisia yhteistyöyhteyksiä on olemassa osoittaen että suomalaiset julkiset tiede- ja teknologialaitokset soveltuvat monikansallisten yritysten T&K strategioiden toteuttamiseen, toisin kuin hollantilaiset julkiset tiede- ja teknologialaitokset.

Asiasanat: Monikansalliset yritykset, Innovaatio, T&K yhteistyö, Tiede- ja teknologia instituutiot

Contents

1. Introduction

A number of recent papers have emphasized the role of governance infrastructure as an important determinant of foreign direct investment (FDI) (Globerman and Shapiro, 1999, 2003). A favorable governance infrastructure includes an effective and transparent legal system, stable public institutions and open markets supporting government policies, which all create opportunities for domestic and foreign investors

For small countries it is of great importance to attract firms that are not footloose. FDI through multinational enterprises (MNEs) affect the domestic economy of small countries much more than large economies in terms of trade flows, employment and knowledge generation. The decision to close a subsidiary in a host country has more impact on the economy of e.g. Finland or the Netherlands than on the United States economy. Governments of small countries should concentrate on creating the relevant economic fundamentals to become attractive for non-footloose MNEs (Blomström and Kokko, 2003). Examples of economic fundamentals are political and macroeconomic stability, high level of real income, large market size and the availability of a good physical and knowledge infrastructure (Globerman and Shapiro, 2003).

Many developed small countries are not strongly different from each other with regard to political macroeconomic stability and the level of real income. Their small domestic market can be considered an impediment for the attraction of non-footloose FDI, but increased market integration (EU, NAFTA) has reduced this barrier. With regard to physical and knowledge infrastructure developed host countries often differ from each other.

In this study we examine a particular part of the governance infrastructure by concentrating on the knowledge infrastructure of two countries, Finland and the Netherlands. The choice for these two countries is motivated because of their small size and differences in innovation policies.[1] In Finland innovation policies are much more concentrated on networking and integrating firms and universities in a national innovation system than in the Netherlands and therefore Finnish innovation policies can be expected to link foreign firms to the domestic S&T institutions, i.e. universities, academic hospitals and public knowledge institutes, much more than in the Netherlands.

The first problem to be investigated is whether or not foreign firms are less or more involved in R&D co-operation with domestic S&T institutions than domestic firms. The second question under examination is whether or not domestic S&T institutions in Finland and the Netherlands are attractive R&D partners for

[1] Although the Netherlands has twice as much inhabitants as Finland, it is still considered a small country in the European Union.

innovating foreign firms, i.e. do domestic S&T institutions supply knowledge that is considered to be of value for innovating foreign firms?

Our results show that in Finland no difference exists between foreign and domestic firms in the probability to co-operate in their research activities with domestic S&T institutes. Finnish innovation policies in which R&D collaboration is an explicit requirement to receive R&D subsidies irrespective whether the firm is of domestic or foreign origin, contribute to this result. The second finding is that foreign firms in Finland are strongly linked to domestic S&T institutions as they consider knowledge supplied by domestic S&T institutions valuable for transforming their own ideas to concrete innovations. In the Netherlands where innovation policies are less demanding on R&D co-operation foreign firms do not consider domestic S&T institutions of value for their innovations originating from their own ideas.

The paper is organized in seven sections. In the next section the benefits of R&D co-operation between firms and S&T institutions for both partners are described. Differences in economic structure and R&D collaboration policies of Finland and the Netherlands are shortly described in section 3. In section 4 a model of the determinants of S&T co-operation is presented. Section 5 describes the data used and section 6 presents the empirical results of the model estimations. The final section reports the conclusions.

2. Benefits from R&D collaboration schemes with S&T institutions

Universities and public R&D institutes' resources and skills are attractive for innovating firms because these are complementary to their own skills and knowledge (Bower, 1993; Santoro and Gopalakrishnan, 2000). S&T institutions have access to and develop fundamental or basic research while firms have practical knowledge of market opportunities for new products and financial resources to finance R&D. The complementarity characteristic of such R&D co-operations is most important for innovating firms because it gives them access to knowledge they are not able to produce themselves economically. The incentive for universities and public R&D institutes arises of increasing pressure of public budget cuts. R&D co-operation with firms allows them to increase their financial means.

A factor of importance is that universities and public R&D institutes produce substantial R&D spillovers and therefore contribute to the goal of maximizing the social return of innovations. S&T-institutions, especially universities are involved in basic R&D, which is estimated to have a high rate of return (Mansfield, 1980; Adams, 1990). Also university patents are more frequently and generally cited than average patents (Henderson et. al, 1998). These spillovers promote growth and increase the development of local industry (Blomström and Kokko, 2003).

Recent research for the US suggests that knowledge spillovers from S&T institutions tend to be more localized than those from industries (Adams, 2001; Keller, 2002). Firms have to move to the vicinity of the S&T institutions in order to benefit from their knowledge spillovers. This is particularly true for foreign firms that tend to have a greater degree of mobility with regard to their corporate research and therefore consider the quality of a country's or region's S&T institutions as an important motive to invest in research capabilities of their overseas affiliates (Cantwell and Iammarino, 2003).

Until the mid 1980s innovation in MNEs took mainly place at the headquarters in the home country. Technological activity located overseas was adaptive and strongly dependent on the centralised knowledge base in the headquarters (Dunning, 1988). From the mid-1980s on internationalisation of R&D through MNEs increased substantially. Foreign subsidiaries started playing an important role in technology generation. As both national and international firms are under continuous pressure to maintain and upgrade their technological know how, the R&D capabilities of host countries have become an important location-specific characteristic (Blomström and Kokko, 2003).

3. Economic structure and R&D collaboration policies in Finland and the Netherlands

Finland and the Netherlands are interesting cases for our research because they are small countries but different from each other with regard to economic structure and innovation policies. In order to get an idea of these differences some data in Table 1 are presented. At first glance it is clear that the part of total investment that originates abroad is higher in the Netherlands than in Finland. In other words, MNEs are more dominantly present in the Netherlands than in Finland.

Table 1. R&D- and MNE data in a comparative setting

	Inward FDI as % of total gross investment averages 1997–2002	High and medium high technology manufactures share in total value added (%), 2000	R&D intensity of domestic manufacturing firms, 2001	R&D-intensity of foreign manufacturing MNEs, 2001
Finland	20.2	11.10	2.89	0.48
Netherlands	46.1	5.98	1.32	0.36
Germany	15.1	11.70	2.19	0.51
UK	28.2	7.29	1.14	0.74
USA	11.2	7.87	2.37	0.40

Sources:
World Investment Report 2003 for "inward FDI as % of total gross investment",
OECD Technology and Industry Scoreboard, 2003 for the other columns.

The economic structure of the Finnish economy as shown in the third column of Table 1 is more oriented to high and medium high technology manufactures than the Dutch economy. The latter reveals a low share of total value added that originates in high-technology sectors, also in comparison with larger economies like Germany, UK and the USA. This is also reflected in the R&D intensity of Dutch domestic firms, which is substantially lower than that of domestic firms in Finland.[2] However, the R&D intensity of foreign MNEs in the Netherlands is not substantially different from that of Finland. This suggests that Finland's relative strong specialization in high technology sectors and Finnish innovation policies may have attracted new types of FDI in high-technology manufacturing sectors, on average foreign firms' R&D investments have not been particularly high (Pajarinen and Ylä-Anttila, 2001).

[2] This latter result is partly dominated by Nokia in the Finnish case, which inflates the domestic firms' R&D intensity (see also Daveri and Silva, 2004).

Both countries are members of the EU, which suggests that their domestic limited market size is not an impediment for attracting foreign MNEs. The geographical position of the Netherlands is more favorable than that of Finland because of the Dutch orientation towards the large German market. Before 1989 the Finnish geographical position was favorable towards the Soviet Union. The collapse of the Soviet Union in 1989 was an important cause of a deep economic crisis in Finland and forces the country to a radical policy change by starting to promote an active innovation policy in which the central element was to strengthen the domestic S&T infrastructure (Castells and Himanen, 2002).

Innovation policies in both countries are differently shaped. Finland acknowledged the importance of a good functioning National Innovation System (NIS) relatively early. Despite the severe economic crisis in the early 1990s, budgetary investments into research and technological development grew strongly throughout the 1990s, aiming at the integration of universities, public research institutes, and all actors in the NIS into a balanced entity permeated with cooperation and spillovers. In 1993 the Finnish government decided that "cooperation of the universities will be increased with other parts of the research system, sectoral research and especially with financiers and conductors of technical research" (Nieminen and Kaukonen, 2001). The National Technology Agency of Finland (TEKES) supports R&D in companies based in Finland and Finnish research institutes and universities. Networking and co-operation within the university system and between universities and industry are very important criteria for funding irrespective whether firms are of domestic or foreign origin (Castells and Himanen, 2002).

The Dutch approach has been concentrated on general innovation policies through financial instruments like tax credits that address firm's production costs. Also national agencies exist – SENTER and SYNTENS – granting technology subsidies to firms. A gradual change took place by the establishment of so-called Top Technological Institutes in 1997. These are institutes in four scientific fields (material science, food science, polymer science and telematics) in which private firms and scientific organizations co-operate on fundamental research that should be made applicable in the longer term. Although networking and R&D collaboration between firms and public knowledge institutions play a role as conditions for some subsidies, it aims not at a fully integrated national innovation system as in Finland (Hjerppe and Kiander, 2004).

4. Data

For further investigation data from the Community Innovation Surveys (CIS) of Finland and the Netherlands are used. In the Finnish case we have the availability of data for the years 1996 and 2000 and in the Dutch situation the years 1996 and 1998 are available.[3] The total number of firms for both years in the Finnish CIS data (210 respectively 159) is lower than in the Dutch data (1544 respectively 988).

If high- and medium-high technology firms have a higher chance to start R&D co-operation with universities and/or public knowledge institutions it is quite likely that in Finland more R&D collaboration schemes with the S&T institutions can be found than in the Netherlands due to the sector structure. An indication of how innovative foreign firms are relative to domestic firms, and how important the foreign firms' R&D collaboration with domestic S&T institutions are, is provided in Table 2.

Table 2 shows R&D collaboration schemes of innovating domestic and foreign firms with domestic S&T institutions in Finland and the Netherlands. Three conclusions can be drawn. First, the share of permanent innovators in the total number of innovators is higher in Finland than in the Netherlands, which goes together with the relative strong specialization of Finland in high-technology production. Second, the number of foreign firms relative to the total number of firms is higher in the Netherlands than in Finland. This is coherent with the conclusion based on Table 1 that MNEs are more dominantly present in the Netherlands than in Finland. Third, in Finland the share of permanent innovators involved in R&D co-operation is twice as high as the Netherlands. Moreover, in Finland the share of R&D co-operation with domestic S&T partners in total R&D co-operations is substantially higher than in the Netherlands as well. This might be the result of Finnish innovation policies in which industry-science co-operation is an essential part.

[3] The Dutch CIS-3 data reporting for the year 2000, reveals a substantial decline in foreign firms. This decline cannot be explained by economic factors and therefore renders the dataset inappropriate for the present study.

Table 2. R&D collaboration of innovation firms with domestic S&T institutions: numbers and percentages for Finland (panel 1996–2000) and the Netherlands (panel 1996–1998)

	Finland			Netherlands		
	Total	Domestic	Foreign	Total	Domestic	Foreign
			All firms			
Total innovators	210	175	35	1544	1139	405
Permanent innovators[1]	162 (77%)	133 (76%)	29 (83%)	769 (50%)	555 (49%)	214 (53%)
R&D co-operation of permanent innovators						
total[2]	134 (83%)	108 (81%)	26 (90%)	307 (40%)	213 (38%)	94 (44%)
domestic S&T partners[3]	115 (86%)	92 (85%)	23 (88%)	171 (56%)	124 (58%)	47 (50%)
			Manufacturing firms			
Total innovators	159	134	25	988	692	288
Permanent innovators[1]	134 (84%)	112 (84%)	22 (88%)	712 (72%)	503 (73%)	209 (72%)
R&D co-operation of permanent innovators						
total[2]	107 (80%)	88 (79%)	19 (86%)	274 (38%)	183 (36%)	91 (44%)
domestic S&T partners[3]	97 (91%)	79 (90%)	18 (95%)	144 (53%)	100 (55%)	44 (48%)

Notes:
1 = % share of permanent innovators in total innovators
2 = % share of total R&D co-operation in permanent innovators
3 = % share of R&D co-operation with domestic S&T partners in total R&D co-operations.

Source:
Community Innovation Survey databases of Finland and the Netherlands: years 1996, 1998 and 2000.

5. The Model

We specify the following model in which the determinants of R&D collaboration schemes will be investigated. The exact explanation of the variables is reported in the Annex.

$$\Pr(Coop_t) = \beta_0 + \beta_1 Size_{t-1} + \beta_2 MNE_t + \beta_3 RD\,\text{int}\,ensity_{t-1} + \beta_4 Brnt_{t-1} + \beta_5 Brnf_{t-1} + \beta_6 Basicness_{t-1} + \beta_7 Brnt_{t-1} * MNE_{t-1} + \beta_8 Brnf_{t-1} * MNE_{t-1} + + \beta_9 Basicness_{t-1} * MNE_{t-1} + \beta_9 Barriers_{t-1} + \beta_{10} Sector_t + \beta_{11} Other_{t-1} + \varepsilon_t \quad (1)$$

The dependent variable is 1 if a firm co-operates on R&D efforts with an external partner ($Coop_t$) and 0 otherwise. This can be a collaboration scheme with other firms but also organizations that belong to the Science and Technology (S&T) infrastructure like universities and/or public R&D institutes.

The first determinant of R&D co-operation is firm size, measured as the natural logarithm of the firm's turnover in the previous period ($Size_{t-1}$). The direction of the effect is ambiguous. On the one hand, larger firms have more room to innovate on their own and a negative effect for β_1 can be expected. However, the increasing internationalization of R&D in the last decade also means that more R&D co-operation with external partners is likely because speed and complexity of R&D make it hard to do everything alone (UNIDO, 2002). Based on this argument a positive effect is expected for the $Size_{t-1}$-variable.

The size variable is lagged with 1 period in order to deal with causality problems. Are large innovating firms more involved in R&D collaboration or are R&D collaborators larger than non-collaborating innovating firms. As R&D collaboration of a firm in the present period t cannot determine its size in the past ($t-1$) the causality must go from size to collaboration.

The second effect (MNE_t) is the impact of being an affiliate of a foreign firm on the probability to co-operate in R&D efforts. This variable is 1 if a firm is a foreign affiliate and 0 otherwise. If the dependent variable is measured as domestic S&T-institutions of the host country, a significant positive (negative) coefficient shows that the probability of foreign affiliates to co-operate with domestic S&T institutions is higher (lower) relative to domestic firms. The impact of a foreign affiliate on the probability to co-operate with S&T institutions in the host country is a priori to be expected negative. Foreign firms have a preference for R&D collaborations with foreign S&T-institutions for reasons of language, cultural differences, etc. However, as argued in section 2 of this study, since the second half of the 1980s R&D investments of foreign firms have become more decentralized and consider the quality of the S&T system and policies as important location factors. The active innovation policies of the Finnish government leading to an upgrading of the national innovation system are expected to eliminate the nega-

tive coefficient of the MNE_t-variable. This means that a foreign firm's probability to co-operate with a domestic S&T institution is not lower than the probability of domestic firms to get engaged in these R&D co-operation schemes. Less active innovation policies like in the Netherlands are expected not to influence the low probability of foreign firms to co-operate with domestic S&T institutions relative to domestic firms. The coefficient for MNE_t is therefore expected to be negative in the Dutch situation.

The variable $RDintensity_{t-1}$ measures whether a firm invests intensively and frequently in R&D. It consists of two variables, R&D employees as a share of the total number of employees in a firm, and a dummy variable that reveals whether the firm performs R&D frequently (value = 1) or incidentally (value = 0). Nieminen and Kaukonen (2001: 71) show that the more firms invest in in-house R&D the more they are involved in R&D co-operation schemes with universities. The own knowledge capacity or 'absorptive capacity' needs to be sufficiently developed in order to use the fruits of R&D co-operations with S&T institutions for commercial use (Cohen and Levinthal, 1989). A positive coefficient of β_3 is expected.

The information source variables are twofold. The first variable describes whether the information source of the innovation comes from inside the firm ($brnt_{t-1}$). A positive effect of $brnt_{t-1}$ on the probability to co-operate with domestic S&T partners shows that innovating firms initiate R&D co-operation and consider the knowledge supplied by these partners of complementary value to their own knowledge. This means that firms know what kind of knowledge is available in domestic S&T institutions, which can be stimulated by innovation policies that encourage R&D co-operation with S&T partners. The external knowledge spillovers that may be an incentive to start R&D collaboration with S&T partners are proxied by $brnf_{t-1}$, the information source of the innovation is from outside the firm. This variable is defined as information from analyses of competitor's products, investigations of existing patents and external databanks and investigations from scientific journals. A positive significant effect of $brnf_{t-1}$ on the probability to co-operate with domestic S&T institutions suggests that ideas from the firms' external environment stimulate them to co-operate with domestic universities and public R&D institutes.

The basicness variable ($basicness_{t-1}$) refers to the ratio of fundamental to applied innovations and is assumed to work out positively on R&D collaboration with domestic S&T partners as these are assumed to supply fundamental knowledge.

The information source variables are also incorporated as cross terms with the MNE_{t-1}-variable to separate domestic and foreign firms' effects. The MNE-variable in the cross-terms is lagged with one period as the source and basicness variables are lagged as well.

The barriers-to-innovation variables are 1) organizational barriers, 2) barriers due to uncertainty with regard to sales and finance, and 3) cost barriers. These are considered as possible impediments to co-operate with external partners.

The variable $Sector_t$ describes the impact of the sector structure on the probability to co-operate and consists of five dummy-variables of which three refer to the Pavitt (1984) sector classification. As described by Pavitt (1984), science-based industries such as chemicals or electronics are heavily dependent on knowledge, skills and techniques from academic research. In scale-intensive industries such as extraction and processing of bulk materials or automobiles, technological progress consists mainly of incremental technological improvements in complex production processes and complex products. The design, building and operation of complex production processes and/or products are considered as the main source of technological accumulation. In specialized supplier industries such as machine tools or software, technological progress has been fast but based on incremental improvements. Most of the companies are small and provide high performance inputs into complex production systems.[4] The other two sector variables are only relevant for the services sector. These refer to financial, ICT and engineering services and to utility and trading services.

The sector dummies of the Pavitt (1984) classification are expected to be positive for the scientific-oriented firms with regard to R&D co-operation with S&T institutions. The large scale–orientation of firms can be considered of importance for reasons sketched out in the discussion above on the $Size_{t-1}$ variable.[5] Special supplier industries are expected to affect positively the probability to co-operate with domestic S&T institutions because their knowledge needs are particularly available in technical universities.

With regard to the service sector dummies a negative sign can be expected as services do generally not require fundamental knowledge as provided by S&T institutions. However, if other partners are involved the sign might be positive as also in services sectors co-operation with non S&T organizations may be of importance.

Finally, the $other_{t-1}$ variables $avbrnt_{t-1}$ and $avbrnf_{t-1}$ have been included to deal with heterogeneity of sectors. $Avbrnt_{t-1}$ is the average of the scores on $brnt_{t-1}$, "information source of the innovation comes from inside the firm" per sector. A significant impact of $avbrnt_{t-1}$ on the probability to co-operate provides a correction for a sector effect on the $brnt_{t-1}$-variable. Along the same lines,

[4] Pavitt (1984) defines as a fourth category 'supplier-dominated industries' with textiles as a typical example. In these industries, suppliers drive technological change. The relative importance of this category is captured by the constant term.

[5] The effect of large-scale industries is therefore expected to correlate with the "size"-variable.

$avbrnf_{t-1}$ generates a heterogeneity control variable for the external knowledge spillover variable $brnf_{t-1}$.

6. Estimation results

In Table 3 some descriptives of relevant variables are reported.

Table 3. Descriptive Statistics

	All	Domestic	Foreign		All	Domestic	Foreign
	Finland				Netherlands		
lnS_{t-1}**	11.413	11.350	11.791	LnS_{t-1}***	10.051	9.844	10.701
	(1.752)	(1.491)	(0.211)		(1.496)	(1.474)	(1.373)
$Rdsal_{t-1}$	0.077	0.072	0.104	$Rdsal_{t-1}$**	0.045	0.0418	0.052
	(0.124)	(0.118)	(0.153)		(0.085)	(0.080)	(0.097)
$Brnt_{t-1}$***	0.568	0.550	0.657	$Brnt_{t-1}$***	0.518	0.476	0.640
	(0.233)	(0.228)	(0.239)		(0.246)	(0.235)	(0.235)
$Brnf_{t-1}$	0.393	0.392	0.396	$Brnft_{t-1}$***	0.249	0.239	0.279
	(0.168)	(0.168)	(0.165)		(0.176)	(0.169)	(0.192)
$Bscrd_{t-1}$**	-0.696	-0.723	-0.555	$Bscrd_{t-1}$	-0.835	-0.848	-0.799
	(0.630)	(0.654)	(0.080)		(0.875)	(0.882)	(0.854)

Notes:
- standard deviations in parentheses;
*** = difference in means between co-operating and non-co-operating firms at 1 %
** = difference in means between co-operating and non-co-operating firms at 5%
* = difference in means between co-operating and non-co-operating firms at 10 %.

Table 3 shows that in Finland the mean values of R&D intensity and source-outside variable between domestic and foreign firms are not significantly different from each other. With regard to the Netherlands only the basicness of research variable is not significantly different between domestic and foreign firms. The other variables differ significantly between domestic and foreign firms.

In Tables 4 and 5 probit estimates of the model are reported for the whole sample and a sample restricted to manufacturing firms respectively. A dataset has been constructed with the year 2000 as the actual year for Finland and 1998 for the Netherlands. The lagged variables refer to 1996 for both countries. The sample has been restricted to innovating firms only.[6]

[6] Correction for selectivity bias by means of a Heckman procedure is not necessary because non-innovating firms do not have R&D collaboration schemes.

Table 4. Probit estimates of co-operation with partners in the Dutch and Finnish S&T infrastructure: all sectors in 1998 (NL) and 2000 (F)

	1	2	3	4	5	6
	partner		domestic S&T partner		domestic S&T partner	
	Finland	Netherlands	Finland	Netherlands	Finland	Netherlands
Constant	-5.348***	-3.001***	-7.402***	-3.613***	-7.762***	-3.651***
	(1.662)	(0.434)	(1.581)	(0.517)	(1.647)	(0.515)
LnS_{t-1}	0.381***	0.211***	0.460***	0.227***	0.493***	0.225***
	(0.087)	(0.026)	(0.093)	(0.030)	(0.096)	(0.030)
MNE_t	0.331	-0.165**	0.143	-0.253***		
	(0.322)	(0.083)	(0.281)	(0.098)		
$Rdsal_{t-1}$	4.753**	1.378***	3.316***	1.031**	3.370**	1.019**
	(2.000)	(0.475)	(1.130)	(0.444)	(1.125)	(0.454)
$Rdfrq_{t-1}$	-0.346	0.008	-0.087	0.108	-0.124	0.105
	(0.286)	(0.080)	(0.285)	(0.100)	(0.287)	(0.100)
$Brnt_{t-1}$	1.017*	0.282*	1.479***	0.229	1.259**	0.385*
	(0.549)	(0.165)	(0.535)	(0.192)	(0.596)	(0.206)
$Brnf_{t-1}$	1.295**	0.359*	0.985	0.559**	1.109	0.474*
	(0.661)	(0.204)	(0.655)	(0.230)	(0.708)	(0.271)
$Bscrd_{t-1}$	-0.126	0.105***	0.053	0.258***	-0.042	0.289***
	(0.187)	(0.040)	(0.191)	(0.047)	(0.208)	(0.056)
$Brnt_{t-1} * MNE_{t-1}$					1.380	-0.647*
					(0.870)	(0.260)
$Brnf_{t-1} * MNE_{t-1}$					-1.031	0.310
					(1.386)	(0.458)
$Bscrd_{t-1} * MNE_{t-1}$					0.966	-0.113
					(0.454)	(0.097)
$Orgimp_{t-1}$	1.958	0.578**	-1.004	0.173	-0.968	0.185
	(1.282)	(0.238)	(0.849)	(0.268)	(0.796)	(0.269)
$Finsalunc_{t-1}$	0.561	0.133	0.770*	0.062	0.723*	0.045
	(0.479)	(0.140)	(0.439)	(0.152)	(0.433)	(0.152)
$Costimp_{t-1}$	0.070	0.152	0.023	0.866***	0.011	0.876***
	(0.968)	(0.299)	(0.963)	(0.331)	(0.970)	(0.331)
$Science_t$	0.732*	0.421**	0.771*	0.435*	0.719*	0.424*
	(0.395)	(0.203)	(0.398)	(0.249)	(0.403)	(0.249)
$Scale_t$	-0.208	-0.049	-0.199	-0.022	-0.163	-0.002
	(0.355)	(0.106)	(0.368)	(0.126)	(0.363)	(0.126)
$Spectoel_t$	0.283	0.039	0.542*	0.264*	0.553*	0.275*
	(0.310)	(0.128)	(0.311)	(0.151)	(0.311)	(0.151)
Va_{t-1}	0.586	0.031	0.458	-0.041	0.410	-0.037
	(0.955)	(0.151)	(0.802)	(0.186)	(0.810)	(0.186)
$Pespec_{t-1}$	-0.109	-0.051	-0.704	-0.298**	-0.953	-0.285**
	(0.669)	(0.109)	(0.579)	(0.133)	(0.592)	(0.134)
$Avbrnt_{t-1}$	0.024	1.077	1.139	0.807	1.308	0.777
	(1.505)	(0.810)	(1.421)	(0.992)	(1.470)	(0.981)
$Avbrnf_{t-1}$	0.339	-1.776	0.127	-1.842	-0.023	-1.729
	(2.554)	(1.135)	(2.326)	(1.352)	(2.327)	(1.358)
n	210	1544	210	1544	210	1544
Wald Chi (15 df)	62.48***	146.20***	84.71***	161.56***	87.53***	161.07***
Pseudo R^2	0.266	0.080	0.353	0.127	0.366	0.130

Notes: standard errors in parentheses.

In Table 4 regressions 1 and 2 explain whether a firm has partners with which it co-operates on R&D. These include S&T- and non-S&T-partners. Regressions 3 and 4 show the firms' determinants of co-operating with a partner in the S&T system. Regressions 5 and 6 are the same as regressions 3 and 4 except for the inclusion of cross-terms of source and basicness variables with foreign firms. The variables of main interest are MNE_t, $Brnt_{t-1}$, $Brnf_{t-1}$ and $Bscrd_{t-1}$ and their cross-terms.

Regressions 1 and 3 show that foreign affiliates of MNEs do not affect significantly the probability to co-operate in Finland (MNE_t). Whether a firm is foreign or domestic is not of importance in explaining the probability to co-operate on R&D with external partners. This remains valid if partners are defined as Finnish S&T partners only. In the Dutch regressions (2 and 4) the effect of foreign firms on R&D collaboration is significantly negative. Innovating firms of foreign origin in the Netherlands have a lower probability to co-operate in their R&D efforts with Dutch S&T institutions than their domestic counterparts. As sketched out in the previous section it is quite likely that foreign firms co-operate less with domestic institutions than domestic firms. The lack of a significant negative effect in Finland can be explained by either Finnish innovation policies or by the Finnish sector structure that is more biased towards scientific sectors than the Dutch sector structure. The latter effect is filtered out by the sector dummies.

If the dependent variable ($Coop_t$) is broadly defined (regression 1 and 2) a significant positive effect of the "information source from inside the firm" ($brnt_{t-1}$) is shown for both countries, i.e. innovative ideas from inside the firm increase the probability to co-operate with partners. This effect becomes stronger if the probability to co-operate with domestic S&T institutions is the dependent variable and regression 3 reveals that firms in Finland actively look for external R&D-partnerships with S&T institutions, i.e. they know what kind of knowledge is supplied by Finnish S&T institutions and they consider it of value to develop their own ideas to innovations. In case of the Netherlands – where R&D co-operation conditions of innovation policies are less relevant – this variable shows an insignificant effect (regression 4). Firms in the Netherlands do not look actively for partnerships with Dutch S&T institutions. They either do not know what kind of knowledge is supplied by Dutch S&T institutions or they know it but consider it of no use.

The $brnf_{t-1}$-variable is significant in the Finnish regression 1 in which the dependent variable consists of co-operation with S&T and non-S&T partners. The coefficient declines and becomes insignificant if the dependent variable is restricted to domestic S&T partners (regression 3). Ideas from outside the firm – external knowledge spillovers – among which those from scientific journals affect the private sector's motivation to co-operate with S&T institutions positively but not significant. The negative though insignificant effect of the "basicness of research" variable ($bscrd_{t-1}$) in the Finnish regression 1 shows that applied inno-

vations are more important if non-S&T partners are also included in the dependent variable. If only domestic S&T institutions are taken into account this coefficient turns positive and shows that fundamental research is more important, as expected. However, this effect is very small and not significantly different from 0. Together with the significant positive effect of the $brnt_{t-1}$-variable this suggests that in Finland innovating firms do co-operate with Finnish S&T-institutions but not necessarily on fundamental work.

The Dutch results in regression 4 show an opposite picture. The coefficient of the variable $brnt_{t-1}$, is positive but not significantly different from zero while the coefficient of $brnf_{t-1}$ is positive as well but also significant. The "basicness of research" variable is positive and significant in all Dutch regressions. In the Netherlands with innovation policies that are less demanding on collaboration with S&T institutions than in Finland, innovating firms look actively for non S&T partners but much less for Dutch S&T partners. External knowledge spillovers are more important for explaining R&D co-operation with Dutch S&T institutions than in case of non S&T partners (regression 2). The fundamental character of research is relevant in all kinds of R&D co-operations but especially in co-operations with S&T institutions, which is as expected.

The estimates in Table 5, in which the sample consists of manufacturing firms only, reveal the same picture as in Table 4.

With regard to the other coefficients in Tables 4 and 5, some observations are relevant. The size variable is significantly positive in all regressions of Tables 4 and 5 as expected. R&D intensity as measured by $Rdsal_{t-1}$ is positive, which implies that R&D input of firms is an important drive to co-operate with all partners in both countries. Only in the Finnish regressions 9 and 11 the $Rdsal_{t-1}$ estimates are not significant. $Rdfreq_{t-1}$ is insignificant in all regressions, which can be attributed to collinearity with the $Rdsal_{t-1}$ -variable.

Barriers to innovations do mostly not affect the probability to co-operate with S&T institutions. Noteworthy is that cost barriers are considered important by firms in the Netherlands but not by firms in Finland. This is consistent with R&D subsidies in Finland that are provided conditional on R&D co-operation with Finnish S&T institutions. If R&D subsidies are an incentive to start R&D co-operation with domestic S&T institutions, cost barriers to innovation are not relevant.

With respect to the Pavitt sector-dummies, as expected, the science-dummy affects all partnerships positively. The scale dummy is less important because a substantial part of this effect is picked up by the $size_{t-1}$-variable ($\ln S_{t-1}$). The dummies for special suppliers industries ($spectoel_{t-1}$) are significantly positive except in regressions 1 and 2. The service sector dummies are negative as ex-

pected though mostly not significant except with regard to S&T collaboration in case of the Dutch sales and utilities services sector ($pespec_t$).

Table 5. Probit estimates of co-operation with partners in the Dutch and Finnish S&T-infrastructure: manufacturing sectors in 1998 (NL) and 2000 (F)

	7	8	9	10	11	12
	Partner		domestic S&T partner		domestic S&T partner	
	Finland	Netherlands	Finland	Netherlands	Finland	Netherlands
Constant	-8.711***	-3.073***	-8.604***	-3.466***	-9.507***	-3.452***
	(2.278)	(0.513)	(2.122)	(0.603)	(2.175)	(0.600)
LnS_{t-1}	0.378***	0.219***	0.387***	0.213***	0.433***	0.210***
	(0.103)	(0.035)	(0.109)	(0.039)	(0.112)	(0.039)
MNE_t	0.313	-0.205**	0.164	-0.222*		
	(0.379)	(0.102)	(0.300)	(0.116)		
$Rdsal_{t-1}$	4.867**	1.306**	2.189	1.015**	2.155	1.013**
	(2.230)	(0.588)	(1.357)	(0.512)	(1.351)	(0.516)
$Rdfrq_{t-1}$	-0.362	-0.014	-0.296	0.087	-0.354	0.086
	(0.344)	(0.108)	(0.350)	(0.130)	(0.352)	(0.131)
$Brnt_{t-1}$	2.022**	0.391*	1.660**	0.230	1.253	0.315
	(0.825)	(0.211)	(0.725)	(0.241)	(0.802)	(0.264)
$Brnf_{t-1}$	1.216	0.343	1.031	0.494*	1.180	0.425
	(0.826)	(0.256)	(0.777)	(0.282)	(0.832)	(0.332)
$Bscrd_{t-1}$	-0.313	0.118**	0.023	0.231***	-0.157	0.244***
	(0.250)	(0.052)	(0.221)	(0.059)	(0.242)	(0.078)
$Brnt_{t-1}$* MNE_{t-1}					2.865**	-0.378
					(1.347)	(0.321)
$Brnf_{t-1}$* MNE_{t-1}					-0.943	0.164
					(1.767)	(0.549)
$Bscrd_{t-1}$* MNE_{t-1}					1.826***	-0.044
					(0.499)	(0.113)
$Orgimp_{t-1}$	1.583	0.706**	-0.159	0.180	-0.266	0.205
	(1.740)	(0.297)	(1.256)	(0.340)	(1.153)	(0.340)
$Finsalunc_{t-1}$	0.550	0.169	0.920*	0.055	0.880*	0.040
	(0.489)	(0.164)	(0.489)	(0.176)	(0.504)	(0.177)
$Costimp_{t-1}$	-0.278	0.168	-0.651	0.713*	-0.427	0.706*
	(1.067)	(0.376)	(1.134)	(0.398)	(1.174)	(0.398)
$Science_t$	1.300***	0.758***	1.048**	0.684***	1.154**	0.672***
	(0.489)	(0.226)	(0.444)	(0.259)	(0.464)	(0.258)
$Scale_t$	0.253	0.127	0.045	0.119	0.036	0.131
	(0.420)	(0.129)	(0.385)	(0.153)	(0.382)	(0.153)
$Spectoel_t$	0.692*	0.249*	0.665**	0.410**	0.677**	0.411**
	(0.360)	(0.146)	(0.335)	(0.168)	(0.341)	(0.168)
$Avbrnt_{t-1}$	0.571	1.082	1.273	0.910	0.776	0.860
	(1.848)	(0.994)	(1.830)	(1.169)	(1.957)	(1.152)
$Avbrnf_{t-1}$	4.852	-2.631**	4.286	-2.518*	5.967	-2.449*
	(4.438)	(1.278)	(4.223)	(1.468)	(4.271)	(1.469)
N	159	988	159	988	159	988
Wald Chi (15 df)	55.85***	109.72***	57.84***	102.31***	75.60***	101.81***
Pseudo R^2	0.317	0.098	0.310	0.112	0.343	0.110

Notes: standard errors in parentheses.

The lack of significance for the variables $avbrnt_{t-1}$ and $avbrnf_{t-1}$ reveals that no heterogeneity could be found. The exception is the Dutch regression 8 on manufacturing.

In regressions 5, 6, 11 and 12 the MNE-effect is estimated as cross terms with the $brnt_{t-1}$ (β_7), $brnf_{t-1}$ (β_8) and $bscrd_{t-1}$-variables (β_9) in order to allocate the effects of the "sources" and "basicness"-variables to domestic and foreign firms (see model specification in section 5). The MNE_{t-1} variable in the cross-terms is lagged with one period. As this variable correlates strongly with the unlagged MNE_t used as an independent variable in the regressions without cross-terms, we have not incorporated MNE_t as a separate variable in the regressions 5, 6, 11 and 12. The domestic firms' effects are picked up by coefficients β_4, β_5 and β_6 and the foreign firms' influence is presented by $\beta_4 + \beta_7$, $\beta_5 + \beta_8$ and $\beta_6 + \beta_9$. These coefficients are reported in Table 6.[7]

Table 6. Probit estimates of co-operation of domestic and foreign firms with S&T partners in Finland and the Netherlands in 1998 (NL) and 2000 (F)

	Finland		The Netherlands	
	Domestic	Foreign	Domestic	Foreign
	All sectors			
$Brnt_{t-1}$	1.259**	2.639***	0.385*	-0.262
	(0.596)	(0.837)	(0.206)	(0.267)
$Brnf_{t-1}$	1.109	0.078	0.474*	0.784**
	(0.708)	(1.289)	(0.271)	(0.393)
$Bscrd_{t-1}$	-0.042	0.924**	0.289***	0.176**
	(0.208)	(0.418)	(0.265)	(0.081)
	Manufacturing sectors			
$Brnt_{t-1}$	1.253	4.118***	0.315	-0.063
	(0.802)	(1.371)	(0.265)	(0.322)
$Brnf_{t-1}$	1.180	0.237	0.425	0.589
	(0.832)	(1.732)	(0.332)	(0.469)
$Bscrd_{t-1}$	-0.157	1.669***	0.244***	0.200**
	(0.242)	(0.455)	(0.078)	(0.089)

Notes: standard errors in parentheses.

The previous observation that in Finland innovative ideas from inside the firm affect the probability to co-operate with Finnish S&T institutions positively is valid for both domestic and foreign firms. However, the effect is more relevant

[7] Standard errors for the foreign firms in Table 6 are derived by the δ-method, see also Spanos (1986: p. 200/201).

for foreign than for domestic firms.[8] The Dutch results show an opposite picture. If Dutch firms' innovations originate from own ideas the chance to co-operate with domestic S&T institutions increases, while foreign firms' probability to co-operate with Dutch S&T institutions decreases. Dutch S&T institutions are not considered as attractive R&D partners to co-operate with by foreign in order to transform their own ideas to concrete innovations and therefore do not fit in their R&D strategies. Knowledge of Finnish S&T institutions is considered of importance by foreign firms and therefore these institutions might fit in the R&D strategies of MNEs.

The positive though insignificant effect of the external knowledge spillovers is also valid for both domestic and foreign firms in Finland but to a much smaller extent for foreign enterprises. Again, the Dutch results are opposite to the Finnish. Domestic but particularly foreign firms' innovations based on ideas of outsiders affect their probability to co-operate with Dutch S&T institutions positively. Foreign firms in the Netherlands consider knowledge supplied by public S&T institutions only useful for innovations based on ideas extracted from the firm's external environment. In Finland ideas from the external environment are not important for foreign firms to co-operate with Finnish universities and public R&D institutes.

The ratio of fundamental relative to applied innovations ($bscrd_{t-1}$) affects the probability to co-operate with Finnish S&T institutions positively only in case of foreign firms. If Finnish firms develop fundamental innovations their attitude to do that in co-operation with Finnish S&T institutions is negative although the result is not significantly different from zero. Knowledge of Finnish S&T institutions is used by Finnish firms because of its applied character. The Dutch results show that both domestic and foreign firms' probability to co-operate with Dutch S&T institutions increases if the innovations are fundamental. Foreign firms in both countries co-operate with domestic S&T institutions if innovations are fundamental.

[8] These are careful conclusions as especially in the case of Finland the extension of the regressions with the cross terms reduces the number of foreign firms in the cross terms.

7. Conclusions and questions for further research

This paper presents a comparative investigation of the determinants of R&D co-operation of innovating firms in Finland and the Netherlands with S&T institutions, with special emphasis on the role of foreign MNEs. It contains a detailed empirical analysis based on data from two waves of Community Innovation Survey (CIS-) data of Finland (1996–2000) and the Netherlands (1996–1998). The first question to be investigated is whether or not foreign firms are less involved in R&D co-operation schemes with domestic S&T institutions than domestic firms. It is expected a priori that foreign firms are less involved in R&D co-operation with domestic S&T institutions than domestic firms. This appears to be the case for the Netherlands. In Finland no difference exists. This suggests that Finnish innovation policies in which R&D subsidies are provided conditional on R&D co-operation with domestic universities and public R&D institutes, eliminate the negative bias towards foreign firms.

The second question examines whether or not domestic S&T institutions in Finland and the Netherlands are attractive R&D partners. In Finland domestic and foreign firms use R&D co-operations with domestic S&T institutions to transform ideas originating in the innovating firm to innovations. Finnish S&T institutions fit in global R&D strategies of MNEs. Foreign firms in the Netherlands, however, do not consider fundamental knowledge in Dutch S&T institutions of use for the development of innovations based on these firms' ideas and hence these institutions are likely not important in global R&D strategies of MNEs. If foreign firms are located in the Netherlands and innovative ideas from the external environment come up an incentive to co-operate with Dutch universities and public R&D institutions exist to transform these external ideas into concrete innovations.

The fundamental character of the innovations is important in both countries. Remarkably, domestic firms in Finland tend to use R&D partnerships with Finnish S&T institutions for applied knowledge.

Although it is quite likely that the differences between the two countries can be explained by the powerful Finnish innovation policies in which linkages between firms and S&T institutions are an important condition, some questions are left over for future research. First, the result that Finnish firms' R&D co-operations with domestic S&T institutions are stimulated if the innovations are applied instead of fundamental, leads to the question whether Finnish innovation policies provide (implicit) incentives for S&T institutions to switch to applied work. In order to receive R&D subsidies firms and S&T institutions might perform strategic behavior, which provides an incentive for the institutions to supply applied-oriented knowledge. Second, the result that Dutch S&T institutions are not considered attractive partners by foreign firms reveals that knowledge supplied by

these institutions does not match with the requirements of the foreign innovators. This induces the question in which sectors the mismatch takes place. Further investigation at a sectoral level must shed light on this issue. A problem in the framework followed in this study is the reduction of data points if an analysis at the sectoral level is executed.

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Annex. Explanation of variables

Variable		Explanation
Cooperation	$Coop_t$	Firm co-operates with other domestic or foreign partners in the S&T system in period t
Size	LnS_{t-1}	the natural logarithm of the size of the firm, measured by its turnover in period t-1.
MNE	MNE_t	1 if the firm is a dependent or independent part of a firm and 0 otherwise in period t.
R&D-intensity	$Rdsal_{t-1}$	R&D employees as fraction of a firm's total employees in period t-1
	$Rdfrq_{t-1}$	Firm innovates permanently in period t-1
Sources	$Brnt_{t-1}$	Score variable ranging from 0 - 3: Information source for the innovation is from inside the firm in period t-1
	$Brnf_{t-1}$	Score variable ranging from 0 – 3: Information source for the innovation is from outside the firm in period t-1 (proxy for knowledge spillovers)
Basicness	$Bscrd_{t-1}$	natural logarithm of the ratio of fundamental to applied innovations in period t-1 (basicness of research)
Barriers	$Orgimp_{t-1}$	Score variable: a higher value means more barriers to innovation in its organization in period t-1
	$Finsalunc_{t-1}$	Score variable: a higher value means more barriers to innovations due to uncertainty with regard to sales and finance in period t-1
	$Costimp_{t-1}$	Score variable: a higher value means more cost barriers to innovations in period t-1
Sector	$Science_t$	Pavitt dummy for Science Based Industrial firms in period t
	$Scale_t$	Pavitt dummy for Scale Intensive Industrial firms in period t
	$Spectoel_t$	Pavitt dummy for Specialised Equipment Suppliers in Industrial firms in period t
	Va_{t-1}	Dummy for valued added services in period t-1
	$Pespec_{t-1}$	Dummy for pre-specified services in period t-1
Other	$Avbrnt_{t-1}$	Average of inside the firm innovation source variable in period t-1
	$Avbrnf_{t-1}$	Average of outside the firm innovation source variable in period t-1

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