UNIVERSITEIT GENT

FACULTEIT ECONOMIE EN BEDRIJFSKUNDE

TWEEKERKENSTRAAT 2
B-9000 GENT
Tel. : 32 - (0)9 – 264.34.61
Fax. : 32 - (0)9 – 264.35.92

WORKING PAPER

When do firm-technology intermediary interactions result in cognitive capacity additionality?

Mirjam Knockaert[*]

André Spithoven[†]

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[*] Faculty of Economics and Business Administration, Ghent University, Tweekerkenstraat 2, 9000 Gent, Belgium and University of Oslo, Norway.
[†] Belgian Science Policy, Brussels, Belgium

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Abstract

Governments have increasingly become involved in stimulating cooperation for innovation and R&D and have less focused on direct R&D subsidies. One set of initiatives is targeted at providing financial support for technology intermediaries. In this paper, we shed light on when technology intermediaries contribute to learning or networking outcomes generated by the firms that call upon them. We hereby focus on network and competence additionality as measures for cognitive capacity additionality and study the impact of collective research centres on their member firms. The results indicate that absorptive capacity of the collective research centre does not affect cognitive capacity additionality generated by the member firms for R&D activities, but higher levels of absorptive capacity tend to negatively affect cognitive capacity additionality generated by member firms engaging in R&D related activities. The absorptive capacity of the member firms does not directly affect cognitive capacity additionality generated by the member firms, but the results on mediation analysis show that member firms with higher levels of absorptive capacity use the services of the collective research centre more intensively, and generate higher levels of cognitive capacity additionality.

Introduction

Over the previous decades, governments worldwide have been active in drawing policy measures oriented towards the stimulation of R&D. According to Autio et al. (2008), the major theoretical rationale to justify government intervention in innovative activity is based on the notion of market failure: governments are better able than individual firms to shoulder risks inherent in R&D activity, and they also have means to enhance the appropriability of R&D investments (Arrow, 1962). This rationale states that firms, which are left to themselves, will underinvest in innovative activities because of their inability to appropriate all the benefits arising from these activities (Luukkonen, 2000; Nelson, 1959; Dasgupta and David, 1994).

Questions on the efficiency and effectiveness of public financing of business R&D are however of growing importance to policy makers (OECD, 2006). The concept of additionality rests originally on the neo-classical market failure rationale (Metcalfe and Georghiou, 1997), but has gained importance over the past decades (Luukkonen, 2000). Luukkonen (2000) states that with regard to collaborative R&D programs, market failure does not relate to the production of R&D per se, but to the transfer and flows of information between firms or firms and public sector research institutes. This is confirmed by the observation made by many authors (Dodgson and Rothwell, 1994; Nooteboom, 1994) that success of firms, and especially SMEs, will be dependent on their ability to utilize external networks efficiently. According to Mowery (1994), as a result, government policy will promote transfer of knowledge through networking and collaborative R&D programs, since costs of transferring and exploiting scientific and technological knowledge are high. This view is confirmed by Autio et al. (2008) who observe that innovation policy interventions have progressed beyond promoting first-order additionality through R&D subsidies.

This government orientation has been inspired by innovation studies that have underlined the crucial role played by the interaction of different organisations in fostering the innovation process (Dodgson and Rothwell, 1994; von Hippel, 1988). Cohen and Levinthal (1990) argue that the ability to exploit external knowledge is a critical component of innovative capabilities. Muscio (2007) points out that both innovation and regional studies conclude that the success of SMEs against larger competitors may be determined by their ability to utilise external networks

efficiently. Or, as Waalkens et al. (2004) argue that, in an SME context, companies are less R&D driven and more reliant on their external environment when undertaking innovation activity.

In line with Buisseret et al. (1995), Falk (2007) argues that several additionality concepts have been proposed as a way to measure the effects of public assistance on firms' innovation activities. The author classifies these concepts in three broad categories: resource-based concepts, result-based concepts and concepts that measure the success of policy intervention by examining desirable changes in the process of innovation. The most refined of the resource-based concepts is, according to the author, **input additionality** which measures whether, and to what extent, firms increase their private spending on innovation-related activities when supported, i.e. whether the firm itself spends at least one additional Euro on the research project for every Euro received in subsidy. **Output additionality**, as a result-based concept deals directly with the most decisive impact, and is either defined in terms of marketable output (e.g. patents or successful innovations) or commercial outputs (e.g. sales or profits that are directly attributable to public R&D assistance). Falk (2007) points out that there is an increased awareness of the fact that traditional additionality concepts do not adequately capture the impact of public intervention on the innovation process itself. Besides, the author argues that applying knowledge to commercial ends often requires a high level of absorptive capacity. Accordingly, a third notion of additionality was introduced, known as "behavioural additionality". Behaviour additionality indicates whether there was a change in the behaviour of the firm resulting from the intervention (Georghiou, 1997). **Behavioural additionality** may include scope additionalities, cognitive capacity additionality (which are often overlapping, according to Falk, 2007) and acceleration additionalities. Bach and Matt (2002) refer to the positive impact on competencies and expertise as cognitive capacity additionality. Cognitive capacity additionality may occur if new partnerships are built and if collaboration and networking involve both individual and organisational learning, thereby increasing the competencies of the actors and enhancing their absorptive capacity (Falk, 2007). Cognitive capacity additionality therefore refers to two types of additionalities: network and competence additionality.

While there are numerous econometric studies on both input and output additionality, as Falk (2007) points out, empirical evidence on behavioural additionality has remained sparse and mainly anecdotal. Davenport et al. (1998)'s explorative research on a New Zealand government scheme, which sponsors collaborative research, provides some indications on the existence of behavioural and input additionality of the scheme. Autio et al. (2008) analyze first- and second-order additionality and learning outcomes in collaborative R&D programs. They define first-order additionality as outcomes resulting from direct R&D subsidy and second-order additionality as enhancing identification with a community of practice among R&D program participants. Even though communities of practice is a particular concept, it is closely related to the concept of cognitive capacity additionality, uniting network and competence additionality. Furthermore, Autio et al. (2008) indicate that there is a dearth of empirical studies that address the organization-level impact of meso-level innovation mechanisms and argue that it is important to develop testable hypotheses that predict organization-level innovation outcomes.

This research aims at addressing this gap by studying cognitive capacity additionality realized by firms through working with technology intermediaries. Technology intermediaries may facilitate the interaction between different organisations. According to Howells (2006) technology intermediaries are involved in various activities,

ranging from diffusion and technology transfer, over innovation management, establishment of systems and networks (f.i. partner matching) to providing technology services, such as specific troubleshooting. Technology intermediaries are often framed in an industry-level analysis in which innovation systems, constituent sectors and their boundaries are central (Malerba, 2002; Sapsed et al., 2007, Nelson, 2008). In these systems, technology intermediaries are instrumental in the mission of technology transfer (Bessant and Rush, 1995; Howells, 2006). As Autio et al. (2008) argue, policy initiatives are progressing and moving away from R&D subsidies towards initiatives promoting externalities that facilitate firm-level innovation and learning outcomes (Cantner and Pyka, 2001; Malerba, 1997; Park, 1999). To our knowledge, no research has studied how and under which conditions working with technology intermediaries results in behavioural additionality or cognitive capacity additionality.

This paper aims at providing an understanding of when working with technology intermediaries results in cognitive capacity additionality, starting off from the theoretical concept of absorptive capacity. We hereby hypothesize that the impact of engaging in activities with the technology intermediary will be dependent on the absorptive capacity of the interacting firm, the absorptive capacity of the technology intermediary, and finally, the interaction between firm and technology intermediary.

In order to do so, we analyze the results of a survey conducted with member firms of collective research centres in Belgium. To complement the data obtained through the survey on cognitive capacity additionality, we carried out interviews with the managers of each of the twelve collective research centres. These centres are private initiatives devised by policy in the aftermath of the Second World War and were, initially, created to encourage scientific and technological research in specific low tech sectors of the economy to improve productivity, quality and production. Even though collective research centres are unique actors, we believe that the results of this research are generalizable to other technology intermediaries. For instance, we found the functioning of the "Centres Techniques Industriels" in France to be quite similar to that of the collective research centers. Collective research centres play a gatekeeping role, and fulfill various roles, namely a knowledge searching function for capturing external sources of information, a transcoding function for translating the meaning of such an information and a transferring function for disseminating accumulated and local knowledge (Lasaric et al., 2008).

In what follows, we first provide an overview of the theoretical framework used, namely the framework of absorptive capacity and we provide a hypothesis framework for the impact of absorptive capacity on cognitive capacity additionality. Next, we provide an overview of the methodology used. In the fourth section, we elaborate on the research results. Finally, we present conclusions and directions for further research.

Theoretical framework and hypotheses

Muscio (2007) points out that, due to the nature of their operations and their size (Waalkens et al., 2004), SMEs are less R&D driven and more reliant on their external environment when undertaking innovation activity. In order to acquire new knowledge, firms must know where and how to find it, and how to assimilate and diffuse it through their own corporate structure. Cohen and Levinthal (1990) argue that the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends is critical to its innovative capacity. They argue that the ability to evaluate and utilize outside knowledge is largely a function of the level of prior related

knowledge. These abilities were collectively defined as a firm's "absorptive capacity" and are derived from the cognitive structures that underlie learning (Cohen and Levinthal, 1990). Experience or performance on some previous learning task may influence and improve performance on some subsequent learning tasks (Ellis, 1965; Estes, 1970). Zahra and George (2002) define absorptive capacity as a set of organizational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capability. These capabilities enable the firm to reconfigure its resource base and adapt to changing market conditions in order to achieve competitive advantage. Cassiman and Veugelers (1999) found evidence of two dimensions of absorptive capacity in Belgian manufacturing firms: the ability to scan the market for technology and the ability to absorb the technology acquired. Arbussa and Coenders (2007) show that the first dimension, namely the capability to scan the external environment does not involve complex scientific or technological knowledge, but knowledge about technology at user level and knowledge of business trends. They relate this capacity to all innovation activities of firms. The second type of absorptive capacity allows a firm to integrate external, complex, disembodied knowledge into its own activities and is supposed to relate to R&D activities.

The firm's absorptive capacity depends on the individuals who stand at the interface of either the firm and the external environment or at the interface between the subunits of the firm. Within a firm, some members are likely to assume the role of "gatekeeping" or "boundary-spanning" roles (Allen, 1977; Tushman, 1977). Gatekeepers may emerge to the extent that such role specialization relieves others from having to monitor the environment. Cohen and Levinthal (1990) argue that these gatekeepers have to be internal to the organization. They argue that absorptive capacity is difficult to buy, for example, by hiring new personnel, contracting for consulting services, or even through corporate acquisitions. At the level of the firm, as Cohen and Levinthal state, absorptive capacity can be generated in a variety of ways: by investing in R&D, as a byproduct of a firm's manufacturing operations, or by sending personnel for advanced technical training. Lane and Lubatkin (1998) studied absorptive capacity in contexts of interorganizational learning in dyads and argue that understanding the relevant basic knowledge permits the student firm to understand the assumptions that shape the teacher's knowledge and hereby be in a better position to evaluate the importance of the new knowledge for its own operations. Similarly, Wong and He (2003) mention that a firm's internal climate for innovation functions as a moderator for the relationship between R&D support and firm innovation behaviour. Or, Muscio (2007) puts that firms learn from a variety of external sources (Malerba, 1992) and must master the capabilities required to search, find, access and interpret for their own use, information embodied in external organisations, in order to successfully access new knowledge through collaborations. Based on these arguments, we argue that, in order for a firm to capture value out of working with the technology intermediary, the firm should dispose of absorptive capacity. Or, put otherwise: the member firm will have to have sufficient absorptive capacity in order to evaluate the importance of new knowledge offered through the technology intermediary.

This leads to the following hypothesis:

H1: The higher the absorptive capacity of the member firm, the higher cognitive capacity additionality obtained by the member firm through working with the technology intermediary

However, since technology intermediaries are also actors in the innovation system that have to be able to evaluate the relevance and importance of information that is available in the environment, they will also require absorptive capacity in order to play a role in technology intermediation. If this is the case, not only the need for absorptive capacity by the "clients" of the technology intermediaries will affect the impact of technology intermediary activities, but so will also the need to build absorptive capacity in-house at the technology intermediary. Or, as Lane and Lubatkin (1998) put it, the ability of a firm to learn from another firm is jointly determined by the relative characteristics of the student firm and the teacher firm. Acs et al. (2003) and Lazaric et al. (2008) indicate that both recipient and the emitter of knowledge have to dispose of absorptive capacity in order for successful knowledge exchange to take place.

This leads to the following hypothesis:

H2: The higher the absorptive capacity of the technology intermediary, the higher cognitive capacity additionality obtained by the member firm through working with the technology intermediary

Besides, in their seminal work on absorptive capacity, Cohen and Levinthal (1990) indicate that, in order to develop an effective absorptive capacity, whether it is for general knowledge or problem-solving or learning skills, it is insufficiently merely to expose an individual briefly to the relevant prior knowledge. Intensity of effort is critical. Similarly, but in another context, Autio et al. (2008) argue that the frequency of interaction among the members of a community is one of the most important mechanisms for the formation of community identification (Bouty, 2000; Yli-Renko et al., 2001). Community identification develops gradually through recurring informal exchanges (Granovetter, 1985; Ring and Van de Ven, 1994). Through repeated interaction, community members develop shared subcultures, which facilitate further identification among community members (Autio et al., 2008). Autio et al. (2008) found full and partial mediation effects for the strengthening of interaction frequency and community identification on direct technological learning. Other authors (Kirat and Lung, 1999; Asheim and Gertler, 2005) claim that continuous and frequent interactions are a precondition for successful innovation collaborations. Similarly, Falk (2007) argues that variables to capture behaviour would have to be regressed on the incidence or even the size of public assistance while one controls for other influencing factors.
Bennett and Robson (1999) found similar indications on the importance of intensity of contact in another context. They studied suppliers and clients of business services and found that the outputs are evaluated by SME clients as having higher impact the higher the interaction intensity in service delivery. They contribute this to information asymmetries between buyer and seller, which can be decreased through intense interaction.

This leads to the following hypothesis:

H3: The more intense the use of the technology intermediary services by the member firm, the higher cognitive capacity additionality obtained by the member firm

Methodology

The sample and data collection

To examine the question how absorptive capacity of technology intermediaries and their member firms affects cognitive capacity additionality, we study the activity of collective research centres in Belgium. These centers were originally purposefully allowed by policy makers in the aftermath of the Second World War in 1947 to encourage scientific and technological research in specific sectors of the economy to improve productivity, quality and production. Given the long history of the collective research centres, they demonstrate the importance they have for their member companies and the legitimate position which they have obtained. These centers are privately owned by the member firms and operate on behalf of a particular sector. The twelve collective research centres under study cover industrial sectors such as wood (to which, in 2006, the furniture industry was added); ceramics; machinery (expanded in the course of time with twelve other sectors into the 'technological' industry); roads; construction; cement; textile (created as collective research centre in 1975, but existed already from 1950), diamond, coatings and paintings, metallurgy, welding, and packaging. The centres represent about 80,000 members. In a first stage, information was collected on the collective research centres' activities and their resource base through face-to-face interviews. Following the Frascati manual (OECD, 2002), these activities were split up in R&D and R&D related activities. Other activities (such as administration, marketing, reception,…) that are mainly internal to the CRC (Collective Research Centre) were not taken into account. The first stage resulted in a list of R&D and R&D-related activities that member firms call upon and that were used in the second stage. In this second stage, we asked the CRC's member firms to respond to a questionnaire on their engagement in activities with the CRCs. In order to do so, we presented an overview of the activities generated in the first phase of the project and asked them to indicate the extent to which they called upon the specific activities over the previous three years. An overview of the activities and the extent to which the member firms called upon it over the past three years is included in Table 1. Besides, in case the member firm had used one of the CRC's services over the past three years, we asked the member firm to answer a number of questions on cognitive capacity additionality. Additionally, data on the age, size and R&D intensity of the member firm was collected.

Table 1: Overview of use made by the member firm of CRC services

To which extent does your company call upon the following CRC services? (1=never; 7= often)	**Mean**	**Median**	**Used over last 3 years? (%)**
R&D related activities			
- R&D laboratory for use of company	2.73	1	38
- Information on R&D European programmes	2.16	1	24
- Access to technical library	3.66	3	56
- Provision of qualified personnel	2.91	2	38
- Sales of equipment	1.37	1	5
- Right to use inventions (licences)	1.48	1	6
- Small scale in-depth technological consultancy (GTA)	3.49	3	55
- Support and advice concerning standardisation	3.04	2	43
- Information on intellectual property	1.70	1	13
- Certification	2.45	1	31
- Consulting and audits	2.23	1	24

- Testing	3.28	2.5	46
- Feasibility studies	1.95	1	17
- Provision of information through website	3.56	3	54
- Provision of information through publications	3.66	3	55
- Provision of information through newsletters	3.80	4	63
- Norm antennas	2.86	2	38
- European technology platform	2.07	1	17
- Matching parties in industry and science	2.27	1	27
- Organisation of studydays and seminars	3.40	3	57
- Technology watch and roadmapping	1.89	1	18
- Solving specific problems (troubleshooting)	3.03	2	42
- Technical advice	4.09	4	68
R&D activities			
- Research contract between CRC and company (bilateral research)	2.04	1	22
- Research contract on a collective basis (CRC, your company, and Third parties)	2.26	1	25

N=490

The data collection process was initiated by the CRCs, which selected randomly about 11% of their member firm population and requested the members to fill out the online questionnaire. The respondents could answer the questionnaire either in French or Dutch. 856 answers were received, pointing to a response rate of 9.4%. The fact that the CRCs contacted the potential respondents could potentially have generated a selection bias. An analysis of the answers received however does not suggest any selection bias. First, the R&D intensities of the respondents were in line with sector averages. The expected average of R&D intensities, based on official statistics (Belgian Science Policy) (weighted by the number of respondents per sector) was 1.9% of sales, whereas the weighted reported average of R&D intensities was 2.39%, which indicates a minor discrepancy. Besides, the size of the respondents was similar to the size of the total population. 214 respondents indicated not to have been in contact with any of the CRCs over the past 3 years. Even though the analysis of the characteristics of these respondents shows that member firms that engage in collaboration with CRCs are significantly larger and significantly more R&D intensive than those that do not, this does not affect the validity of the results since our focus is on an analysis of effects on those firms that did collaborate with the CRCs. 290 valid answers on the activities they engaged in with the CRC were received. 352 respondents indicated to have been in contact with the CRC over the past three years, but did not fill out the questions on additionality. These respondents seem to be significantly smaller and less R&D-intensive compared to those who filled out the questionnaire and may lead to potential bias. We will comment on this potential bias in the results section.

Measures

Dependent variables

As Falk (2007) indicates, one way to assess behavioural additionality is to question assisted firms directly (e.g. Davenport et al., 1998). For both R&D related and R&D activities, we assessed network and competence additionality. The source of items was a study carried out on behalf of IWT (2006), in which the scales were tested and validated. In case the member firm indicated that it had used the CRC's service over the past 3 years, it

received a list of items on potential cognitive capacity additionality of the service, and was asked to indicate on a 7-Likert scale the extent to which the respondent agreed on the statement (1= disagree entirely; 7= agree entirely).

Cognitive capacity additionality	R&D related activities	R&D activities
Network	The intervention by the CRC allowed my company to identify potential partners	The project allowed us to network with universities or public research centres
	The intervention by the CRC allowed my company to cooperate with other companies	The project allowed us to network with other companies
	The intervention by the CRC allowed my company to cooperate with knowledge institutes, such as universities or research institutes	The project allowed us to build research networks
	Cronbach-Alpha: .89	**Cronbach-Alpha: .90**
Competence	The intervention by the CRC allowed my company to acquire new knowledge	The project increased our skills to network with universities or public research centres
	The intervention by the CRC allowed my company to increase our innovation management capabilities	The project increased our skills to network with other companies
	The intervention by the CRC allowed my company to upgrade its human resources	The project allowed us to acquire new knowledge
		The project allowed us to upgrade our human resources
		The project increased our innovation management capabilities
	Cronbach-Alpha: .89	**Cronbach-Alpha: .83**

N=289 for R&D related activities; n=115 for R&D activities

The construct's Cronbach-Alphas allowed calculating summated scales (averages) for network and competence additionality for R&D related and R&D activities. These four measures will be used as dependent variables throughout the analysis.

Independent variables

Absorptive capacity. Cohen and Levinthal (1990) argued that the ability to exploit external knowledge is largely influenced by the level of prior knowledge, which they refer to as "absorptive capacity". According to Muscio (2007), R&D efforts are rightly seen as a viable proxy for absorptive capacity. We construct 2 variables for the absorptive capacity of the member firm and the collective research centre. Absorptive capacity of the member firm was measured as a categorical variable, indicating R&D expenses as a percentage of sales (1= no R&D expenses; 2= R&D expenses account for less than 5% of revenues; 3= R&D expenses account for between 5 and 10% of revenues; 4= R&D expenses account for more than 10% of revenues). Absorptive capacity of the CRC is measured as the R&D personnel in Full Time Equivalents (FTEs).

Intensity of use. For each of the services in Table 1, we asked to indicate the extent to which the member firm used the service, using a 7-Likert scale (for question and scale, see Table 1). We use a summated scale of the engagement in R&D related activities (see Table 1) by taking the average of the engagement in each of the R&D related activities. Cronbach-Alpha for the scale was .93. We construct a summated scale of the engagement in R&D activities by taking the average over the 2 items (Table 1). Cronbach-Alpha for the scale was .80.

Control variables

Slack. George (2005) argues that slack may affect behaviour of firms, in turn affecting financial performance. For instance, studies have indicated that slack is a predictor for risk taking (Wiseman and Bromiley, 1996), innovation (Nohria and Gulati, 1996) and performance (Bromiley, 1991; Tan and Peng, 2003; George, 2005). Slack is used to stabilize a firm's operations by absorbing excess resources during periods of growth and by allowing firms to maintain their aspirations and internal commitments during periods of distress (George, 2005; Cyert and March, 1963). Given the impact that slack may have on firm behaviour, we control for it. Following George (2005), we measured slack as the ratio cash flow of the firm/average cash flow in the sector, taking into account that slack may be industry specific.

Age. We control for age, given that age is an important moderator of the effectiveness with which firms deploy resources (George, 2005; Stinchcombe, 1965; Thompson, 1967) and may therefore affect the extent to which working with the technology intermediary generates cognitive capacity additionality.

Results

In what follows, we first present the results of the analysis on R&D activities, followed by the analysis for R&D related activities. For each type of activities, we first present the descriptives for the variables used.

R&D activities

Descriptives

Table 2 provides an insight into the dependent and independent variables. Engaging in R&D activities with the CRCs resulted for the average firm in network additionality of 4.34 and competence additionality of 4.78. The average CRC engaged 70 people in R&D, which is representing the absorptive capacity of the CRC. Respondents were on average 29 years old and disposed on average of 12,492 Euro of slack.

Table 2: Descriptives for R&D activities

Variable	**Minimum**	**Maximum**	**Mean**	**s.d.**
Dependent variables				
Network additionality	1	7	4.34	1.57
Competence additionality	1	7	4.78	1.07
Independent variables				

Absorptive Capacity CRC	8	133	70.07	48.13
Absorptive Capacity member firm				categorical
Age (years)	1	97	29.19	21.47
Intensity of use	1	7	3.94	1.54
Slack	-4,250	560,234	12,492	70,309

N=115.

Regression Analysis

We used Ordinary Least Squares regression analysis with both network and competence additionality for R&D activities as dependent variables.

Correlations between variables were all below 0.2. In order to make sure that multicollinearity was not an issue, variance inflation factors were calculated, and were found to be below 3.0 (maximum value 1.2), suggesting that multicollinearity was not an issue (see Hair et al, 1998).

The first iteration of the regression analysis for cognitive capacity additionality of R&D activities does not show support for hypothesis 1 or 2. The analysis shows support for hypothesis 3, indicating that a higher intensity of use of the technology intermediary services by the member firm affects cognitive capacity additionality positively (see Table 3). Further analysis however shows that the relationship between the absorptive capacity (AC) of the member firm and cognitive capacity additionality is mediated by the intensity of use (right hand columns of Table 3).

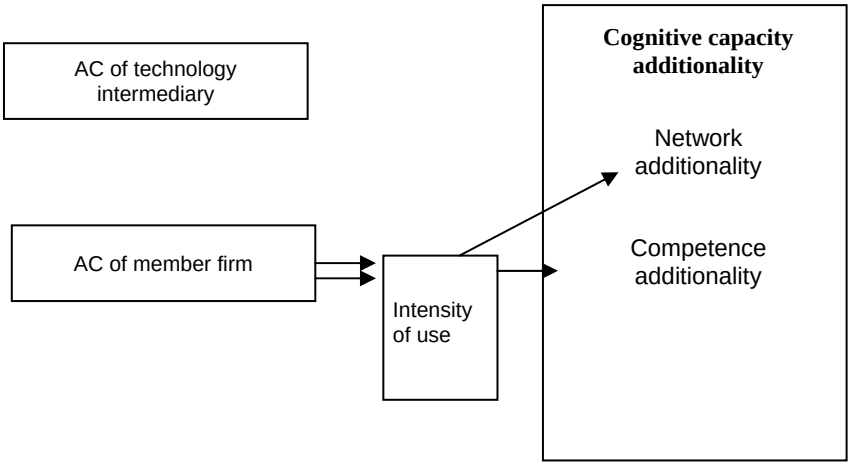
Table 3: OLS regression results for R&D activities

			Mediation Test	
	Network additionality	Competence additionality	Network additionality	Competence additionality
Independent variables				
Absorptive Capacity CRC	-.02	-.07	-.08	-.11
Absorptive Capacity member firm	.14	.08	.25***	.18*
Intensity of use	.43****	.36****		
Control variables				
Age	-.02	.03	.05	.09
Slack	-.04	-.05	-.11	-.11
Adjusted R^2	.21	.14	.05	.03
F	7.03****	4.56***	2.49**	1.91

N=115; *p<.10, **p<.05, ***p<.001;****p<.0001

In order to test for full and partial mediation effects, we ran the regression analysis without the intensity of use in the equation, in line with Autio et al. (2008). To show full mediation, the independent variables should become significant. We do find full mediation effects for absorptive capacity of the member firm. The regression analysis without the intensity of use in the equation indicates a significant effect of the absorptive capacity of the member firm on cognitive capacity additionality. By including the intensity of use in the equation, the F-values are significantly improved and the effect for absorptive capacity of the member firm becomes insignificant, pointing to full mediation effects. We do not find any mediation effects for the absorptive capacity of the technology intermediary.

The analysis points to the following model for the relationship between independent and dependent variables for R&D activities:



The model indicates that, the higher the absorptive capacity of the member firm, the higher the engagement of the member firm in R&D activities with the technology intermediary, resulting in higher cognitive capacity additionality.

Below, we analyze the extent to which the results also hold for R&D related activities

R&D related activities

Descriptives

Table 4 provides an insight into the dependent and independent variables. The average member firm tends to generate more competence additionality than network additionality from R&D related activities.

Table 4: Descriptives for R&D related activities

Variable	Minimum	Maximum	Mean	s.d.
Dependent variables				
Network additionality	1	7	3.66	1.53
Competence additionality	1	7	5.16	1.24
Independent variables				
Absorptive Capacity CRC	2	133	84.85	50.28
Absorptive Capacity member firm			Categorical variable	
Age (years)	0.2	125	26.59	20.88
Intensity of use	1	7	3.09	1.18
Slack	-19,598	560,234	7,684.87	50,835.78

N=289; *p<.10, **p<.05, ***p<.001;****, p<.0001

Regression Analysis

We used Ordinary Least Squares Regression analysis with network and competence additionality for R&D related activities as dependent variables. Correlations between variables were all below 0.25. In order to make sure that multicollinearity was not an issue, VIF factors were calculated, and were found to be below 3.0 (maximum value 1.1), suggesting that multicollinearity was not an issue (see Hair et al, 1998).

The results provide partial support for H1, no support for H2 and full support for H3: the intensity of use between technology intermediary and member firm positively affects cognitive capacity additionality by the member firm. Furthermore, absorptive capacity by the member firm does not show any positive effects for network or competence additionality. Interestingly, the effect for the absorptive capacity of the technology intermediary was in the opposite order than expected: a higher level of absorptive capacity by the technology intermediary affects cognitive capacity additionality in a negative way. Again, we tested for mediator effects and found both full and partial mediator effects. In order to test these effects, we ran the regression analyses again, without "intensity of use" in the equation. These results are also reported in Table 5.

Table 5: OLS regression results for R&D related activities

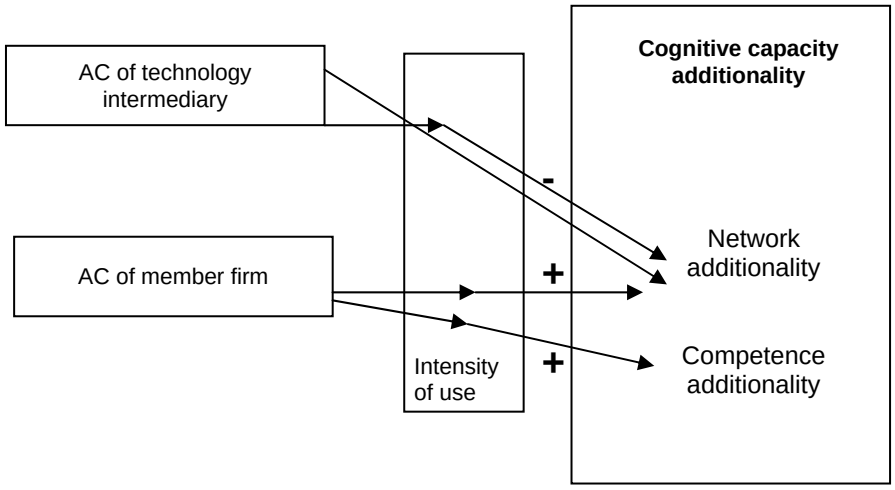
			Mediation Test	
	Network additionality	Competence additionality	Network additionality	Competence additionality
Independent variables				
Absorptive Capacity CRC	-.13**	.05	-.11*	.08
Absorptive Capacity member firm	.03	.03	.10*	.12*
Intensity of use	.41****	.51****		
Control variables				
Age	-.02	-.05*	.02	.00

Slack	.00	.01	-.03	-.01
Adjusted R^2	.18	.25	.02	.02
F	13.32****	20.59****	2.09*	1.13

N=289; *p<.10, **p<.05, ***p<.001;****, p<.0001

In the case of network and competence additionality, the absorptive capacity (AC) of the member firm had a positively significant effect, but the effect disappeared after including the intensity of use in the equation, pointing to a full mediation effect. Besides, we do find a partial mediation effect for absorptive capacity of the technology intermediary for network additionality.

The analysis points to the following model for the relationship between independent and dependent variables for R&D related activities:



The results indicate that higher levels of absorptive capacity by the member firm result in an increased engagement in technology intermediary R&D related activities, and results, through the mechanism of intensity of use, in higher network and competence additionality. Interestingly, the absorptive capacity of the technology intermediary affected network additionality in a negative way, both directly and mediated by the intensity of use between member firm and technology intermediary.

Conclusions and discussion

Governments are more and more turning to the stimulation of interaction between parties during the innovation process instead of granting R&D subsidies. Little evidence however exists on the impact of initiatives aimed at stimulating interaction, such as the creation or financing of technology intermediaries. One of these initiatives are the collective research centres which were set up in Belgium in the course of the post war period in order to increase technological innovation. There are a number of types of impact that government initiatives may have on

additionality. These were labelled input, output and behavioural additionality (Falk, 2007). This research specifically focussed on one dimension of behavioural additionality, namely cognitive capacity additionality, obtained by member firms collaborating with collective research centres. As measures for cognitive capacity additionality, we specifically studied network and competence additionality for R&D and R&D related activities of the technology intermediaries. Basing ourselves on the concepts of absorptive capacity, we anticipated that the absorptive capacity of the technology intermediary and the member firm, and the intensity of use of the technology intermediary's services would positively affect cognitive capacity additionality. We found that, both for R&D and R&D related activities, cognitive capacity additionality was positively affected by the intensity of use of the services offered by the technology intermediary. We however also found that this effect was mediated by the absorptive capacity of the member firm, with more R&D intensive member firms calling more frequently upon the technology intermediary's services. We did not find the absorptive capacity to affect the cognitive capacity additionality reached by the member firms positively, and even found a negative effect for the impact of absorptive capacity of the CRC on cognitive capacity additionality of the member firm. Additionally, we do not believe the potential selection bias due to the fact that respondents tend to be less R&D intensive to occur. The results on the absorptive capacity of the member firm partially confirm hypothesis 1 through a mediation effect. Since low R&D intensive member firms are underrepresented in the sample, we may expect this effect to occur to a larger extent if more low R&D intensive member firms had been included.

Overall, the results show that especially those companies that dispose of absorptive capacity to engage in R&D and innovation activities benefit from working with the technology intermediary. This effect mainly occurs through the intensity of the involvement in CRC activities. When we discussed this conclusion with the collective research centre representatives, they pointed to the fact that over the past years, they had worked less with smaller, and especially lower R&D intense member firms. The reason for lower collaboration with low R&D and smaller firms lies, according to the representatives of the CRCs, in the fact that government has urged them to increase their ambitions on an innovation and technology level, and to work towards technological breakthroughs that would also provide more visibility to the work of the technology intermediary and the government investment. This has led to less investment by the CRCs in awareness creation with small and low R&D intensive companies and to increased interest in larger projects, carried out with companies that already dispose of an R&D department. This indicates that working with technology intermediaries is relevant to firms that already dispose of absorptive capacity, and that, if awareness creation for technology or innovation is the main goal, governments should reward or finance technology intermediaries based on their involvement in awareness creation. Another interesting finding was that higher levels of absorptive capacity at CRC level resulted in lower network additionality for R&D related activities. The interviews with the CRCs indicated that they find their personal engagement in R&D crucial: without having in-house R&D personnel, they do not believe to have the relevant absorptive capacity to provide relevant services to their members. This holds for both R&D and R&D related activities. For instance, for R&D activities, they indicated that they would never be able to define relevant research topics and disseminate the results to the relevant members without following up on technological evolution and trends by engaging in R&D themselves. The results however do not indicate that CRC R&D capacity affects cognitive capacity additionality positively. This may point to the fact that other knowledge or capacities may be more relevant to member firms than absorptive capacity at R&D level. Further research should indicate what specific knowledge/capacity at CRC

level would result in higher levels of cognitive capacity additionality at member firm level. Alternatively, these results could suggest that CRCs are not seen as providers of networking opportunities, but could instead be seen as vehicles that replace the member firm's own networking activities. In this way, the CRC would play a gatekeeping role on behalf of the member firm, with the firm expecting the CRC to maintain its relationships, which would not have been captured with the questions on cognitive capacity additionality, since these study the complementary role of the CRC in relation to the member firm's activities.

This research has a number of implications for industry, policy makers and academics.

For industry, this research points to the importance of building absorptive capacity internally, in terms of R&D capacity, in order to benefit from working with parties in the environment. Besides, it indicates that, in order for higher levels of absorptive capacity to be generated, intensity of interaction is crucial in firm-technology intermediary interactions.

For policy makers, this paper has three main interesting findings. First, this paper indicates that, apart from potential input or output additionality generated through working with technology intermediaries, member firms also benefit from working with these intermediaries, through increasing networking and cognitive capabilities, which is an indication of the effectiveness of government money spent. Second, the results however also indicate that companies may be over reliant on technology intermediaries, and may expect technology intermediaries to take over some of their roles, for instance, engaging in networks on behalf of the member firm. And third, the results show that technology intermediaries may be less effective in encouraging companies, especially smaller ones to engage in R&D and innovation activities, especially when the government program supporting the technology intermediary is focussing on breakthrough technological developments. The results show that especially those companies that already have built absorptive capacity internally engage in activities with the technology intermediary and generate higher levels of cognitive capacity additionality.

For academics, this research is a renewed call for extended measures for absorptive capacity that allow to capture the human capital and knowledge base of firms.

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