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RESEARCH REPORT

Open innovation: The role of collective research centres in stimulating innovation in low tech SMEs

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1 Introduction

Firms have to become increasingly open towards external knowledge sources to become more innovative. Indeed, the innovative activities of firms leave the trodden paths of linear conversion of internal R&D activities into internally developed products that are then distributed on the market. The environment in which firms operate is gradually converting into an enhanced dependency on external knowledge and alternative ways to the market. Especially the reliance on external sources of knowledge poses great challenges to firms in so-called low tech activities. Many small and medium sized firms in low tech sectors have insufficient in-house absorptive capacity or receptivity to screen external ideas and incorporate these in their company. Besides, a market failure for R&D efforts has been identified and states that R&D is inherently an uncertain activity: firms engaging in it often cannot predict in advance whether their efforts will bear fruit. This observation has provided a key justification for government intervention in innovative activity (Autio et al., 2007). One of these initiatives are the collective research centres in Belgium, which have been set up in order to facilitate transfer from science to industry, especially focussing on SMEs in low tech sectors.

Collective research centres (CRCs) are a particular type of intermediaries already created in Belgium in the aftermath of the Second World War. They are comparable with other initiatives, such as the CTIs (Centres Techniques Industriels) in France, and gather all companies in a specific sector. As the institutional background changed, the collective research centres adapted their functioning. Now, in the era of open innovation, they serve as a knowledge filter to small and medium sized firms that no longer have the capabilities to engage in either network related activities or individual actions to screen for the latest best available technologies. The collective research centres typically belong to traditional sectors such as textile, cement, building, machinery, metallurgy, paints and coating, roads, ceramics, … In 2005, these centres, taken together, employed 831 FTEs.

This report presents the results of our research aimed at understanding how CRCs play a role in fostering innovation in Belgium. We especially focus on SMEs, and analyze the effects of the CRC's intervention on behavioural additionality. In what follows, we first analyze the role of the collective research centres in the innovation system. Secondly, we analyze the extent to which demand for CRC services matches supply that is offered on the market. And thirdly, we analyze under which conditions the engagement of the member firm in activities of the CRC affects behavioural additionality.

Each of the chapters has been converted into working papers. The first working paper on the role of CRCs in the Belgian innovation system was presented at the ISPIM Conference for Open Innovation in Tours, France, in June 2008.

2 Collective research centres in the innovation system

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2.1 Introduction

Since Chesbrough published his book on open innovation, the idea that external knowledge is an essential element to optimize in-house innovation has been revitalized (Chesbrough, 2003a). External knowledge is known to be distributed over various actors (Tether, 2002) and accessible through a multitude of channels (Coombs et al., 2003; Howells et al., 2003; Acha and Cusumano, 2005). In such a context, firms are part of an environment that is characterised by distributed knowledge, and the innovation process itself is distributed across a number of actors (Acha and Cusumano, 2005). Open innovation is not new (see e.g. von Hippel, 1988). Gibbons et al. (1994)'s ideas about the 'new production of knowledge' already emphasized the need for external knowledge insourcing. At that time, they argued that the production of knowledge itself was changing from a clearly delineated mode to a new dynamic, interactive and multi-faceted system.

Chesbrough and Crowther (2006) define two types of open innovation companies may engage in: inbound open innovation and outbound open innovation. In the case of inbound open innovation, companies monitor the environment of the firm to insource technology and knowledge in addition to in-house R&D. In the case of outbound open innovation, companies do not only rely on internal paths to market, but also look for external organisations that are better suited to commercialise a given technology. In this chapter, we focus on inbound open innovation. Inbound open innovation or the internalisation of external knowledge requires search processes that are supposed to be available within the company. These search processes are generally known as "absorptive capacity". Cohen and Levinthal (1990: 128) defined the concept of absorptive capacity as "the ability of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends". Absorptive capacity can be built by engaging in in-house R&D activities, can occur as a side effect of manufacturing, or can be obtained by sending staff to advanced technical training (Cohen and Levinthal, 1990). The firm's absorptive capacity will depend on the individuals who stand at the crossroads of the firm and the external environment. The concept of absorptive capacity has been most often studied in the case of large and R&D intensive companies (Zahra and George, 2002). This does not imply that small or medium sized companies in traditional sectors refrain from engaging in inbound open innovation (Muscio, 2007; Thérin, 2007).

Chesbrough and Crowther (2006) show that companies in traditional industries apply the concepts of open innovation and engage in inbound-oriented activities. However, the way in which they enter into inbound open innovation activities may be different from their larger counterparts or companies in high tech sectors. Firms operating in traditional sectors typically dispose of limited in-house absorptive capacity (Muscio, 2007). Gann (2001) indicates that, in a traditional sector such as the construction sector in the UK, investment in R&D is low, in contrast to, for instance, companies working in fast-moving science and technology based sectors. Hence, the research question we investigate in this chapter is: how do companies in traditional sectors cope with the lack of absorptive capacity needed to be efficient in organising inbound open innovation activities?

The chapter has several theoretical contributions. First, we add to the literature on absorptive capacity by further exploring the different components of the construct "absorptive capacity". Whereas the empirical literature on absorptive capacity has to a large extent limited itself to the amount of R&D

expenditures or presence of an R&D unit as a measure of absorptive capacity, we further disentangle the concept by making a distinction between R&D activities that are aimed at developing new knowledge (the knowledge explorer function) and other activities such as knowledge intelligence and knowledge dissemination activities. We show that the latter activities are in some cases even more important than the pure knowledge development ones. Secondly, we add to the literature on open innovation by integrating the concept of absorptive capacity as a pre-condition for organising inbound open innovation activities. The literature on open innovation has made the need for openness in the innovation process explicit and has emphasized sub processes such as search routines. We make the role of absorptive capacity in this open innovation explicit and therefore converge the absorptive capacity literature and the open innovation one. We specifically show how absorptive capacity contributes to the ability of firms to engage inbound innovation activities. This open innovation is facilitated by investing in both R&D and search routines. Finally, we contribute to both literatures by showing that in a distributed innovation environment, firms can develop absorptive capacity in a concerted way instead of developing this internally.

The chapter is structured as follows. First, section 2 provides the theoretical background on open inbound innovation and the role of absorptive capacity. Next, section 3 provides an insight into the methodology and the data collection. Section 4 describes the results of the data analysis. The final section concludes, and provides directions for further research.

2.2 Theoretical background

The upsurge of technology markets over the past decades has mobilised knowledge and technology (Arora et al., 2001) and witnessed the birth of many intermediaries (Howells, 2006). Open innovation stresses the ‘abundance’ of external knowledge outside firms waiting to be captured by them and converted into profitable innovating products and services (Chesbrough, 2003a; Chesbrough, 2003b; Christensen et al., 2005). The use firms make of external knowledge for their production is called inbound open innovation (Chesbrough and Crowther, 2006). But this external knowledge does not percolate smoothly through the boundaries of the firms. Knowledge has to be identified first, and firms have to look for mechanisms to assimilate and transform this knowledge. Otherwise stated, they have to rely on absorptive capacity to take advantage of inbound open innovation. Each of these elements will be discussed in some depth by reviewing the recent literature and we will relate this to our research theme on collective research centres. By doing so, we enrich the understanding of absorptive capacity at an inter-organisational level.

2.2.1 Inbound open innovation

In the ‘era’ of open innovation (Chesbrough, 2003b), the need to access external ‘public’ knowledge has gained a lot of importance (Lichtenthaler, 2008). In this context, firms are part of an environment that is characterised by distributed knowledge, and the innovation process is distributed across a number of actors in the innovation system (Tether, 2002; Acha and Cusumano, 2005). This invokes the capabilities to manage and co-ordinate external knowledge outside the boundaries of the firm dependent on resource shortages, and involves interaction in specialised networks (Tidd et al., 1997; Ritter and Gemünden, 2003). Many authors refer to an increasing ‘distributedness’ of the innovation processes itself (e.g. Coombs et al., 2003; Howells et al., 2003) coupled to an increasingly distributed nature of production processes since many products and services are developed and delivered through several contributing organisations. More recently, the ideas on open innovation further equate the importance of external sources of R&D with internally developed knowledge (Chesbrough, 2003a, 2003b). Key to open innovation is the transparency of the firm’s boundaries to take into account the available knowledge outside the company boundaries (Chesbrough, 2003a; Huston and Sakkab,

2006), which has been further explored by looking at the breadth and depth of each other's search routines (Laursen and Salter, 2004, 2006). Yet, little attention is paid to absorptive capacity which needs to be developed in companies in order to successfully engage in inbound open innovation activities.

The concepts of innovation can be split up into two main types of activities (Chesbrough and Crowther, 2006): inbound open innovation and outbound open innovation. In the case of inbound open innovation, R&D external to the firm stemming from suppliers, customers and other external actors is absorbed (for instance through technology in-licensing, acquisition and joint development) to increase the innovativeness of the firm. In the case of outbound open innovation, companies look for external organisations that are better suited to commercialise (part of) the firms' given technology (for instance through intellectual property or brand out-licensing). As mentioned in the introduction, the focus of this chapter is on the first type of open innovation, namely inbound open innovation activities, and the absorptive capacity which needs to be built in order to successfully engage in inbound open innovation activities.

2.2.2 Absorptive capacity

Cohen and Levinthal (1990: 128) argue that the ability of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends is critical to its innovative capacity. Therefore the concept of absorptive capacity is key in understanding successful inbound open innovation which is characterised by the reliance on external knowledge. According to Cohen and Levinthal, the ability to evaluate and use outside knowledge is a function of the knowledge source and the level of prior related knowledge and depends on the ability to appropriate this external knowledge (Todorova and Durisin, 2007). These abilities were collectively defined as a firm's "absorptive capacity". The importance of internal R&D for building absorptive capacity is, according to Cohen and Levinthal (1990), part of the build up of prior knowledge and depends on the learning environment. In environments in which learning is less demanding, a firm's in-house R&D has little impact on absorptive capacity. In the extreme case in which external knowledge can be assimilated without any specialised expertise, a firm's internal R&D would have no effect on its absorptive capacity. 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 by-product of a firm's manufacturing operations, or by sending personnel for advanced technical training.

Cohen and Levinthal (1990: 135) highlight the potential role of externally organized forms of absorptive capacity. However, they remain sceptical about the potential success of externally developed absorptive capacity. They warn against too much optimism because of the firm specificity of certain types of information. The development of a technology market (Arora et al., 2001; Howells, 2006), however, implies that at least some absorptive capacities of firms are available at the organisational level. The way in which the communication runs at the inter-organisational level, therefore, becomes a critical factor. Dyer and Singh (1998) and Lane and Lubatkin (1998) relate absorptive capacity to the inter-organisational level. First, Dyer and Singh (1998) stressed the presence of external resources of firms and inter-firm linkages as a source of competitive advantage. They, however, theorize about value creating linkages between independent organisations, whereas this is only partially the case for collective research centres as they are member organisations and hence not entirely independent. Ouyang (2008) refers to this as non-equity alliances and clearly differentiates these from licensing activities, joint ventures and acquisition. In sum, the relevant part of the insights of Dyer and Singh (1998), pertains to the distributedness of the resources and abilities (like absorptive capacity) of a company over different organisations.

Lane and Lubatkin (1998) reconceptualised absorptive capacity as a construct at dyad level and referred to it as 'relative' absorptive capacity. The arguments of learning ability depend on the

knowledge base, the organisational structure and the dominant logics between the organisations. As to the similarity of the knowledge base, Lane and Lubatkin (1998) follow Cohen and Levinthal (1990:136) and state that prior knowledge in a firm must meet two criteria to identify and value new external knowledge: a similar knowledge base between the receiving and transferring organisation and a partial diversity to use the new specialised knowledge. This is precisely the case for the collective research centres in Belgium.

Four years later, Zahra and George (2002) review the literature on the concept and redefine absorptive capacity as a set of organisational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organisational capability. These four dimensions enable the firm to reconfigure its resource base and to adapt itself to changing market conditions in order to achieve competitive advantage. In their article they criticise the earlier conception of Cohen and Levinthal (1990) by dropping the dimension on identification and value and introducing the constructs of potential absorptive capacity, i.e. acquisition and assimilation, and realised absorptive capacity, i.e. transformation and exploitation (Zahra and George, 2002). They also introduced the notion of social integration mechanisms which facilitate the translation from potential to realised absorptive capacity. The key idea behind this notion is that all four dimensions of absorptive capacity are made up of social interactions and are therefore affected by the interplay of social integration mechanisms (Zahra and George, 2002; Todorova and Durisin, 2007) also between organisations (Dyer and Singh, 1998).

Although the element of social integration mechanisms was hailed and extended to all dimensions of absorptive capacity, Todorova and Durisin (2007) disagreed with Zahra and George (2002) on the neglect of the dimension on the identification and valuation of external knowledge. Depending on the knowledge base of a firm, it might fail to identify new and potentially valuable external knowledge. Hence the original concept as used in the analysis of Cohen and Levinthal (1990) and Lane and Lubatkin (1998) remains of considerable importance in understanding all dimensions of absorptive capacity.

At the empirical side, Cassiman and Veugelers (2000) found evidence of two dimensions of absorptive capacity: the ability to identify 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 identify 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. Absorptive capacity also allows a firm to integrate external, complex, disembodied knowledge into its own activities and is supposed to relate to R&D activities. Zahra and George (2002) and Todorova and Durisin (2007) refer to this as the dimensions assimilate and transform, although they differ in respect to the way these operate: sequentially as in Zahra and George (2002) or as alternative routes as in Todorova and Durisin (2007). In line with Cohen and Levinthal's seminal article, absorptive capacity is usually operationalised as the existence and/or intensity of a company's R&D activities (Veugelers, 1997; Lane and Lubatkin, 1998; Lin, 2003; Oltra and Flor, 2003; Leahy and Neary, 2007; Thérin, 2007; Zahra and Hayton, 2008). There has been increasing critique on this operationalisation of absorptive capacity. Lennox and King (2004) and Schmidt (2005) emphasise that absorptive capacity is a multidimensional concept and should be operationalised as such. Absorptive capacity is also measured through the use of skilled employment figures or other measures that proxy qualified personnel (Mowery and Oxley, 1995). Also qualitative measures proxying absorptive capacity exist, e.g. the presence of a separate R&D unit (Veugelers, 1997). This chapter uses several important elements of absorptive capacity pertaining to the organisation of technology intermediation as a qualitative indicator and the employment of qualified personnel and R&D activities as quantitative indicators.

2.2.3 Inbound open innovation and absorptive capacity in low tech sectors

Both the concept of open innovation and absorptive capacity originated from case studies in large, R&D intensive companies such as Xerox (Chesbrough, 2003). The validity and use of these concepts have been applied to traditional sectors and SMEs without questioning the validity of these concepts in these different contexts.

Traditional industries which are predominantly characterised by the presence of SMEs only exhibit a limited R&D intensity (European Communities, 2006) and innovation capacity (von Tunzelmann and Acha, 2004). In fact, we can expect that the number and qualification of the employees of many of these firms fall below a critical mass necessary to sparkle open innovation through absorptive capacity, let alone set up an independent R&D unit. Therefore, we might expect that these firms will call upon third parties that can help them to build absorptive capacity. Collective research centres seem to fulfil this role in Belgium. They help their member companies build the ability to scan the market for emerging technologies, develop the ability to absorb the technology acquired, and even to perform original complementary R&D activities if needed (either on demand or spontaneously). However, the concept of absorptive capacity also suggests that these centres have to dispose of sufficient absorptive capacity themselves in order to fulfil their functions. If this is the case, not only the need for absorptive capacity by the members or 'clients' of the centres will affect the technology intermediary activities, but so will the need to build sufficient absorptive capacity in-house at the level of intermediary organisation. This emphasizes the importance of the R&D activities of the collective research centres themselves.

2.3 Collective research centres in Belgium as a research theme

To examine the question how absorptive capacity enables inbound open innovation activities by firms in low tech industries, we study the activity of collective research centres in Belgium. These centres 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 centres are privately owned by the member firms and operate on behalf of a particular sector. We analyse this research question in a sample of twelve collective research centres in Belgium, which represent around 80,000 member firms. 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. These centres are grouped in the Union of Collective Research Centres (UCRC). Table 1 below provides an insight into the main figures of the collective research centres.

These centres represent a unique sample frame since a) they are developed on the initiative of the firms rather than the government; b) they obtained a legal status in the aftermath of the Second World War so longitudinal data on their performance is publicly available and c) given the long history of these collective research centres, they demonstrate a huge adaptability in the face of technological changes and changing business models. In addition to objective data, primary data was collected during interviews to provide an updated insight into the rationale of member companies to call upon the intermediaries, the activities they carry out on behalf of their members, and the sources of information that collective research centres access in order to build their own absorptive capacity. Even though collective research centres are unique actors, we believe that the results on their modus operandi when helping to build absorptive capacity can be generalizable to other technology

intermediaries. For instance, the functioning of the “Centres Techniques Industriels” in France proved to be quite similar to that of the collective research centres in Belgium.

To understand how collective research centres build up absorptive capacity to engage in inbound open innovation by helping to build absorptive capacity, we collected primary data through interviews with the CEOs and triangulated this information with member views, policy maker views and objective data on each of these centres. Because absorptive capacity is not well understood in its empirical operationalisation (Lane et al., 2006), we chose an inductive approach based upon the interviews as a way to collect in depth insights in the activities they perform and the components of absorptive capacity.

First of all, the data indicate that the centres are very heterogeneous, with the number of members ranging from 3 in the cement sector to 74,000 in the construction sector. As can be seen in Table A1 in the Appendix, the majority of these sectors have a medium or low R&D intensity. The number of members they represent is dependent on the type of collective research centre. Some directly originated from the law of 1947 that makes membership obligatory for all firms in a specific sector. Others are ‘free’ collective research centres that give companies in the sector the choice to join or not. The number of members also reflects the degree of fragmentation in the industry they represent. This implies, if only in terms of technology transfer activities, organisational differences between these research centres. In total, these centres employed 901 persons or 835.6 full time equivalents (FTEs) in 2005. The correlation between the number of members and the employment in FTE is 0.64, which indicates that the more members a centre has, the larger its size and related set of activities are.

Table 1: Key figures on collective research centres

Name of Collective research centre	*Sector coverage*	*Year of crea-tion*	*Number of members*	*Employ-ment in FTE in 2005 (b)*	*R&D activity (in % of FTE employment) (b)*	*Tech transfer activity (in % of FTE employment) (b)*	*Ratio tech trans-fer / R&D*
CENTEXBEL	Textiles	1975	900	107.0	24.8	60.0	2.41
CRIC	Cement	1959	3	38.3	21.5	37.6	1.75
BCRC	Ceramics	1973	50	22.9	60.7	21.8	0.36
SIRRIS	Technology	1949	2500	142.8	40.8	33.9	0.83
BRRC	Road	1952	1000	109.0	37.6	16.5	0.44
BBRI	Construction	1960	74000	198.9	67.0	16.8	0.25
TCHN-CTIB	Wood	1947	700 (a)	17.3	18.4	27.5	1.50
WTOCD	Diamond	1977	160 (a)	15.1	93.4	6.6	0.07
CoRI	Coating	1957	40	22.0	100.0	0.0	0.00
CRM	Metallurgy	1948	32	134.3	84.7	6.7	0.08
BWI	Welding	1972	350	15.0	100.0	0.0	0.00
BPI	Packaging	1954	200	13.0	12.3	20.0	1.63
Total centres			79935	835.6	54.0	24.0	0.45

Note: (a) estimation by the authors based on social security data
(b) Source: CFS/STAT, 2007

In line with Cohen and Levinthal (1990), we distinguish between R&D investments and investments in related activities such as dissemination (see column 6 and 7 of Table 1). R&D activities are defined as creative work directed to, systematically and planned, augmenting the general knowledge and its application (OECD, 2002). As indicated in section 2, the performance of R&D activities is the most used proxy for absorptive capacity to date (Cohen and Levinthal, 1990; Veugelers, 1997; Lane and Lubatkin, 1998; Leahy and Neary, 2007). These R&D activities are the cognitive foundations on which the knowledge base is build. A central characteristic in R&D activities is the element of newness (OECD, 2002: 30). As the collective research centres are also acting as technology intermediaries, they deploy various R&D related activities. These activities are: scientific and technical information

services; general purpose data collection; testing and standardisation; feasibility studies; patent and license work; policy related studies and routine software development (OECD, 2002). We label the R&D related activities of these centres as “Tech Transfer” activities as they represent the dissemination of knowledge instead of the exploration of knowledge. The bi-annual OECD R&D survey, organised in Belgium by the CFS/STAT, collects these data for all collective research centres (CFS/STAT, 2007). Interestingly, half of the centres spend more time on R&D related activities than R&D activities strictu sensu. This means that, to understand absorptive capacity as a construct, it is crucial to have an in-depth understanding of the R&D related activities. These activities can also be interpreted as being related to the absorptive capacity of other organisations since it is directed to facilitate spillovers of in-house R&D as well as externally sourced ideas. This aspect of absorptive capacity has been understudied up to now. A prerequisite for collective research centres to engage in technology transfer activities is, however, the in-house availability of specialised in-house personnel.
R&D activities are a key element in the mission of collective research centres as they range, in terms of employment, from 12.3% in the packaging industry up to 100% in paintings and coatings and in welding. As the collective research centres are privately held nonprofit organisations, they have to disseminate this knowledge for the benefit of their member organisations. This is done by the technology transfer activities that, partly, mirror their R&D activities. Both R&D and technology transfer activities do not always sum up to 100% due to the existence of other activities that are not at all related to R&D. In general, the centres devote more than double effort to R&D activities than to R&D related activities (the ratio tech transfer to R&D is 0.45). This is also the case for two thirds of the centres. Four centres are more engaged in related R&D activities directed at technology transfer. With the exception of CENTEXBEL in the textile industry, these centres are particularly small and show a moderate number of members.
Because the element of human capital is vital in both R&D and technology transfer activities, we must look closer at the functions of the employees and their qualifications in Table 2.

Table 2: Personnel of collective research centres by qualification and function – in FTE in 2005

	Qualification			
Function	*University degree*	*Postsecondary degree*	*Other qualifications*	*Totals*
Researchers	260.2	117.4	73.2	450.8
Technicians	97.2	73.3	30.2	200.7
Other	68.0	63.8	52.3	184.1
Totals	425.4	254.5	155.7	835.6

Source: CFS/STAT, 2007

The majority of personnel, 54%, are employed as researchers. Researchers are occupied in the creation of new knowledge, products, processes, and the management of projects yielding new knowledge (OECD, 2002). Only more than half of them, 58%, have a university degree indicating that the research performed is probably of a more applied nature. Technicians and equivalent staff are engaged in activities that demand technical knowledge. These activities involve the application of readymade concepts and operational methods (OECD, 2002). Other R&D personnel are skilled and unskilled supporting employees, e.g. secretariat, craftsmen, etc. participating in or associated with R&D projects (OECD, 2002). Although most functions require a university degree, the test of association, chi-square, shows that a statistical significant association exists, meaning that the distribution of qualifications differs according to the function that employees perform. The correlation of these attributes, however, shows that this association is weak.

As seen in Table 1, the collective research centres do not exist for all sectors in the economy. The total R&D investment in 2005 for all sectors having collective research centres amounted to 1,350 million euro, or 35.7% of total business R&D expenditures (CFS/STAT, 2007). The in-house R&D expenditures in 2005 of all collective research centres amount to 55.6 million euro, i.e. 64.9% of their

total expenditures. Most of the R&D expenditures (70.4%) represent labour costs. Working and equipment costs amount to 23.3% and investment takes a share of 6.3%. Looking at the sources of funding of R&D expenditures, the business sector takes, with 65.1%, the bulk of funding. Federal and regional authorities fund 25.7% and the European Union funds 9.2% of R&D expenditures.

2.4 Analyses and results

The interviews conducted with CEOs of the collective research centres provided an insight into the role in the organisation of absorptive capacity aimed at facilitating inbound open innovation activities of their members. In order to understand this organisation of absorptive capacity the analysis is structured as follows. First, the rationale of member companies to call upon the intermediaries demonstrates if, and to what extent, the lack of absorptive capacity of member firms forces them to call upon collective research centres. We subsequently study the organisation of absorptive capacity by collective research centres carried out on behalf of their members and show that these can be seen as a set of three interrelated functions. Based on this set of functions, the various activities are examined. Finally, the sources of information that collective research centres access in order to build their own absorptive capacity are examined. In order to fulfil their role as technology intermediary, these centres have to organise absorptive capacity collectively at the organisational level.

2.4.1 Lack of absorptive capacity at member firm level: the 'raisons d'être' of collective research centres

Since collective research centres are created by the member firms and react to bottom up demands, it is instructive to gain an insight into the factors that drive members of collective research centres to call upon their services. As our premise goes that these firms operate in traditional sectors and are small sized, it is expected that factors related to absorptive capacity range higher. The question is put to the CEO of the collective research centre and not to the member firms as such. Consequently, the result reflects, first and foremost, the self evaluation of the centre. This is, however, not without interest because it highlights the opinion of the centre on what it believes to be its strong and weak points.
As such, it also frames their operation(s) vis-à-vis insourcing of knowledge, technical information and R&D activities. It is assumed that, given the moderate R&D intensities of the sectors under research (Appendix A1), the lack of absorptive capacity is driving member companies to call upon collective research centres for help in building absorptive capacity.
Section 2 showed that, empirically, absorptive capacity is captured by several dimensions, among which the ability to identify and monitor the market for technology and the ability to assimilate and transform this technology fruitfully. Aspects of these dimensions also figure in Table 3 which corroborates this: firms mainly lack qualified personnel and technical information to be involved in R&D activities. Besides, the high risk and costs associated with R&D are found to be a major burden.

Table 3: Factors driving member firms to call upon collective research centres (N=12)

Why do companies call upon the collective research centres most?
(1= very low importance; 7= very high importance)

	Median	*Weighted average*
Spread economic risk of R&D	5	5.6
Reduction high cost of R&D	6	5.1
Qualified personnel	6	5.8
Technical information	5	5.2
Market information	2	2.9
Financial resources	4	4.3
Organisational flexibility	4	4.9

Note: The weighted average corrects for the number of R&D employment in collective research centres as in Table 1.

The fact that collective research centres have qualified personnel at their disposal is rated the highest. Table 2 showed that the functions of this personnel are related to R&D activities and technical activities, demonstrating that their role is related to both monitoring the technology market and the internalisation (via assimilation and/or transformation) of R&D in the firm. But, as indicated, most firms are not heavily involved in R&D as both the risks and the costs are deemed high, which necessitates an appeal to collective research centres which are created and to an extent loosely managed by the very firms that need the R&D. Firms have, therefore, devoted relatively fewer human resources to in-house R&D activities and technical information sourcing and thus can put their efforts elsewhere to enter their competitive markets characterised by lower levels of value added and strong competitive pressure (e.g. the textile industry).
Given the importance of qualified personnel and access to information (Cohen and Levinthal, 1990), and given the low involvement in R&D, members of collective research centres thus purposefully lack the necessary absorptive capacity to be involved in R&D and technology transfer activities. However, given that absorptive capacity to some extent has to be present internal to the firm, we may expect that members especially call upon services from collective research centres that help them build absorptive capacity. The services could include activities that either help build the ability to scan the market for technology or that either help build the ability to absorb the technology acquired (Cassiman and Veugelers, 2000). Therefore, we can expect collective research centres to be involved in technology transfer activities on the one hand and R&D on the other hand. Besides, the concept of absorptive capacity also suggests that collective research centres will have to build their internal absorptive capacity, and therefore also have to engage in R&D (see Table 1).

2.4.2 Absorptive capacity organized by collective research centres

Following Howells (2006), we group some activities that are in the same line of objectives to highlight the key functions of collective research centres. We content-analysed the interview transcripts with each of the CEOs of the collective centres and the transcripts we made based upon the various focus groups that were organised with these centres. This content analysis made clear that the CEOs of the centres basically talk about three interrelated activities that are organised to increase the innovative capacity of their members and thus fall in the definition of absorptive capacity: (i) they see themselves acting as a knowledge intelligence unit by the (upstream) identifying and monitoring relevant technology and knowledge; (ii) they consider themselves functioning as a knowledge agency on demand of the member firm to tackle encountered problems and implement technologies hence performing assimilation and transformation capabilities (Todorova and Durisin, 2007); and (iii) they think they act as a knowledge repository by firms directed to information dissemination which enhances the assimilation capability of the member. We focus on each of these functions to make the roles of the collective research centres explicit. These functions, however, are intimately related to each other and our exposition in the following paragraphs mainly serves to disentangle them from an analytical point of view.

Knowledge intelligence unit. The collective research centres act as a proactive knowledge intelligence unit which refers to various mechanisms ranging from monitoring external technological developments to technology watch activities and technology road mapping in the case of collective research centres (see further for a discussion of the mechanisms) and pure demonstration projects in which prototypes are made to show the functioning of a technology. These activities are also referred to as ‘gatekeeping’ (Allen, 1977; Tushman, 1977; Trott, 1998; Giuliani, 2005) or ‘pushing’ (Berends et al., 2006). In this case, the involvement of the centre is an active one, which is directed towards all members (and even non-members if they pay for the service). The activity of knowledge intelligence is considered by the collective research centres to be highly innovative and collective in nature.

Innovative means that they continuously scan what is going on in the environment, either in a generic (technology watch) or specific (technology roadmapping) way and these activities are always organised for a group of firms (i.e. collective). In the case of technology roadmaps, the group of firms is limited to a small number that collaborates to build a roadmap for the specific products in their value chain or network. In the case of technology watch, the group encompasses a community of firms that can be the entire sector.

Knowledge agency. Secondly, collective research centres act as knowledge agencies. Technology evolves and hence is, therefore, to a large extent, firm-specific (Bessant and Rush, 1995; Lane and Lubatkin, 1998). In the case of collective research centres, this means that their members can suggest research projects which are then further explored by the researchers in the collective centre in order to evaluate the initial idea. Acting as a knowledge agency emphasizes the pro-active involvement of collective research centres to transform knowledge and technology on behalf of the member firm (Lin, 2003; Howells, 2006; Sapsed et al., 2007). This explorer role can be very innovative and firm specific or individual oriented. In this case, the collective research centre almost fulfils the role of a subcontracting R&D unit for an individual firm, but it can be equally collective oriented and innovative or not innovative oriented. In the latter case, the collective research centre analyses to which extent a certain technology can be implemented by a collective of members. In the case of collective, innovative oriented research, the collective research centre partly performs the role of matchmaker. It initiates a collective research project with various members in order to explore new knowledge that might benefit each of the sectors. Since it has knowledge on upcoming events, through technology watch activities and road mapping gained in its function as knowledge intelligence unit, and since it performs in-house R&D to build up its own absorptive capacity and fill in the black holes in the needs of firms, the collective research centre is able to provide enterprises with the necessary contacts to engage in R&D collaboration with third partners.

Knowledge repository. The third function of collective research centres is acting as a repository of knowledge (Tsai, 2001). This knowledge is partly sourced from other actors and partially developed in-house through R&D activities. This function places the act of technology transfer activities centre stage. Functioning as knowledge repository seems to be a crucial component of absorptive capacity since it, basically, is a point of reference for member firms. Especially the fact that collective research centres have been around for a long time, makes them particularly well known within and acquainted with the industry. Some of the firms have established solid trust relations with the collective research centres that speak the same language as the firm. This similarity can be explained by the fact that CEOs of member companies are in the board of directors of collective research centres. In this aspect they differ from other technology intermediaries.
As knowledge repositories, they enter the competition on the technology market with other knowledge intensive business services (Leiponen, 2006), consultants (Bessant and Rush, 1995) or other intermediaries (Howells, 2006). The reliance on tacit knowledge in innovation activities triggers the importance of long lived trust relations and regular interaction on an interpersonal (face-to-face contacts, technological advisors) and inter-organisational (e.g. number of hits on website) level. The greatest difference from other technology intermediaries is related to the nature of knowledge transferred: collective research centres are focussed on tacit knowledge whereas other technology intermediaries often take recourse to codified knowledge (Muller and Zenker, 2001).

We have shown in Table 2 that collective research centres both perform R&D and technology transfer activities. This might seem surprising since most centres were mainly established to transfer technology to the member companies. However, it shows that despite the emphasis on transferring relevant knowledge and technology to the member companies, internal R&D is an absolute necessity to build absorptive capacity of its own and complement the R&D activities of member firms. This aspect of absorptive capacity was originally put forward by Cohen and Levinthal (1990) and enjoyed some empirical verification (see, for instance, Veugelers, 1997). As such, this is in line with the operationalisation of absorptive capacity in most empirical papers. However, at the same time,

absorptive capacity does include much more than only R&D activities, which in more than half of the cases do not take more than half of the time of the staff. In addition to knowledge agency activities, also knowledge repository is an important part of the centres' activities.
Collective research centres are involved in different types of R&D: collective and contract research. First, they are involved in collective research that should be beneficial to all firms in the specific sector. These activities might be done with the involvement of several member companies or, as in the case of road, wood and diamond, without the contribution of member firms. Secondly, these centres carry out R&D on behalf of one member, resulting in joint research with (or on behalf of) one firm or a consortium of firms, which is called contract research. Here, the research results are often disseminated to other member firms, be it at a later stage. Finally, they carry out their own (in some cases fundamental) research. This R&D activity is the 'straightforward' way to gain absorptive capacity in the vain of Cohen and Levinthal (1990).

Next to R&D activities, collective research centres are involved in R&D related intermediary activities or technology transfer services. Table 4 provides an insight, based on the interviews, into the extent to which intermediary activities are provided to member firms and frames these in the functions we have described earlier. As such we get an idea how collective research centres organise absorptive capacity on behalf of the firms and, at the same time, we get an idea how well these activities are thought to serve the member firms.

Table 4: Activities used to build absorptive capacity by firms and provided by collective research centres by function (N=12)

Provision by collective research centres of activities to build absorptive capacity
(1= not provided at all; 7= provided to all members)

Activities	*Function*			*Median*	*Weighted average*
	Knowledge intelligence unit	*Knowledge agency*	*Knowledge repository*		
R&D laboratory for use of company	+	+	+	7	5.5
Technology advisory services	-	+	+	7	6.8
Technology innovation stimulation	+	+	-	7	5.8
Information on R&D European programmes	+	+	-	4	5.1
Access to technical library	-	+	+	7	6.4
Provision of qualified personnel	+	+	+	7	6.0
Sales of equipment	-	+	-	1	2.7
Right to use inventions (licences)	-	+	-	3	4.1
Provision of advice to external parties active within the sector	+	+	+	7	4.8
Provision of advice to external parties, firms active outside the sector	+	-	-	6	3.9
Provision of advice to external parties, other organisations (universities, PROs)	+	-	-	4.5	2.8

Note: + implies that this activity plays a part in fulfilling this function; - implies that it does not
Note: The weighted average corrects for the number of R&D employment in collective research centres as in Table 1.

These services help member firms build the ability to identify and monitor technology, which was one of the dimensions of absorptive capacity mentioned by Zahra and George, Cassiman and Veugelers,

2000, Arbussa and Coenders, 2007 and Todorova and Durisin, 2007). The collective research centres are to a large extent involved in so-called technology advisory services. Technological advisory has known a long tradition (more than 20 years). The task of a technological advisor is predominantly aimed at providing technological advice and at stimulating innovation. These advisors are also involved in the diffusion of the research results both gathered 'upstream' (universities, attendance at conferences, ...) and generated within the collective research centre where the advisor is located. A full time technological advisor visits on average 50 firms annually, during which he or she offers on average 35 technological innovation advises (IWT, 2006). More than 80% of these firms are SMEs. Up to 75% or 80% of the personnel costs for the technology advisors is financed by regional funding, depending on the region the firm is located in. Technology advisors are typically specialised people with a technical background. They visit the member firms, screen the production process and discuss product improvement and demonstrate the potential use of specialised new technology. Furthermore, they are in close contact with suppliers of knowledge and technology in the environment. Given their specialised and technical background, they dispose of the necessary skills to absorb information and distribute it internally. Next to this, the interviews showed that these technology advisors often are not only involved in technological advisory services but also in the collective and contract research that the centre carries out. This helps them build the absorptive capacity of the collective research centre. They also play the role of gatekeeper for their member firms, which often do not dispose of sufficient absorptive capacity. By engaging into collective or contract research, or by transferring knowledge to their member companies, they help building absorptive capacity at the member firm level. Next to their technology advisory role, collective research centres provide access to technical libraries (through the use of newsletters, meetings, websites), and provide qualified personnel to step in for trouble shooting. These activities fit into the assimilation dimension of absorptive capacity. As can be seen in Table 3, the items on qualified personnel and access to technical libraries clearly demonstrate the lack of firms' absorptive capacity and the reliance or use of collective research centres and knowledge agents and knowledge repositories. Looking at the median score in Table 3, collective research centres also provide technology innovation stimulation, whereas so called 'animators' perform sensibilisation activities and connect firms to networks of technological expertise. Further, they provide access to their R&D laboratory (for testing and prototyping), and provide advice to external parties within the sector. Not all these intermediary activities are provided to the same extent as shown by the scores of the weighted average. The top three – the use of technological advisory services, a technical library and the qualified personnel – are the most provided intermediary activities. Both the knowledge intelligence and repository function seem to be of major importance.

2.4.3 Sources of information for collective research centres

Up to now the analyses show that collective research centres are involved in a number of activities that are carried out in order to help their member firms build absorptive capacity to turn external knowledge into an element of competitive advantage. We identified technology advisors, who are employed by collective research centres, as important players and gatekeepers for the technology intermediary and in their function of knowledge agents on demand of firms or in their capacity of knowledge repository when they are called for by firms in the case of trouble shooting. Collective research centres likewise absorb knowledge in the environment characterised by distributed knowledge and diffuse it to their member companies that are opening up their innovation processes to outside influences. We already pointed to their R&D activities (Table 2) and the training of their personnel to tackle general (collective research projects) and specific (contract research or trouble shooting activities) problems. Hence, in order to complete the picture of inbound open innovation at firm level and which is facilitated by intermediary activities of the personnel of collective research centres (e.g. the technology advisors), the sources of information the collective research centres call upon are brought to the fore in Table 5.

Table 5: Sources of information for collective research centres (N=12)

Technology and knowledge sources to collective research centres for R&D *(1= we never call upon this source; 7= we call upon this source for all of our activities)*	Median	Weighted average
In-house personnel	7	6.2
Clients and members	5	4.5
Acquisition of equipment	4	2.5
Licenses, patents, IPR	2	2.2
Software	2	2.0
Universities	5	5.2
Public research organisations	4	3.9
Other collective centres	4	4.4
Fairs and exhibitions	4	4.3
Publications and specialised magazines	5	5.1
Meetings and conferences	5	5.0

Note: The weighted average corrects for the number of R&D employment in collective research centres as in Table 1.

The CEOs of the centres indicated that the main source of information lies with their own people, who dispose of the background and experience to carry out R&D and to involve in technology transfer activities. This shows clearly that the knowledge intelligence function cannot be seen separately from the knowledge agency function. Other important sources of information are the universities, publications and specialised magazines and meetings and conferences. Conferences reconfirm the fact that own R&D is probably necessary if one wants to be active at such a conference. Especially knowledge generated at universities may be hard to absorb. As Gann (2001) points out, this knowledge is very specialised and requires a critical mass of technically qualified staff in order to develop, absorb and use new ideas. They state that companies working in fast-moving science and technology based sectors usually invest more intensively in R&D than most construction organisations, which are the focus of their research. They show that the lack of absorptive capacity is hindering construction companies to absorb the results of academic research, or work published in middle range journal articles. This research shows that collective research centres specifically absorb the knowledge that does not get transferred easily from science to industry. This may be caused by the high R&D intensity of collective research centres that enable them to absorb very specialised knowledge and transfer it to their members in ways that lead to easier applicable information, for instance through joint R&D or through other tech transfer mechanisms, such as study days, seminars and through communication in general by their technology advisors.

2.5 Conclusions, limitations, and avenues for future research

Starting off from the premise that most firms operating in traditional industries relatively lack absorptive capacity to turn available external knowledge into innovative products and services and strengthen their competitive position, we analysed the functions of collective research centres in respect to absorptive capacity needed to enjoy the benefits of inbound innovation activities. In this way, we focussed on the dimensions of absorptive capacity.

Collective research centres are technology intermediaries that originated in Belgium in the aftermath of the Second World War. Their members operate in traditional industries characterised by a low technology content measured by their R&D investments. The main finding of this research is, first and foremost, that absorptive capacity includes both R&D activities stricto sensu, (which we called knowledge explorer activities) and R&D-related activities (which we called knowledge intelligence and repository activities). In about half of the cases, the knowledge intelligence and repository activities are

more important than the knowledge explorer activities. This sheds some light on the mismeasurement of absorptive capacity if only R&D activities are taken into account.

Secondly, even though authors who have studied absorptive capacity (Cohen and Levinthal, 2000; Zahra and George, 2002; Todorova and Durisin, 2007) argue that absorptive capacity can only be built internally to the firm, we show how technology intermediaries can help build absorptive capacity within their 'client firms' by performing activities that include the knowledge intelligence services (gate keeping, technology watch, road mapping), the knowledge agency functions and the knowledge repository functions (technical libraries, study days, ...) by organising absorptive capacity at a collective level. As such we demonstrated that the concept of absorptive capacity can also be seen at an interorganisational level (Tsai, 2001). Through the interplay of these functions, the collective research centres absorb knowledge from their external environment which is tailormade for their member firms. This knowledge is then used for in-house R&D activities (collective research on behalf of all members, normalisation and standardisation activities, etc.), R&D activities together with or on behalf of the member firms to accommodate urgent or specific research needs or troubleshooting, or is transferred to the member firms through general dissemination channels (websites and newsletters) or though the activities of technology advisors.

Thirdly, we show that 'absorptive capacity' is an important element in the organisation of inbound open innovation activities. Our empirical analyses show that collective centres get their information – next to in-house R&D – from universities and conferences which are usually places difficult to access.
Even though collective research centres are a specific type of intermediaries, we believe that the results of their functioning, knowledge insourcing and drivers for their existence of these technology intermediaries are generalizable towards other technology intermediaries. For instance, they show considerable similarities with the French "Centres Techniques Industriels", that are also sector-based and to a large extent privately funded. They are, however, not privately owned by their member firms. These centres also employ technology advisors who embody the bridging function between external knowledge and the member firms.
However, our research shows some limitations. This research focussed on the functioning of collective research centres with respect to helping firms active in traditional industries to overcome the drawbacks from their lack of absorptive capacities. The aim of the chapter was to highlight the position of the collective research centre and did not take the opinions of the members firms into account. Therefore the discussion is largely based on the self reporting by collective research centres. Obviously this is an important avenue for further research.
Another limitation is the focus on the situation within one country, hindering the conclusions on the 'subsidiary' role of collective research centres in the issue of absorptive capacity for firms lacking is to be externally validated. A comparison with similar technology intermediaries from other countries, like, e.g. the Centre Technique Industriels in France, or public intermediaries such as the Max Planck institute in Germany, might be indispensable for assessing the relevance for collective research centres in addressing the lack of absorptive capacity.

2.6 Appendix A1 - Technological content of industrial activities in the manufacturing sector

Table A1 presents a list of the classification used by the European Commission of activities in the manufacturing sector according to their technological content.

Table A1: Technological content of industrial activities in the manufacturing sector

Manufacturing			
High-technology	*Medium-high-technology*	*Medium-low-technology*	*Low-technology*
Pharmaceuticals	Chemicals	Coke, refined petroleum products and nuclear fuel	Food and beverages
Office machinery and computers	Machinery and equipment	Rubber and plastic products	Tobacco products
Audio, TV and communication equipment	Electrical machinery	Other non-metallic mineral products	Textiles
Instrument engineering	Motor vehicles	Basic metals	Clothing
Manufacture of aircraft and spacecraft	Other transport equipment	Fabricated metal products	Leather products
		Building and repairing of ships and boats	Wood products
			Pulp and paper products
			Publishing and printing
			Manufacturing n.e.c.
			Recycling

Source: European Commission, 2006

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3 Matching demand and supply of CRC services

André Spithoven and Mirjam Knockaert

3.1 Introduction

As firms are increasingly dealing with complex technology and scientific knowledge, the need for external knowledge resources (von Hippel, 1988) and the dynamic capabilities to use them (Eisenhardt and Martin, 2000) becomes more acute (Chesbrough, 2003). Technology transfer is, therefore, recognised as an indispensible ingredient in the development of innovative capabilities. The concept of technology transfer has several definitions. Dodgson et al. (2008) define it as "the movement of technological capability – typically a package of artefacts, rights and services – from supplier(s) to potential user(s)." (Dodgson et al., 2008: 303). Bozeman (2000) cites Roessner's definition as "the movement of know-how, technical knowledge, or technology from one organizational setting to another." (Bozeman, 2000: 629). This multitude of definitions points to the contextual dependency of technology transfer (Williams, 2007). Technology transfer can be organised internally (Hansen, 1999; Haas and Hansen, 2007) or externally (Kessler and Bierly, 2000) to the firm (Eisenhardt and Santos, 2002). Dodgson et al. (2008) also identify 'quasi-internal' transfers between dependent organisations such as joint ventures and alliance partners. McEvily and Marcus (2005) also detect joint problem-solving arrangements facilitating acquisition of capabilities. They, however, use suppliers as offering services and use the term "embedded ties" to stress their dependency.

Technology intermediaries can be seen as crucial nodes in the network with and between a variety of users (Bessant and Rush, 1995; Howells et al., 2006). These intermediaries deploy particular activities and offer specialised services. On the other hand, users are recipients of these activities and services, often on their own explicit demand. This chapter analyses the collective research centres in Belgium to explain how technology intermediaries serve their users, and to what extent these services are used and appreciated by the users themselves. These collective research centres are part of the Belgian innovation system (Capron and Meeusen, 2000). They are private initiatives in particular industries and as such are governed by private stakeholders. These are usually large firms that are heavily involved in technical progress. Being heavyweights, they determine for a large part what research topics are to be addressed. Smaller firms benefit from the trickle down mechanism through the various dissemination channels of the collective research centres. As these collective research centres are organised to a large extent in a bottom-up way, the expectation is that they identify the needs of their users sufficiently. In other words, we expect a match between the perceptions made by collective research centres when confronted with the views of their users (Boardman and Bozeman, 2006). Two dimensions are reviewed in this chapter: the motives of users to call upon these technology intermediaries and the use and appreciation of the various services offered by collective research centres.

Therefore, probing into the motives of firms to start up search strategies becomes an issue. Three motives are identified in the literature. First, firms are involved in search strategies with other organisations to look for new research possibilities, knowledge and technologies (von Hippel, 1988; Onida and Malerba, 1989; Lee, 2000). Second, firms need to strengthen their knowledge base internalising new knowledge and techniques (Santoro and Chakrabarti, 2002). Third, search strategies are aimed at interacting with specialised and skilled labour (Schartinger et al., 2001).

Technological intermediaries such as collective research centres have designed a supply of activities directed to meet the needs of their sector. These needs are, consequently, to be identified correctly by

these intermediaries if they are to exert an influence and act as a means of leverage directed at more or better output. The array of support activities are depicted by pointing to them in terms of variety or use and intensity or appreciation. Both characterisations of services provided by collective research centres are to be examined to highlight the way in which these organisations support users and, therefore, the ways in which the interaction runs and the effects they (be it indirectly) resort. Hence, the level of analysis is on the dyadic relationships between intermediaries and their users. The users of collective research centres are often firms active in traditional and mature industries; e.g. textile, machine building, and construction. These firms are far less R&D intensive than firms active in emerging industries or in the case of high-tech start-ups (Colombo et al., 2006), like bio- or nanotechnology, or than science based industries such as pharmaceuticals. Much debate on knowledge and technology transfer has been done in the case of these emerging sectors (Sapsed et al., 2007), but far less research has been performed in the case of traditional industries.

This chapter aims to address this shortcoming by focussing on the search strategies for knowledge and technology of firms active in traditional and mature industries. A substantial part of this type of industries have since long created a specialised private technology intermediary – the collective research centre – with various tasks. One of these tasks is to screen and translate the latest available technology on behalf of and for the application by the users of these centres; another is to address troubleshooting and providing information. Either these requests are initiated by the user in a bottom-up way, or the centre takes the initiative and distributes the relevant findings.

Search strategies on support for innovation by firms have been subject of vehement investigation in the past (Laursen and Salter, 2004, 2006). Search strategies are a vital part in building innovative capabilities (Dodgson et al., 2008). Following Katila and Ahuja (2002) they are defined as activities designed to mix and combine new or existent knowledge and technology targeted at solving problems. Starting from the seminal work of van Hippel (1988) demonstrating the need for external sources for innovation, the role of search strategies has been further explored to explain the use of external sources. In most cases, search strategies have been studied in the context of university-industry relationships (OECD, 2002; Laursen and Salter (2004). This is usually done through large scale surveys (e.g. the Community Innovation Survey in most European countries) that are not especially designed to capture these strategies.

The reasoning behind search strategies connected to external knowledge relations is the lack of internal capacities to generate the needed information in order to innovate and grow. Search strategies are, however, determined by internal capabilities like absorptive capacity (Cohen and Levinthal, 1990) and human capital (Haesli and Boxall, 2005), etc. But search strategies are also framed by the availability and accessibility of external knowledge (Klevorick et al., 1995). External knowledge comes in many forms and through many channels (Laursen and Salter, 2006). In the case of traditional firms the reliance on external knowledge resources is only possible if specialised technology intermediaries exist. The aim of this chapter is to provide an understanding of the search strategies for innovation of firms with technology intermediaries. The novelty of this paper lies in the fact that the dyadic relationship between the user and the intermediary is appreciated from the two sides, whereas previous studies have either looked at the transferor or receiver of information (e.g. all papers using the community innovation surveys, e.g. Laursen and Salter, 2004; Tether and Tajar, 2008).

Also we introduce the need for extending the notion of absorptive capacity by pointing to the need to emphasize the role of knowledge articulation in dyadic relationships. The receptiveness of firms to search strategies is mostly seen in disconnection to the ways in which the provider of services offers technology transfer and knowledge. Yet, these channels and mechanisms are extremely important in getting the messages through. In the case of universities this is most clearly seen: they perform research which is ‘automatically’ captured by whichever firm has enough absorptive capacity to realise what is going on (Laursen and Salter, 2004). Universities as a source of innovation are much less

important than universities as cooperation partner (Spithoven and Teirlinck, 2006; Becker, 2003). In the case of smaller firms in traditional industries, the resources that form absorptive capacity are limited from the start (Gann, 2001). This has resulted in a high reliance on technology intermediaries, especially by smaller firms in traditional industries (Spithoven et al., 2008).

The need for external knowledge is not restricted to firms in emerging or high tech industries but also counts for firms active in traditional industries. Besides, this need has become more intense given that technical progress has enlarged the complexity of producing to the extent that no firm has all the relevant knowledge (Chesbrough, 2003). However, this last category often lacks the resources to engage in dyadic relationships with external agents. These relationships can be kept with other enterprises, such as clients, suppliers, other firms within the sector, or they can be maintained with public research organisations, such as universities or research centres. Several public and private initiatives have however been taken in order to facilitate these relationships. One of these initiatives are the technology intermediaries. These intermediaries or bridging institutions are created with the goal to perform the transfer function between those that offer the services (transferors) and those demanding them (recipients). Some of these intermediaries have been in place for a long time and the transformation of the economy to a knowledge based economy also puts them into a challenge to respond to these new circumstances.

Because users are involved to a significant extent in the agenda setting of the centres by means of their presence in the technical committees, the relationship between collective research centres and their users is one in which transfers can be characterised as quasi internal. It is expected that quasi internal technology transfer suffers less from the public good dilemma that considers knowledge a public good from which every user can benefit irrespective to its contribution to the creation of this knowledge (Cabrera and Cabrera, 2002; Becker and Knudsen, 2003).

The key research questions are the following. What determines the search strategies of the users of technology intermediaries? Possibilities range from R&D activity or intensity, absorptive capacity, resource constraints, and competences to interact. Are there (mis)alignments in the opinions held by the collective research centres compared to their users on the motivation to call upon a centre and the use and appreciation of support activities? A proper attentiveness of the centres is expected since they are to an extent guided by their users in technical committees. But if misalignments occur, do they exert an impact on performance measures?
This chapter is organised as follows. Section 2 reviews the theoretical aspects involving search strategies for knowledge and technology and offers a hypothetical framework. Three lines of theoretical building blocks are reviewed: absorptive capacity, resource based view, and knowledge articulation. Finally, the two protagonists in technology transfer are confronted with each other and the expected effects of the knowledge and technology transfer are highlighted. Section 3 looks closer at the data, conceptualisations and empirical methods. Section 4 presents the results of the analysis and discusses them in the light of the literature. Section 5 concludes by summarising the main results and points to limitations and future work in this domain.

3.2 Conceptual framework – determinants of search strategies

In what follows, we elaborate on those theoretical insights that may allow us to better understand the search strategies of users calling upon the technology intermediary. In what follows, we build on absorptive capacity, the resource based view and knowledge articulation.

3.2.1 Absorptive capacity

Cohen and Levinthal (1990) launched the concept of “absorptive capacity” emphasizing the ability of firms to recognise and assimilate valuable external knowledge and technological information and to use it to commercial ends. In their view, the effective evaluation and use of external sources of knowledge depend on the ability to benefit from the transfer of this knowledge and technology (Todorova and Durisin, 2007). Identifying external knowledge and technology does not assume the use of complex scientific or technological knowledge, but requires knowledge about technology at the user level and knowledge of business trends (Arbussa and Coenders, 2007). Szulanski (1996) and Reagans and McEvily (2003) argued that limited absorptive capacity of users acts as a barrier to knowledge and technology transfer.

At firm level, absorptive capacity can be generated in a variety of ways: by investing in R&D, as a by-product of a firm’s manufacturing operations or by sending personnel for advanced technical training (Cohen and Levinthal, 1990). But Cohen and Levinthal (1990) explicitly acknowledge that absorptive capacity can be organised externally. They remain, however, sceptical about the potential success of absorptive capacity organised in this way because of the firm specificity of certain types of information. On the other hand, the development of a specialised market for technology (Arora et al., 2001; Howells, 2006) suggests that at least some absorptive capacity of firms is available outside the firm boundaries. These intermediaries (Howells, 2006) act on behalf of their users or clients and therefore have to be well aware of their needs (Bessant and Rush, 1995). Bell (2005) and Hervas-Oliver and Albors-Garrigos (2007) even discussed a cluster level of absorptive capacity, stressing longitudinal relations between two or more organisations.

The supply of support services by technology intermediaries had to be picked up by their users in order to be effective. Hence these users have to mobilise their resources and develop appropriate capabilities to internalise the knowledge and technology. This is what Cohen and Levinthal (1990) call absorptive capacity. In the case of collective research centres it is said that part of the absorptive capacity is localised in these centres themselves (Spithoven et al., 2008), making technology transfer a function of the ability of centres to transmit technology (Mahnke et al., 2003).
Dyer and Singh (1998) and Lane and Lubatkin (1998) relate absorptive capacity to the inter-organisational level. First, Dyer and Singh (1998) stressed the presence of external resources of firms and inter-firm linkages as a source of competitive advantage. They, however, theorise about value creating linkages between independent organisations, whereas this is only partially the case for collective research centres as they are member organisations and hence operate not entirely independent. Ouyang (2008) refers to this as non-equity alliances and clearly differentiates these from licensing activities, joint ventures and acquisition. In short, the relevant part of the insights of Dyer and Singh (1998) pertains to the distribution of the resources and abilities (like absorptive capacity) of a company over different organisations.

Lane and Lubatkin (1998) reformulated absorptive capacity as a construct at dyad level and referred to it as ‘relative’ absorptive capacity. The arguments of learning ability depend on the knowledge base, the organisational structure and the dominant logics between the organisations. As to the similarity of the knowledge base, Lane and Lubatkin (1998) follow Cohen and Levinthal (1990:136) and state that prior knowledge in a firm must meet two criteria to identify and value new external knowledge: a similar knowledge base between the receiving and transferring organisation and a partial diversity to use the new specialised knowledge. This is precisely the case for the collective research centres in Belgium.

The previous discussion leads to hypothesising the following relations between absorptive capacity and the use of support services.

Hypothesis 1a: the higher the absorptive capacity of users and CRCs, the more active use is made of support activities

Hypothesis 1b: the higher the absorptive capacity of users and CRCs, the higher the support activities are appreciated

3.2.2 Resource constraints

Another theoretical line of thought that is relevant in the study of knowledge and technology transfer is the resource based view. Since the 1980s the resource based view of the firm has been developed to highlight some strategic options an organisation takes (Wernerfelt, 1984). This theoretical framework has sparked others to investigate search strategies (Barney, 1991; Barney et al., 1994). Resources and capabilities are deemed to be unique from a firm's perspective (Teece et al. 1997). Reasons for this can be found in the shortage of organisational flexibility in developing new capacities, the costs of input diminishing potential returns, and the lack of an appropriate market mechanism for key assets involving tacit knowledge (Teece et al., 1997). Following Barney (1991), Laursen and Salter (2006) see search strategies as inevitable instruments empowering firms to affect their initial resource endowments. Firms and other users do not always possess enough resources to engage in innovative activities. The resource based view sees firms as having accumulated unique resource endowments or developed firm specific capabilities (Nelson and Winter 1982; Wernerfelt, 1984; Barney, 1991; Teece et al., 1994). Resources can be financial, technological, human or organisational by nature (Barney, 1991). Mowery et al. (1998) add to this type of resources specific market knowledge or knowledge on user needs. These items are particularly relevant in the context of quasi internal transfer activities.

The resource based view argues that the motive behind knowledge and technology transfer is the need for users to access external knowledge and specific help to implement the latest technology that they are not capable or willing to develop internally. Some specific resources might be missing in order to tap into external knowledge flows and/or to transfer/translate the necessary (complementary) information into use of the firm. That is why the resource based view has been used in the past to examine partner choice in collaborative agreements, and especially in the search strategy for external technology capabilities (Mowery et al., 1998). Companies may therefore call upon technology intermediaries in order to bridge their gap in resources. Recently, the resource-based view has also been applied to act as determinant for the interactions of university researchers (van Rijnsoever et al., 2008).

It therefore can be expected that the resource constraints that companies are faced with will affect their search strategies. Moreover, the suggestion in the context of open innovation practices is that firms no longer need to have full control over these resources (Dahlander and Wallin, 2006). Sourcing them from quasi internal organisations like collective research centres suffices for users in traditional industries.
Although the resources in question are often intangible assets and closely related to knowledge components (e.g. technical information), we do not use the knowledge based view because it fails to serve as a theory of strategy and when used as such knowledge is considered a resource (Eisenhardt and Santos, 2002). Moreover, the resource based view originates from and is often applied at the level of organisations (van Rijnsoever et al., 2008). We, however, use this tradition to examine the dyadic relationship between centres and their users to transfer knowledge and technology.

The considerations expressed above result in the following hypotheses:

Hypothesis 2a: The more resource constraints users have, the more they call upon the services offered by the technology intermediary

Hypothesis 2b: The more resources constraints users have, the more the provision of support activities is appreciated

3.2.3 Knowledge articulation

Absorptive capacity refers to the receptiveness of individuals and organisations to screen and adopt external knowledge and technology. A twin concept is the transferring capacity of an organisation (Knudsen and von Zedtwitz, 2003). As demonstrated earlier (Spithoven et al., 2008), technology intermediaries are explicitly aimed at transferring relevant knowledge and technology and information. But this knowledge and technology have to be successfully communicated and conveyed from one actor to the other, especially in the case of external knowledge sourcing (Becker and Knudsen, 2003). This presupposes similarities between organisations either in terms of small cognitive distances (Nooteboom, 2001), or in terms of equal knowledge levels between transferring and receiving organisations (Knudsen and von Zedtwitz, 2003). When particular technology intermediaries are governed in a bottom-up fashion, and technology transfer becomes quasi internal the cognitive distances are indeed very small.

Zahra and George (2002) introduce the notion of social integration mechanisms which facilitate absorptive capacity. The key idea behind this is that all dimensions of absorptive capacity are made up of social interactions and, therefore, affected by the interplay of social integration mechanisms (Zahra and George, 2002; Todorova and Durisin, 2007) also between organisations (Dyer and Singh, 1998). The way in which the communication runs at the inter-organisational level, therefore, becomes a critical factor.
Haas and Hansen (2007) discern two distinct types of knowledge sharing mechanisms: electronic or written documents and personal interactions. Various channels carry personnel interactions: face-to-face; phone; meetings; site visits; and e-mail (Bennet and Robson, 1999; Haas and Hansen, 2007). Mowery et al. (1998) label these channels as integrative mechanisms in their discussion of internal knowledge transfer. As our samples of technology intermediaries are organisations that have strong ties with their users, the forms of personal interactions are deemed most influential in quasi-internal knowledge transfer (Dodgson et al., 2008). This does not, of course, imply that the use of electronic documents or channels that deal more with codified knowledge, is devoid of any relevance.

A key distinction in the literature on knowledge and technology transfer is that between tacit and codified knowledge (Cowan et al., 2000; Haas and Hansen, 2007; and Nooteboom (2001) for a critical view). Teece (1986) pointed to the tacitness of knowledge as an important impediment for knowledge transfer. The reliance on networks or communities has been hailed at facilitating tacit knowledge (Reagans and McEvily, 2003; Inkpen and Tsang, 2005). Technology intermediaries might be considered relevant in this context as they are intimate to the social networks of firms (Tsai, 2001; Reagans and McEvily, 2003). But, as Nooteboom (2001) critically points out, the distinction between tacit and codified knowledge largely remains academic as all knowledge is embedded in cognitive frameworks and remains at least partially tacit because using codified knowledge calls for re-embedding it into the cognitive framework in order to absorb it. And this re-embedding depends on tacit knowledge.

The previous discussion demonstrates clearly the theoretical struggle to extend the concept absorptive capacity in terms of the capacity to communicate knowledge and technology. Absorptive capacity as such is a static concept. Therefore, based on Lazaric et al., (2003) and Kale and Singh (2007), we use the term knowledge articulation to highlight the amalgam of factors at work to facilitate knowledge and technology transfer in the context of alliances. Hence, knowledge articulation becomes an indispensable ingredient in the transfer of knowledge and technology (Lazaric et al., 2003). Interorganisational flows of knowledge and technology are characterised by various impediments to transfer and by search costs (Szulanski, 1996; Zander and Kogut, 1995; Tsai, 2001; Reagans and

McEvily, 2003). Failing to engage in knowledge articulation because of inadequate communication channels or interaction might lead to soaring transaction costs (Mahnke et al., 2003; Kautz and Mahnke, 2003). Chesbrough (2003) presupposed the existence of abundant knowledge in his popular ideas on open innovation. This revived the scientific interest on the uptake of external information by stressing key elements of search strategies (Laursen and Salter, 2004, 2006) and absorptive capacity (Cohen and Levinthal, 1990). As demonstrated earlier (Spithoven et al., 2008), collective research centres are explicitly aimed at transferring relevant knowledge, technology and information. Tailoring the support services by technology intermediaries to their users is influenced by the intensity of interaction and trust (Bennet and Robson, 1999).

Hence two additional hypotheses are formulated:

Hypothesis 3a: The more intense the knowledge articulation between technology intermediaries and users is, the more active use is made of support activities

Hypothesis 3b: The more intense the knowledge articulation between technology intermediaries and users is, the higher the support activities are appreciated

3.2.4 Effects of technology intermediaries: do users benefit?

Absorptive capacity, resource constraints and knowledge articulation help to understand the motives and mechanisms that play a role in the interaction with technology intermediaries. As such, all elements are expected to exert an effect beneficial to the users. Cohen and Levinthal (1990) frame their discussion on absorptive capacity in the ability to exploit the external knowledge internally and gaining from it in the process in terms of commercialisation of new products or services. The effects of knowledge and technology transfer on performance have also been stressed by the knowledge based view of the firm (Grant, 1996) which is itself part of the resource based view (Eisenhardt and Santos, 2002). Here the effects are measured in terms of creating and sustaining competitive advantage by the user (Eisenhardt and Martin, 2000). As indicated earlier, knowledge articulation functions as the oil of the machine by facilitating knowledge and technology flows.

Standard performance measures, however, capture many additional influences apart from the reliance on technology intermediaries. Therefore, this chapter looks into the direct effects of knowledge and technology transfer by technology intermediaries by looking at various performance measures. These can be split up into two groups: those related to market performances and those related to productivity effects.

Dyadic relationships lead, potentially, to differing opinions or perceptions by emittent and recipient. Users of support services may perceive their usefulness differently than the technology intermediaries offering them. Since our type of technology intermediaries, the collective research centres, are governed in a bottom-up way, the expectation is that this usefulness is negligible. Or, the other way around, the technology intermediaries are expected to be attentive to the needs of their users. In the remainder of this chapter the (mis)alignments between the perceptions of users and technology intermediaries are seen as a measure of “attentiveness” to the needs of the users by technology intermediaries. The potential effects of (mis)alignments can be seen by looking at their performances in terms of the effects of the technology transfer activities by the technology intermediaries.

We saw earlier that collective research centres and their users are intimately related since the users, at least partially, steer the actions and define the interest domains of these centres (e.g. by technical committees). But these centres also possess a fair amount of autonomy. This implies that attentiveness by collective research centres for their users is not automatically assured. If technology transfer is to be ensured or facilitated and resorts positive benefits, it might be expected that similarities in perceptions are to be welcomed. Dissimilar organisations are less likely to engage in

technology transfer (Cantwell and Barrera, 1996). On the other hand, the use of support services offered by collective research centres, even if their importance is perceived in perfect alignment, presupposes that the 'receiver' possesses capabilities that complement the technology transferred (Cohen and Levinthal, 1990). In short, all elements have to be taken into consideration if a complete picture is to be drawn.

The previous discussion leads to the following set of testable hypotheses:

Hypothesis 4a: The use and appreciation of support services from technology intermediaries are beneficial to the performance of users

Hypothesis 4b: Knowledge articulation positively affects performances of users

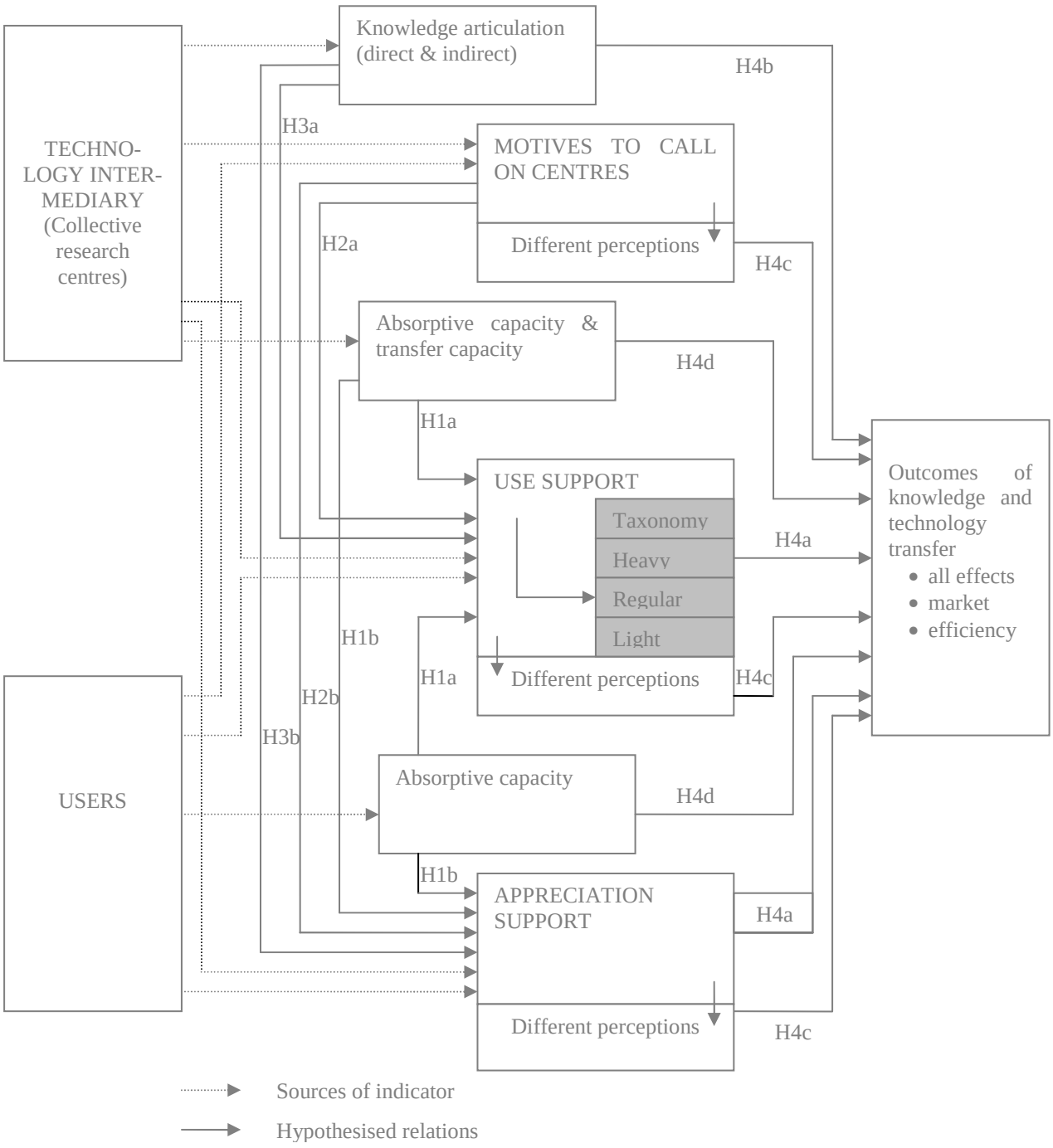
Hypothesis 4c: Attentiveness of technology intermediaries to users' needs – i.e. similarity in perceptions – exerts a positive impact on the performance of users

Hypothesis 4d: A higher absorptive capacity of users and technology intermediaries positively influences the performances of users

3.2.5 A conceptual model of knowledge and technology transfer

Figure 1 summarises the conceptual framework that aims to unpack the mechanisms explaining the relevance of collective research centres.

Figure 1: Conceptual model of technology transfer



3.3 Data and method

3.3.1 Samples

This chapter aims to contrast the views of the collective research centres with those of their users. Two distinct populations have been identified. The first consists of all twelve collective research centres that are active in Belgium. They are dedicated to do collective and contract research on behalf of their members and other users. It has already been pointed out that most of them have compulsory membership. All but one of the smallest collective research centres have completed the semi-structured questionnaire that was sent to them. The CEO of the collective research centres, often together with their technology transfer officer, had to assess the use and appreciation of their offered support services by their users. This information reflects the ways in which these centres see their value added and it helps them devise internal policies and organisations to reach the majority of their users (some of which are present in their board of directors and their technical committees).

The second population draws upon the users of the collective research centres. These data were gathered with the aid of the collective research centres. They sent the internet based questionnaire to their database addresses. These are, however, not all members of the centres. As indicated, the users' database consists of member firms, non-member firms and other organisations such as federations, research centres, universities. A similar questionnaire has been sent out to the acquaintances of the collective research centres. These acquaintances include organisations that have worked with these centres before or have not worked with them. Moreover, they present also a mix of members and non-members. By constructing the sample this way, it consists of a balanced number of different users. In total 856 responses were received. The issue of representativeness is dealt with in the following way: both the users of the collective research centres and those not relying on or working with these centres were asked to provide the data on the evolution of employment and turnover and the R&D intensity. The Pearson chi-square tests did not reveal any significant differences between the two groups and hence it is concluded that they do not differ significantly.

The level of analysis in this chapter is, however, the dyadic relation between the collective research centre and its users. Since it is known, for each user, with which collective research centre it has interacted, the combined database coupled the opinions of the collective research centre to those of the user. Therefore, the potential of usable answers is 642 users.

3.3.2 Variables and constructs

This section reviews the variables that are used in the subsequent analysis and demonstrates how the constructs are made. All variables and constructs are summarised in the Table A1 in the Appendix.

Use of support services. The collective research centres offer a wide range of different support services. The list was compiled from consulting the websites of the centres and from interviews with their representatives. The respondents of the surveys were given a list of services: use of the R&D laboratory by the user; information on European R&D programs; access to the technical library; use of qualified personnel from the centre; sale of equipment; use the right to use inventions; use the results of contract and collective research performed by the centre; use thorough technical advice; support and advice on normalisation and standard setting; information on intellectual property rights; use of certification services; use of consulting and audits; performing testing and experiments; feasibility studies; use of information (websites, publications, newsletters); use of norm antennas; use of the centre in European technology platforms; rely on the networking activities of centres in industry-science relations; use the organisation of study days and seminars by centres; use the results of technology watch and technological roadmapping; use specific advice (troubleshooting, technical

advice, technology guidance and technical innovation stimuli). The respondents were asked to indicate the extent to which they used the service (for users) or they believed their members to use the service (for CRCs). A 7-point Likert scale was used, ranging from 1 (= never used) to 7 (= often used). Summated scales were used to capture the total use of the support services by the users (USE); Cronbach $\alpha = 0.93$.

Appreciation of support services. The identical set of support services was reviewed with respect to the importance the users attached to these services and, therefore, can be seen as an appreciation of these services. Again, we asked both users as collective research centres to indicate the appreciation for each of the activities mentioned above. A 7-point Likert scale was used, ranging from 1 (little importance) to 7 (high importance). Summated scales captured the total appreciation by users made of the support services (APPR); Cronbach $\alpha = 0.94$.

Absorptive capacity. We construct variables for absorptive capacity at user and centre level. Following Cohen and Levinthal's seminal article, absorptive capacity is usually operationalised as the existence and/or intensity of a company's R&D activities (Veugelers, 1997; Lane and Lubatkin, 1998; Oltra and Flor, 2003). Lane and Lubatkin (1998), moreover, criticise the reduction of absorptive capacity in this way as if it were a static resource instead of a capability. Further critique on the interpretation of absorptive capacity in terms of R&D activities states that it ought to be viewed as a multidimensional concept (Lennox and King, 2004; Schmidt, 2005). Absorptive capacity can also be measured through the use of skilled employment figures or other measures that proxy qualified personnel (Mowery and Oxley, 1995). This chapter uses several important elements of absorptive capacity pertaining to both the user – its R&D intensity – and the technology intermediary – its employment in terms of function and qualification of its personnel. In the specific case of users of collective research centres, which are predominantly not quite research active or research intense, part of the build up of absorptive capacity is 'subcontracted' to the collective research centre (Cohen & Levinthal, 1990; Spithoven et al., 2008). This is why technology transfer is characterised as 'quasi-internal' (Dodgson et al. 2008). For the users, we measure absorptive capacity as the share of R&D expenditures as percentage of turnover, or R&D intensity (RDI). The respondents were asked to categorise their R&D intensity in four intensities: no R&D; R&D intensity less than 5%; R&D intensity between 5 and 10%; and R&D intensity over 10%. For the collective research centres, we measure the number of personnel (in full time equivalents) active in R&D (LPRD) and scientific and technology activities or related R&D activities (aimed at technology transfer to the users) (LPSCT). The qualification of this labour effort is also brought into account: university degrees (LPUNI) and secondary education (LPSUP). For these four variables, we use the natural logarithm.

Resource constraints. As a basis for measuring resource constraints, we use the questionnaire used in the Community Innovation Survey. We measure perceived high economic risk and uncertainty associated with R&D projects (RISK), the costs involved in these projects (COST), the lack of financial resources (FIN), the organisational structure of the user that is often not acquainted with performing R&D activities (ORG), the lack of qualified personnel since most personnel is active doing other indispensable tasks such as sales or production (PERS), and the lack of technological (TINF) or market information (MINF). Respondents had to scale each of these motives for calling upon the centre from 1 (= not important) to 7 (= very important). This question was also put both to the users and the representatives of collective research centres. As before, these representatives had to rate these motives with the users in mind, i.e. why do users call upon your centre.

Knowledge articulation. Users call upon collective research centres to perform part of their R&D activities and screen the environment for available and useful scientific and technological information. Hence they are often not reliant on formal protection mechanisms such as patents (like the pharmaceutical sector) or copyrights (software). They have to benefit from innovations and external knowledge and technology through strategic appropriation (Veugelers & Cassiman). Strategic

appropriation can be proxied by mechanisms such as secrecy, design, lead time to market. But the means to build this strategic appropriation in the case of the users of centres is through the use of the flow of tacit knowledge. This makes the interaction between centres and the users (often through personal relations between the individual within the user organisation and the technology advisor or technology innovation stimulator in the collective research centre) a vital point in transferring knowledge and at the same time safeguarding – partially also due to firm specificity – the knowledge from unwanted spillovers. The interaction between users and centres is characterised in two ways relevant for the transmission of tacit knowledge: direct (face-to-face contact and via meetings) and indirect (phone and mail). These communication channels are labelled knowledge articulation.

Attentiveness. The collective research centres have been created on behalf of their users. These users are member firms, other firms in the sector, and various other private (non-profit) and public (universities, government agencies) organisations. This implies that the organisation of the activities at the centres has to be directed to accommodating their users. This is referred to as "attentiveness" to their users. The attentiveness is measured as the differences in opinion between the centres and their users to see if their views collide. How are these differences measured? For each dyadic relation the Likert score of the item response by the collective research centres is deduced by the score given by the user. In the case where both scores are identical, the difference is zero. Does the opinion of the centre exceed that of the user, the aforementioned is overstating its impact. Are the scores given by the user in excess of those by the centre, the centres have understated the use of their support service. A set of three differences was examined: the motives to call upon collective research centres (DMOT), the use made of support services (DUSE), and the appreciation of the services offered (DAPPR). If the perceptions of the representatives of the collective research centres are in line with those of the users, does that unambiguously imply that the centres perform their tasks well and no adjustment should be made? This calls for investigating the effects of dealing with collective research centres and the role played by the attentiveness.

Effects of knowledge and technology transfer. Using a questionnaire undoubtedly has the advantage to ask directly what effects the reliance on collective research centres brought forth. The focus was on the output indicators related to knowledge and technology transfer. A variable using the summated scales was calculated comprising all eleven possible effects (ATE): develop new products; market new products; enter new markets; enlarge product scale; expand market share; raise turnover; strengthen image; modify production process; offer better services; avoid disputes; save costs. In this construct the Cronbach α = 0.92. Two additional measures were calculated: one with respect to market related effects (MRTE) using the first six items (Cronbach α = 0.95); and one reflecting efficiency related effects (ERTE) using the last four items (Cronbach α = 0.79).

3.3.3 Taxonomy

Even though it can be stated that firms working with collective research centres can be classified as low tech because of their relatively low R&D intensity, firms in these traditional industries are still very heterogeneous when it comes to searching for knowledge and technology. Under this assumption, the users are involved differently in collective research centres. Therefore, as a first step, an explorative k-means cluster analysis might be the appropriate technique to disentangle users by creating a taxonomy. This practice is not uncommon (e.g. Modrego-Rico et al., 2005). As discriminating elements the 25 channels of support activities are used in the grouping (see Table A2 in the Appendix for an extensive list). The cluster analysis using the Euclidian distance measure on the answers on the use of 25 support activities of 394 users, resulted in three separate groups: "heavy users" (110 users or 28%), "regular users" (108 users or 27%), and "light users" (176 users or 45%) of the support activities offered by collective research centres. As can be seen in Table A3 in the Appendix, these clusters place particular emphasis when it comes to using support activities. Heavy users are involved in collective research centres on many fronts, but especially on R&D related matters. Regular users turn

to collective research centres in search of information (technical library, newsletters, websites and publications), normalisation, norm antennas, and seminars. Light users, the third category, are those firms that do not use the collective research centres in any particular way. In the remainder of the chapter a substantial part of the analysis will be done using these three clusters. These search strategies have different characteristics of users' interaction with collective research centres.

3.4 Results and analysis

3.4.1 Motives for calling upon collective research centres: differing perceptions

Table 6: Alignment of motives: scores of collective research centres and differences with their users

Motives	Obs.	Average score of the centre (0.143 and 1.000)	Difference (st.error). signif.	Obs.	Average score of the centre (0.143 and 1.000)	Difference (st.error). signif.
	Total sample			Heavy users		
Economic risk of R&D	413	0.816	0.398 (0.014) ***	103	0.823	0.364 (0.027) ***
High cost of R&D	413	0.784	0.291 (0.017) ***	104	0.756	0.222 (0.028) ***
Lack financial resources	412	0.667	0.202 (0.016) ***	104	0.647	0.182 (0.028) ***
Lack organisational flexibility	402	0.773	0.277 (0.015) ***	105	0.732	0.260 (0.028) ***
Lack qualified personnel	441	0.858	0.088 (0.013) ***	105	0.852	0.010 (0.018)
Lack technology information	472	0.757	-0.054 (0.013) ***	106	0.759	-0.109 (0.019) ***
Lack market information	417	0.523	-0.074 (0.015) ***	106	0.455	-0.172 (0.026) ***
	Regular users			Light users		
Economic risk of R&D	83	0.850	0.430 (0.039) ***	111	0.768	0.397 (0.028) ***
High cost of R&D	83	0.845	0.341 (0.039) ***	111	0.717	0.257 (0.034) ***
Lack financial resources	83	0.710	0.214 (0.038) ***	111	0.617	0.175 (0.031) ***
Lack organisational flexibility	81	0.815	0.351 (0.035) ***	105	0.647	0.235 (0.030) ***
Lack qualified personnel	98	0.863	-0.038 (0.018) **	118	0.847	0.207 (0.031) ***
Lack technology information	106	0.726	-0.207 (0.018) ***	129	0.781	0.064 (0.027) **
Lack market information	87	0.658	-0.038 (0.034)	110	0.418	-0.056 (0.027) **

Table 6 looks at the motives to call upon collective research centres from two different perspectives. First, the centres were asked to rate the relevance of various motives for their users to call upon them. Because we examine the two-way dyadic relationship, the number of observations is higher than the number of centres. These scores are reported in Table 6 as the average score of the centre and this score ranges between 0.143 (less important) and 1 (highly important). The same questions were put to the users themselves. This, inevitably, resulted in a measurement of differing perceptions. These differences, as seen in Table 6, are highly statistical significant for all motives. Clearly, for the total sample, the centres overestimate the importance of the centre for issues such as economic risk, bearing the high cost of R&D and to meet resource needs (financial and organisational). Although overestimated, the difference of perceptions is the lowest for the qualified personnel, which also received the highest score (0.858). On the other hand, the provision of information (both technical and market) is significantly underestimated by the centres, even though, in absolute terms, the differences are only minor.

The taxonomy, made earlier, points to slightly different emphases. In the case of heavy users the same pattern as for the total sample is detected. Only the motive to call upon the collective centre for their qualified personnel is rated identically. Regular users differ more in this respect: here the motive for qualified personnel, which again receives the highest score, is underestimated by the centre, pointing to the need for this personnel to help regular users. As expected, the light users show the

lowest average scores for all motives, but even then most of them are overestimated (except in the case of market information).

3.4.2 Alignment of the use of support services

This section looks at the differences in opinion on the use of support activities. Because the emphasis is on the dyadic relationship, a two-tailed paired t-test is appropriate to look at the difference of means: only for those relationships for which both the view of the collective research centre and that of the user are accounted for. These opinions differ, as measured by the estimation of the centres in which the support service matters for the user (Likert scale between 0.143-1) minus the opinion as formulated by the user him/herself on the same support activity. The results are shown in Table 7.

Table 7: Alignment of the use of support services

Support services	Obs.	Average score of the centre (0.143 and 1.000)	Difference (st.error). signif.	Obs	Average score of the centre (0.143 and 1.000)	Difference (st.error). signif.
	Total sample			Heavy users		
Use R&D lab	488	0.827	0.438 (0.014) ***	109	0.833	0.109 (0.024) ***
EU R&D programs	488	0.800	0.493 (0.016) ***	109	0.735	0.162 (0.038) ***
Technical library	488	0.845	0.321 (0.016) ***	109	0.725	0.032 (0.031)
Qualified personnel	488	0.885	0.468 (0.016) ***	109	0.876	0.196 (0.031) ***
Sale equipment	488	0.251	0.054 (0.010) ***	109	0.252	-0.014 (0.024)
Use inventions	488	0.394	0.182 (0.012) ***	109	0.363	0.049 (0.028) *
Research activities	483	0.754	0.449 (0.014) ***	106	0.742	0.151 (0.032) ***
Technology advice and innovation	392	0.776	0.268 (0.016) ***	109	0.748	-0.001 (0.022)
Thorough technology advice	324	0.598	0.114 (0.019) ***	56	0.593	-0.190 (0.034) ***
Normalisation	324	0.851	0.415 (0.018) ***	56	0.836	0.094 (0.035) ***
Information on IPR	324	0.580	0.359 (0.013) ***	56	0.617	0.214 (0.041) ***
Certification	324	0.853	0.528 (0.016) ***	56	0.849	0.236 (0.045) ***
Consulting and audits	324	0.929	0.623 (0.015) ***	56	0.935	0.384 (0.046) ***
Testing and experiments	324	1.000	0.589 (0.018) ***	56	1.000	0.179 (0.027) ***
Feasibility studies	324	0.700	0.453 (0.013) ***	56	0.725	0.289 (0.038) ***
Information services	324	0.918	0.374 (0.016) ***	56	0.944	0.192 (0.034) ***
Norm antennas	280	0.956	0.537 (0.019) ***	56	0.958	0.248 (0.040) ***
EU technology platform	280	0.791	0.508 (0.016) ***	56	0.838	0.297 (0.037) ***
Networking ISR	280	0.748	0.457 (0.017) ***	56	0.806	0.191 (0.043) ***
Seminars and study days	280	0.941	0.480 (0.018) ***	56	0.966	0.239 (0.034) ***
Technology watch	280	0.824	0.596 (0.012) ***	56	0.831	0.366 (0.041) ***
	Regular users			Light users		
Use R&D lab	108	0.762	0.451 (0.026) ***	175	0.863	0.574 (0.019) ***
EU R&D programs	108	0.935	0.683 (0.027) ***	175	0.753	0.544 (0.018) ***
Technical library	108	0.944	0.129 (0.024) ***	175	0.839	0.523 (0.021) ***
Qualified personnel	108	0.965	0.480 (0.035) ***	175	0.824	0.553 (0.025) ***
Sale equipment	108	0.203	0.028 (0.021)	175	0.273	0.108 (0.013) ***
Use inventions	108	0.335	0.153 (0.021) ***	175	0.423	0.255 (0.016) ***
Research activities	108	0.857	0.644 (0.019) ***	173	0.694	0.470 (0.019) ***
Technology advice and innovation	108	0.803	0.159 (0.022) ***	175	0.777	0.503 (0.016) ***
Thorough technology advice	101	0.588	-0.063 (0.031) **	123	0.608	0.357 (0.018) ***
Normalisation	101	0.867	0.300 (0.032) ***	123	0.847	0.606 (0.017) ***
Information on IPR	101	0.663	0.466 (0.019) ***	123	0.502	0.343 (0.015) ***
Certification	101	0.861	0.529 (0.028) ***	123	0.851	0.644 (0.015) ***
Consulting and audits	98	0.986	0.741 (0.020) ***	120	0.886	0.716 (0.013) ***
Testing and experiments	101	1.000	0.593 (0.028) ***	123	1.000	0.734 (0.022) ***
Feasibility studies	101	0.714	0.484 (0.021) ***	123	0.681	0.510 (0.015) ***
Information services	101	0.985	0.145 (0.017) ***	123	0.861	0.586 (0.017) ***

Norm antennas	101	0.992	0.485 (0.032) ***	123	0.926	0.712 (0.015) ***
EU technology platform	101	0.830	0.554 (0.025) ***	123	0.739	0.565 (0.016) ***
Networking ISR	101	0.822	0.564 (0.026) ***	123	0.662	0.490 (0.018) ***
Seminars and study days	101	0.988	0.404 (0.030) ***	123	0.890	0.653 (0.018) ***
Technology watch	101	0.855	0.672 (0.011) ***	123	0.795	0.637 (0.009) ***

The table above shows that the heavy users of collective research centres have opinions that are the closest to those of the centre. Although, even in this case, the centres clearly overestimate the use (and to a lesser extent the appreciation) attached by users to the services that CRCs offer. These differences are more than twice as strong in the case of regular and light users.

As seen in the table above, the differences in opinion of the collective research centres on why users call upon them are substantial when compared to the opinions of their users. This inevitably will have repercussions on their internal organisation to source knowledge, organise R&D activities and act as technology transfer organisations. The table also reveals serious differences in terms of both the motive and the taxonomy according to search strategy. Overall the collective research centres overestimate the impact to their members. The exceptions are connected to the information provision by CRCs which are deemed more important by the users than thought of by CRCs. In the case of regular users the lack of qualified personnel as a reason to call upon CRCs is estimated to be a more urgent question for the users. The only matches between CRCs and users have to do with personnel and market information.

3.4.3 Determinants of the use and appreciation of support activities

Users' search strategies related to collective research centres require knowledge on the determinants of the use and appreciation of the support activities they provide. The preceding theoretical section suggested several elements that can play a role. These are summarised in Table 8, where the variables on the use and appreciation of support activities are measured as dependent variables.

Table 8: Determinants of the use and appreciation of support activities

	Use of support activities	Appreciation of support activities
Absorptive capacity		
R&D intensity user	0.027 (0.009) **	-0.017 (0.011)
R&D personnel CRC	-0.086 (0.031) **	0.089 (0.038) *
Tech transfer personnel CRC	-0.013 (0.008)	0.029 (0.011) *
University degree CRC	0.075 (0.037) *	-0.143 (0.053) **
Support tasks CRC	0.015 (0.009)	-0.006 (0.010)
Resource needs		
R&D risk	0.068 (0.037)	-0.013 (0.045)
R&D costs	0.021 (0.041)	-0.024 (0.048)
Finance needs	-0.049 (0.039)	0.144 (0.045) **
Organisation	-0.020 (0.036)	-0.013 (0.042)
Personnel needs	0.172 (0.058) **	-0.087 (0.071)
Technical information	0.008 (0.062)	0.269 (0.082) ***
Market information	0.081 (0.034) *	0.004 (0.040)
Knowledge articulation		
Direct interaction	0.578 (0.093) ***	0.179 (0.113)
Indirect interaction	-0.602 (0.112) ***	0.015 (0.131)
Use of support activities		0.464 (0.071) ***
Constant	0.280 (0.061) ***	0.399 (0.097) ***
Number of observations	322	254
F-statistic	12.60 ***	9.41 ***
Adj R-squared	0.336	0.333

Note: The dependent variables are the use and appreciation of support activities. They are calculated as composite indicators of 28 support activities where each activity has the same weight.

The symbols *,**,*** denote the statistical significance at 5%, 1% and 0.1%. Standard errors between brackets.

First, consider the determinants of the use made of support activities offered by the centres. Absorptive capacity plays a nuanced role: at user level the R&D intensity affects the use of support activities positively, but at centre level the relation with R&D personnel is negative. Apparently there is a substitution effect: when the R&D intensity of users necessitates less reliance on the R&D personnel of the centre, and vice versa. This might point to complementarity where R&D activities are concerned. The qualification of the personnel of the centre, although mildly positive for university degrees, is rather irrelevant. Therefore hypothesis 1a on the expected positive effects of absorptive capacity on the use of support activities is supported only partially.

Looking at which resource needs stimulate the use of support activities most, revealed that personnel requirements score most prominent. Only the need for market information is also making itself felt. Hence, hypothesis 2a is supported, but only with respect to the need for qualified personnel. Knowledge articulation also exerts an impact on the use of support activities, although the choice of channel by which the effects run is very important. The data show that direct articulation (i.e. face-to-face and meetings) have a positive impact on the use; whereas this is not the case for indirect articulation (phone and mail) Direct contact seems to be preferred by users as their problems are mainly firm specific. That is why technology guidance and innovation stimulation often rests on site visits. Again, hypothesis 3a is supported only partially.

With respect to the appreciation of the support activities, Table 8 offers estimates at the right hand side of the table. The same variables as before figure in the regression analysis. But since an appreciation can be only meaningful if the support activity is used, this variable is added as an independent variable in the equation. In the case of absorptive capacity hypothesis 1b is supported partially: there is a mild positive effect with regard to the R&D and tech transfer personnel of the centre; but a clear negative effect from the personnel with university degrees. This might indicate that

these qualifications speak 'different languages' than the users which are mostly interested in immediate solutions to their problems and hence are more interested in applied research. The resource needs that are appreciated most are related to financial needs and, especially, technical information, thus supporting hypothesis 2b. The different modes of knowledge articulation did not enhance the appreciation of support activities, thus refuting hypothesis 3b. However, the more use is made of support activities; the higher the appreciation of these activities.

3.4.4 What determines users' search strategies?

What determines the general use and appreciation of search strategies of users in their interaction with collective research centres? The theoretical section pointed towards absorptive capacity, meeting the lack of resources, and knowledge articulation. Table 9 shows the results.

Table 9: Multinomial logistic regression estimates of the determinants of users' search strategies

	Search strategy	
	Heavy users	**Regular users**
Absorptive capacity		
R&D intensity user	0.272 (0.183)	-0.107 (0.216)
R&D personnel CRC	-0.944 (0.634)	3.163 (0.887) ***
Tech transfer personnel CRC	-0.147 (0.181)	0.866 (0.249) ***
University degree CRC	0.913 (0.816)	-3.871 (1.054) ***
Support tasks CRC	0.478 (0.348)	-0.388 (0.192) **
Resource needs		
R&D risk	0.622 (0.794)	-0.030 (0.931)
R&D costs	-0.464 (0.902)	-0.575 (0.974)
Finance needs	-0.406 (0.852)	-0.529 (0.915)
Organisation	-0.339 (0.737)	0.116 (0.875)
Personnel needs	3.395 (1.197) ***	4.186 (1.541) ***
Technical information	-0.103 (1.328)	1.502 (1.733)
Market information	0.599 (0.705)	0.326 (0.808)
Knowledge articulation		
All interaction channels	1.797 (1.421)	4.889 (1.679) ***
Constant	-5.453 (1.342) ***	-5.982 (1.435) ***
Number of observations	279	279
Loglikelihood ratio	146.37 ***	146.37 ***
Pseudo R^2	0.241	0.241

Note: The base category is the light users

The symbols *,**,*** denote the statistical significance at 5%, 1% and 0.1%. Standard errors between brackets.

Table 9 uses the light users as reference category. Absorptive capacity – especially located within the centres – strongly effects the search strategy of regular users when contrasted to light users. As seen in the descriptive statistics in Table A3 (see Appendix), the in-house R&D intensity is the lowest for regular users (1.63 on a scale from 1 to 4), even when compared to light users. Therefore, regular users use the centres more and this especially with an eye to absorptive capacity.

The multinomial logit estimates for heavy users relative to light users reveal statistical significance only for personnel needs. The impact (and significance) is even stronger in the case of regular users. But overall, the resource base is similar for heavy and regular users compared to light users. Table A3 (see Appendix), however, detects that R&D related resource needs (risk and cost) are higher for heavy than for regular users, while this is the other way around for the other resources (except organisational needs which are almost identical). Closer inspection of Table 9 with regard to the signs of the multinomial logit estimates – even when they are not significant in comparison to light users – reveals these differences between the search strategies of heavy and regular users.

The model specification only allowed us to group all knowledge articulation channels because of the existence of multicollinearity between direct and indirect channels. The search strategy of heavy users did not differ from the light users in this respect. But that of the regular users did: obviously, for regular users, the need for interaction with collective research centres is highly important. Again, this corroborates the descriptive statistics in Table A3 in the Appendix.

3.4.5 Effects of using support activities offered by collective research centres

The impact of collective research centres on their users is an important issue. Because these technology intermediaries have no direct impact on the growth of the firm (in terms of employment and turnover), the effect on the output of users was inquired for in a direct way via the questionnaire. Since most support activities are related to knowledge and technology transfer instead of 'pure' R&D activities, the effects that are measured reflect this. These effects are measured by looking at the results of summated scales formed by an amalgam of transfer effects (ATE). These can be divided into two separate constructs measuring market related transfer effects (MRTE) and efficiency related transfer effects (ERTE). Table 10 summarises the findings using ordinary regression analysis.

Table 10: Performance equations: all effects, market related effects, efficiency effects

	Effects of collective research centres on users' operations		
	All effects	**Market related effects**	**Efficiency effects**
User taxonomy			
Heavy users	0.117 (0.046) **	0.106 (0.048) **	0.115 (0.047) **
Regular users	0.025 (0.033)	0.017 (0.034)	0.087 (0.033) ***
Knowledge articulation			
Direct interaction	-0.324 (0.167) *	-0.308 (0.173) *	-0.070) (0.166)
Indirect interaction	0.356 (0.203) *	0.372 (0.210) *	0.087 (0.204)
Attentiveness			
Difference in motives	-0.117 (0.058) **	-0.119 (0.060) **	-0.084 (0.058)
Difference in use	-0.109 (0.110)	-0.116 (0.114)	-0.138 (0.110)
Difference in appreciation	-0.001 (0.145)	-0.005 (0.150)	0.044 (0.146)
Appreciation of support services	0.250 (0.161)	0.243 (0.167)	0.316 (0.160) **
Constant	0.222 (0.130) *	0.197 (0.134)	0.343 (0.129) ***
Number of observations	251	251	253
F-statistic	6.96 ***	6.10 ***	8.12 ***
Adj R-squared	0.160	0.140	0.184

The symbols *,**,*** denote the statistical significance at 10%, 5% and 1%. Standard errors between brackets. The taxonomy of "light users" has been dropped because of singularity.

In all, the effects measuring the impact of the use and the appreciation of the support activities are brought in as independent variables, next to the modes of knowledge articulation and the attentiveness of the centres to the needs of their users. First, consider the model with all transfer effects as dependent variable. The use of support services is considered using the taxonomy devices earlier since the use is not homogeneous among the various users. Heavy users of support activities by collective research centres benefit significantly more in terms of transfer effects than light users do. This is not the case for regular users. The appreciation of the support activities does not seem to be relevant for the transfer effects.

Knowledge articulation is slightly important. As earlier in Table 8, we see opposite effects according to direct and indirect articulation. This time the immediate impact of direct articulation is negative. But

since the effect is also captured partially by its strong positive effect on the use of the support services, it might be inferred that its impact is indirectly positive but further research is necessary. The same reasoning applied to indirect articulation, although here the impact might be indirectly negative.

As to the attentiveness of the centres, only the difference in motives exerts the expected negative impact on the effects of knowledge and technology transfer to the users. Collective research centres misjudge (see Table 6) some of the reasons for users to call on them and this clearly influences their provision of support activities related to knowledge and technology transfer.

Disentangling the total effects in those that are market or efficiency related (the effect on the image of the user was dropped) demonstrates marked differences between these two sets of effects. The similarity of the results for total and market related transfer effects asserts the dominance of the latter. The efficiency effects, however, shows that regular users benefit significantly more than light users from the use of the support services. The appreciation of support activities exerts, this time, a statistically positive influence on the efficiency of knowledge and technology transfer. The modes of knowledge articulation and the attentiveness of the collective research centres vis-à-vis their users are, in terms of efficiency related transfer effects, statistically insignificant.

3.5 Concluding remarks

The research on technology intermediaries and its users pointed to the existence of complex relations between them. Since the users of technology intermediaries are sector dependent, the chapter focussed exclusively on traditional and mature industries. But even then, the users of the support activities offered by technology intermediaries are far from a homogeneous group, warranting a taxonomy of search strategies. Just as the resource based view hammered on the existence of unique inimitable resources, the search strategies mirror these resources because the users are looking to complement them and, therefore, are also largely unique. Although commonalities and best practices do exist (Eisenhardt and Santos, 2002).

In general, users highly value the qualified personnel of the intermediary. Also the risk and cost of R&D are important reasons for calling upon collective research centres. Technology intermediaries differed in their impact when their perceptions of the motives for users to call upon them were confronted with these users. In some cases an ‘overestimation’ occurred – notably in motives related to R&D – and in other cases an ‘underestimation’ showed up (technology and market information). The taxonomy, however, pointed to interesting differences. Regular users, although not highly R&D focussed like heavy users, still value the need for qualified personnel higher than the intermediaries dealing with these regular users. This counterintuitive finding might be explained by bounded rationality (Cooper et al., 1995). Heavy users experienced in R&D are less motivated to call upon qualified personnel than expected by the intermediaries because they are confident that their qualified labour can cope with the knowledge and technology. Light users limited in R&D are also less motivated to call upon qualified personnel because they have limited resources in this respect and lack in-house absorptive capacity. It should be stated that the opinions of the technology intermediaries on the motives were asked for all types of users, and this might introduce a bias, necessitating further empirical investigation.
Technology intermediaries are also ‘overestimating’ the use of most of their support activities on behalf of their users and this was interpreted as ‘weak’ attentiveness. Again the methodological drawback cited earlier might introduce a bias at this point. Although not considered in this chapter, the implications for both users and technology intermediaries of weak attentiveness because of misalignments can be far reaching. For the technology intermediaries this might influence their internal organisation in order to source the relevant knowledge and technology, to perform R&D activities and

to facilitate the transfer of technology, knowledge and information. For the users, a potential mis-alignment might imply that the offered support services do not cover the users' needs.

Absorptive capacity, resource needs and knowledge articulation have different impacts on the use and appreciation of support activities. The use of support activities is influenced by absorptive capacity with respect to R&D activities of both users and centres. The other elements of absorptive capacity only played a role in the appreciation of these activities once used. Except for the provision of qualitative personnel, the resource constraints did not matter. Knowledge articulation, finally, is only very important in the case of influencing the use of support activities, but does so in a very unequal way: a positive effect results from direct interaction and a negative effect from indirect communication channels. This implies that the joint problem solving and innovative activities between technology intermediaries and their users runs through direct personal contact.

The determinants of search strategies depend on the use that is made of it. In the case of regular users versus light users, the first are very much influenced by absorptive capacity. Both regular and heavy users see their search strategies more affected by the need to rely on qualified personnel than the light users. Knowledge articulation proved important in the case of regular users, and the CEOs of technology intermediaries might benefit from this insight since it implies that not all users are open to all channels. Differentiation in this respect might contribute to higher attentiveness by technology intermediaries.

The performances of the users of technology intermediaries differ according to their taxonomy. Heavy users benefit most, both in terms of market related and efficiency effects. Regular users predominantly use technology intermediaries to stimulate their efficiency. Knowledge articulation, both direct and indirect, has an impact on market related effects. The attentiveness of technology intermediaries only exerts a negative impact as differences in the perception of motives are concerned. Finally, the appreciation of support activities makes itself felt in the efficiency related effects of dealing with technology intermediaries. This might be because of the problem-solving and troubleshooting nature of these intermediaries active in traditional industries, which they themselves are unable to monitor.

3.6 Appendix A2 - Description of the variables

Table A2 – Description of the variables

Variables	Definition
Support services	
Use of support services (USE))	Summated scales of 21 different channels (scaled 1 = not used up to 7 = often used) – Cronbach α = 0.93
Appreciation of support activities (APPR)	Summated scales of 21 different channels (scaled 1 = low appreciation up to 7 = high appreciation) – Cronbach α = 0.94
Absorptive capacity	
R&D intensity of user (RDI)	R&D expenditure in percentage of turnover. No R&D intensity = 1 (0%); R&D intensity less than 5% = 2; R&D intensity between 5 and 10% = 3; R&D intensity more than 10% = 4
R&D personnel of centre (LPRD)	Natural log of the R&D personnel of collective research centres in full time equivalent (FTE)
Tech transfer personnel of centre (LPSCT)	Natural log of the personnel of collective research centres engaged in technology transfer activities in full time equivalent (FTE)
University degrees in centre (LPUNI)	Natural log of the personnel of collective research centres with a university degree in full time equivalent (FTE)
Support tasks in centre (LPSUP)	Natural log of the personnel of collective research centres with a secondary degree in full time equivalent (FTE)
Resource needs	**(O = Collective research centre / U= user of the centre)**
High economic risk (RISK)	Motive to call upon collective centre because of high economic risk of performing R&D (1 = unimportant and 7 = important)
High cost (COST)	Motive to call upon collective centre because of high costs of performing R&D (1 = unimportant and 7 = important)
Financial resources (FIN)	Motive to call upon collective centre because of lack of financial means of the user (1 = unimportant and 7 = important)
Organisational flexibility (ORG)	Motive to call upon collective centre because of lack of organisational flexibility of the user (1 = unimportant and 7 = important)
Qualified personnel (PERS)	Motive to call upon collective centre because of availability of qualified personnel at the centre (1 = unimportant and 7 = important)
Technical information (TINF)	Motive to call upon collective centre because of availability of technical information at the centre (1 = unimportant and 7 = important)
Market information (MINF)	Motive to call upon collective centre because of availability of market information at the centre (1 = unimportant and 7 = important)
Knowledge articulation	
Direct articulation (ODIRECT)	Summated scale of two communication channels – face-to-face and meetings – Cronbach α = 0.95
Indirect articulation (OINDIRECT)	Summated scale of two communication channels – phone and mail – Cronbach α = 0.99
Total articulation (OINTER)	Summated scale of all communication channels – Cronbach α = 0.96
Attentiveness	
Difference in motives to call upon centres (DMOT)	Summated difference in score of resource needs between the collective research centre and the user
Difference in use of support services (DUSE)	Summated difference in score on the use of support services between the collective research centre and the user

Difference in appreciation of support services (DAPPR)	Summated difference in score on the appreciation of support services between the collective research centre and the user
Effects of transfer	
Market related transfer effects (MRTE)	Summated scales of 6 output indicators related to market related technology transfer (develop new products; market new products; enter new markets; enlarge product scale; expand market share; raise turnover) – Cronbach α = 0.95
Efficiency related transfer effects (ERTE)	Summated scales of 4 output indicators related to efficiency related technology transfer (modify production process; offer better services; avoid disputes; save costs) – Cronbach α = 0.79
All transfer effects (ATE)	Summated scales of 11 output indicators related to technology transfer (develop new products; market new products; modify production process; enter new markets; enlarge product scale; expand market share; raise turnover; strengthen image; offer better services; avoid disputes; save costs) – Cronbach α = 0.92

3.7 Appendix A3 – Characterisation of users' search strategies

Table A3 – Characterisation of users' search strategies

	Taxonomy of users according to the use of support services			
Variables	**Heavy users**	**Regular users**	**Light users**	**All users**
General information				
Size (employment in 2006)	223.08	74.43	85.41	123.79
Age (years up to 2006)	31.48	24.52	24.18	26.48
Support services				
Use of support services	0.594	0.400	0.232	0.379
Appreciation of support services	0.786	0.775	0.605	0.716
Absorptive capacity				
R&D intensity of user	2.14	1.63	1.75	1.83
R&D personnel of centre	69.05	111.30	53.66	73.76
Tech transfer personnel of centre	40.92	31.09	25.31	31.25
University degrees in centre	71.25	95.58	56.31	71.39
Support tasks in centre	50.19	71.46	33.36	48.50
Resource needs				
R&D risk	0.456	0.420	0.371	0.414
R&D costs	0.531	0.504	0.464	0.499
Finance needs	0.461	0.496	0.446	0.465
Organisation	0.469	0.464	0.414	0.448
Personnel needs	0.844	0.901	0.641	0.786
Technical information	0.869	0.929	0.716	0.830
Market information	0.626	0.696	0.474	0.591
Knowledge articulation				
Direct articulation (a)	0.622	0.738	0.537	0.616
Indirect articulation (b)	0.722	0.834	0.714	0.749
Total articulation (c) (=a+b)	0.672	0.786	0.626	0.683
Attentiveness				
Difference in motives to call upon centres	0.099	0.081	0.151	0.114
Difference in use of support services	0.097	0.399	0.478	0.350
Difference in appreciation of support services	0.041	0.107	0.192	0.125
Effects of technology transfer				
Market related effects (a)	0.594	0.437	0.413	0.479
Efficiency effects(b)	0.694	0.641	0.508	0.610
All effects (c) (=a+b)	0.606	0.452	0.422	0.491

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4 Collective research centres and behavioural additionality

Mirjam Knockaert and André Spithoven

4.1 Introduction

Over the previous decades, governments worldwide have been active in drawing up 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 the 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 and result in an information processing paradigm. 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. 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. Bach and Matt (2002) refer to the positive impact on competencies and expertise as cognitive capacity additionality. Another concept which is often used for behavioural additionality is acceleration additionalities, which are said to be in place in participation in innovation schemes, speeding up the course of the project.

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 are a particular concept, they are closely related to two concepts of behavioural additionality, namely network and knowledge 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 behavioural 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 increasingly 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 when and under which conditions working with technology intermediaries results in behavioural additionality.

This chapter aims at providing an understanding into whether working with technology intermediaries results in behavioural 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 amongst member firms of collective research centres in Belgium. To complement the data obtained through the survey, 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 centres. 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 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 behavioural 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.

4.2 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 subsequent learning tasks 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 by-product 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 sufficient 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 the behavioural 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 the need to build sufficient 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 the 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 the behavioural additionality obtained by the member firm through collaboration with the 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 insufficient 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 is. 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 the behavioural additionality obtained by the member firm

4.3 Methodology

4.3.1 The sample and data collection

To examine the question how absorptive capacity of technology intermediaries and their member firms affects behavioural additionality, we study the activity of collective research centres in Belgium. These centres 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 centres 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 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 them over the past three years is included in Table 11. In addition, 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 behavioural additionality. Additionally, data on the age, size and R&D intensity of the member firm were collected.

Table 11: 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 study days 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 (Federal Science Policy) (weighted with 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. Furthermore, 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.

4.3.2 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 behavioural 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).

Behavioural 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). The categories used were those also used in the CIS questionnaire. Absorptive capacity of the CRC is measured as the R&D personnel in Full Time Equivalents (FTEs).

Intensity of use. We use a summated scale of the engagement in R&D related activities (see Table 11) 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 11). 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).

4.4 Results

4.4.1 R&D activities

Descriptives

Table 12 provides an insight into the dependent and independent variables.

Table 12: Descriptives of additionalities for R&D activities

Variable	Minimum	Maximum	Mean	s.d.
Network additionality	1	7	4.34	1.57
Competence additionality	1	7	4.78	1.07
AC CRC	8	133	70.07	48.13
Age	1	97	29.19	21.47
Intensity of use	1	7	3.94	1.54
Slack	-4250	560234	12492	70309

N=115.

Regression Analysis

We used OLS 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, VIF 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 behavioural 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 behavioural additionality positively (see Table 13). Further analysis however shows that the relationship between the absorptive capacity of the member firm and behavioural additionality is mediated by the intensity of use.

Table 13: OLS regression results for R&D activities

	Network additionality	Competence additionality
Independent variables		
AC CRC	-.02	-.07
AC member firm	.14	.08
Intensity of use	.43****	.36****
Control variables		
Age	-.02	.03
Slack	-.04	-.05
Adjusted R^2	.21	.14
F	7.03****	4.56***

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

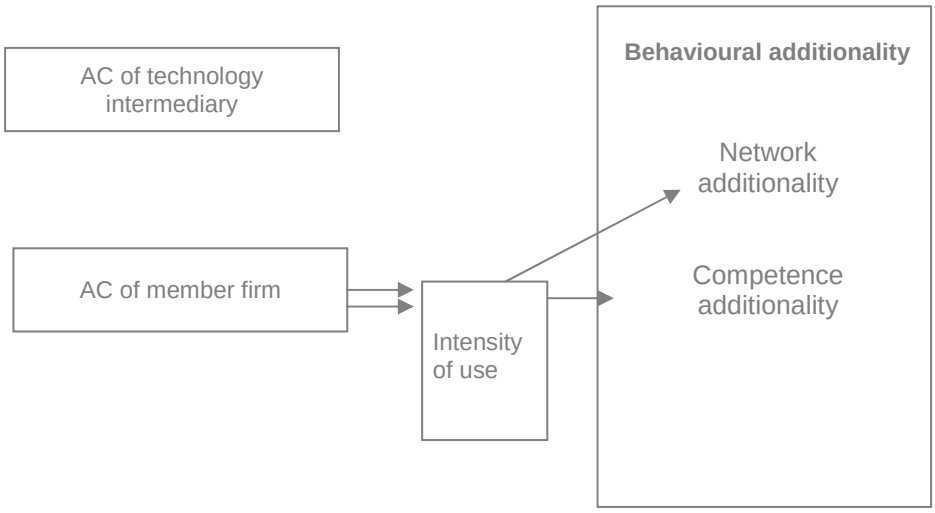
In order to test for full and partial mediation effects, we ran the regression analysis without the intensity of interaction in the equation. To show full mediation, the independent variables should become significant. We do find full mediation effects for absorptive capacity of the member firm. The regression analysis without the intensity of use in the equation indicates a significant effect of the absorptive capacity of the member firm on behavioural additionality. By including the intensity of use in the equation, the F-values are significantly improved and the effect for the 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.

Table 14: OLS regression results behavioural additionality for R&D activities – mediation test

	Network additionality	Competence additionality
Independent variables		
AC CRC	-.08	-.11
AC member firm	.25***	.18*
Control variables		
Age	.05	.09
Slack	-.11	-.11
Adjusted R^2	.05	.03
F	2.49**	1.91

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

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 behavioural additionality.

4.4.2 R&D related activities

Descriptives

Table 15 provides an insight into the dependent and independent variables. For the average member firm, competence additionality tends to be of higher importance than network additionality of R&D related activities.

Table 15: Descriptives for R&D related activities

Variable	Minimum	Maximum	Mean	s.d.
Network additionality	1	7	3.66	1.53
Competence additionality	1	7	5.16	1.24
AC CRC	2	133	84.85	50.28
Age	0.2	125	26.59	20.88
Intensity of use	1	7	3.09	1.18
Slack	-19 598	560234	7684.87	50835.78

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

Regression Analysis

We used OLS 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 behavioural 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 behavioural 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.

Table 16: OLS regression results for R&D related activities

	Network additionality	Competence additionality
Independent variables		
AC CRC	-.13**	.05
AC member firm	.03	.03
Intensity of use	.41****	.51****
Control variables		
Age	-.02	-.05*
Slack	.00	.01
Adjusted R^2	.18	.25
F	13.32****	20.59****

N=288; *p<.10, **p<.05, ***p<.001;****, p<.0001

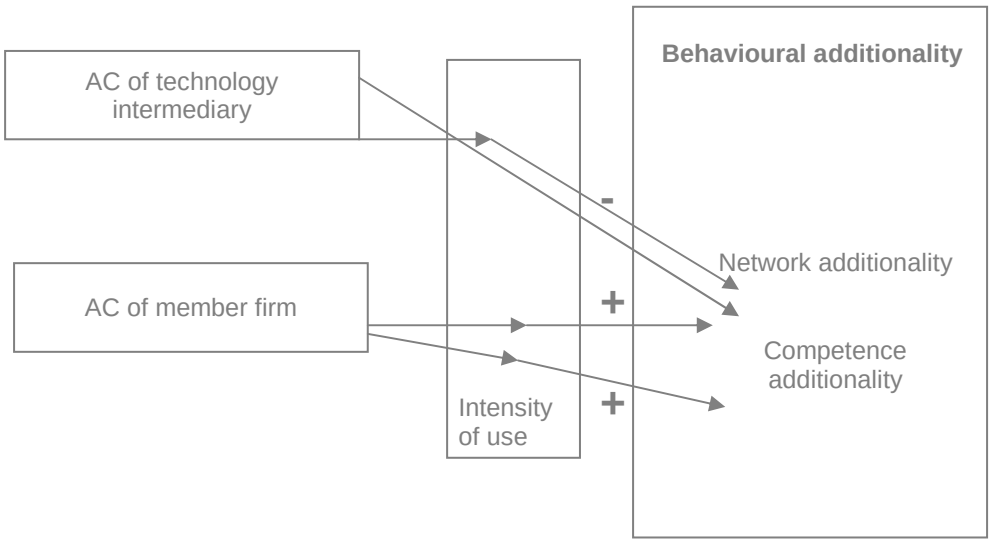
In the case of network and competence additionality, the absorptive capacity of the member firm had a significantly positive effect, but the effect disappeared after including the intensity of use in the equation, pointing to a full mediation effect. Besides, we do find a partial mediation effect for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

Table 17: OLS regression results for R&D activities – mediation test

	Network additionality	Competence additionality
Independent variables		
AC CRC	-.11*	.08
AC member firm	.10*	.12*
Control variables		
Age	.02	.00
Slack	-.03	-.01
Adjusted R^2	.02	.02
F	2.09*	1.13

N=288; *p<.10, **p<.05, ***p<.001;****, p<.0001

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.

4.5 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 the 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 CRCs' 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 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 capturing the human capital and knowledge base of firms.

4.6 References

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5 Conclusions

In the era of open innovation, firms have increasingly become dependent on information and knowledge that is available in the environment of the firm. The access to this information is, however, not always straightforward, especially not for low tech SMEs, which are faced with resource constraints and lack absorptive capacity. Governments have increasingly invested in mechanisms that could facilitate transfer of knowledge generated externally to industry.

This report aimed at providing an insight into one particular type of intermediary: the collective research centres in Belgium. The report first provided an insight into the functioning of the CRC. It showed that CRCs, just as the sectors they service, are heterogeneous in their size, activities, human capital and functioning. We identified three main functions of the CRCs. First, they have a function as knowledge intelligence unit. Second, they operate as knowledge agency and third, they function as knowledge repository. The first chapter identified that members mainly call upon the CRC because of a lack of absorptive capacity: members seem to lack access to technical information and especially qualified personnel. The CRCs provide this access. Furthermore, this chapter showed that CRCs engage in transferring knowledge that is otherwise not easily transferred between science and industry. More specifically, the CRCs indicated that universities are an important source of information for their activities, and that they themselves have a specific role in information transfer to the whole sector. The data in the first chapter, however, only reported on the vision of the CRCs. In the second chapter, we collated the vision of the CRCs with that of the member firms, and looked at whether or not demand for and supply of CRC services matched.

The second chapter identified some misalignments (overestimations in the case of personnel and underestimations in the case of information provision) between the perceptions of CRCs and users with respect to motives and the use and appreciation of support activities. These, however, had no impact on the effects of CRCs on users. The research developed a taxonomy to look at different groups of users and found that especially heavy users of the CRCs, generally companies with a high R&D intensity, and light users, which are typically firms with a low R&D intensity, do not call upon the CRC for the same reasons. We find that the use of the CRC services by the members and the search strategy used by the members are influenced by the absorptive capacity of the members and the collective research centre, and more specifically the R&D intensity. Additionally, we find that users that rely to a large extent upon the CRCs services (called “heavy users”) benefit most from the CRC’s services, and exhibit both market related and efficiency effects. In the third chapter, we specifically looked at when and how working with the CRC resulted in changes in behaviour by the member firm.

More specifically, in the third chapter, we examined the network and competence additionality generated by member firms through cooperation with the CRC. We examined these effects on two levels: R&D activities and R&D related activities. For competence additionality, we found that member firms with higher levels of absorptive capacity (or more R&D intensive) engage to a larger extent in the CRC’s activities, and thus generate higher levels of competence additionality. This was the case for both R&D and R&D related activities. These findings are in line with the findings in chapter 2, which indicated that heavy users benefited the most from the CRC’s activities. This chapter however showed that, very specifically, the more use is made of the CRC’s services, the higher the knowledge and competences are built within the firm. However, it also showed that especially firms with higher R&D intensity engage in this collaboration with the CRC. Even though we had expected that higher levels of absorptive capacity at CRC level (operationalized as R&D intensity) would positively affect cognitive capacity additionality, this was not confirmed by the analyses. This does not mean that R&D activities within CRCs are redundant; these activities may result in other types of behavioural additionality, not captured by cognitive capacity additionality, or may have to be measured in another way, not only

comprising R&D intensity. Further, from an absorptive capacity perspective, it is clear that CRCs would be unable to function as knowledge intelligence unit, knowledge agency and knowledge repository without disposing of sufficient absorptive capacity.