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WORKING PAPER

Building Absorptive Capacity to Organise Inbound Open Innovation in Low Tech Industries

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Abstract: The discussion on open innovation suggests that the ability to absorb external knowledge has become a major driver for competition. In the case of inbound open innovation, companies screen their environment to search for the appropriate technology and knowledge and do not exclusively rely on in-house R&D. A key precondition is that firms dispose of "absorptive capacity" to internalise external knowledge. For R&D intensive large firms, the concept of absorptive capacity is well understood. In contrast, for small firms and firms operating in traditional sectors, implementing the concept of absorptive capacity is less documented. These firms will have to look for assistance to build their absorptive capacity or even to 'outsource' a significant part of this function. This paper, therefore, focuses on the role of collective research centres in Belgium in building absorptive capacity at the intraorganisational dyad level. This type of technology intermediaries are created to help firms operating in traditional sectors to take advantage of the latest technological developments. The aim of the paper is to demonstrate that the trend towards openness of the innovation process forces firms lacking absortive capacity to search for alternative ways to engage in inbound open innovation. The paper highlights the multiple activities of which absorptive capacity is made up; it defines the concept of absorptive capacity as a precondition to open innovation; and it demonstrates how firms lacking absorptive capacity collectively cope with the distributedness of knowledge and innovation.

Keywords: open innovation; absorptive capacity; technology intermediation.

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 paper, 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 crossroad 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 paper 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 paper 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 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. Second, 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 explicit the need for openness in the innovation process and has emphasized subprocesses such as search routines. We make the role of absorptive capacity in this open innovation context 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 paper 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. 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 'abundancy' 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 that firms make of external knowledge in the production process is called inbound open innovation (Chesbrough and Crowther, 2006). But this external knowledge does not percolate smoothly though 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. In what follows, we discuss each of these elements in some depth by reviewing the recent literature and relating these elements to our research theme on collective research centres (a specific type of technology intermediary). By doing so, we enrich the understanding of absorptive capacity at interorganisational level.

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 internal 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 others search routines (Laursen and Salter, 2004, 2006). Yet, little attention is paid to absorptive capacity which is needed 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 paper 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.

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 byproduct 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 capacity of firms is available at 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 sources 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), pertain 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 adapt to changing market conditions in order to achieve competitive advantage. In their article they critisise 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, 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”; These dimensions however differ in the ways they operate: sequantially 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 usualy 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). More qualitative measures for absorptive capacity for instance include the presence of a separate R&D unit (Veugelers, 1997). Our paper uses several important elements of absorptive capacity pertaining to the organisation of technology intermediation as an qualitative indicator and the employment of qualified personnel and R&D activities as quantititive indicators.

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 has been applied to traditional sectors and SMEs without questionning 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 fulfill this role in Belgium. They help their member companies building the ability to scan the market for emerging technologies, developing 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.

3. Collective research centers 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 centers were originally purposefully allowed by policy makers in the aftermath of the Second World War in 1947 to encourage scientific and technological research in specific sectors of the economy to improve productivity, quality and production. Given the long history of the collective research centres, they demonstrate the importance they have for their member companies and the legitimate position which they have obtained. These centers are privately owned by the member firms and operate on behalf of a particular sector. We analyse our 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 is publicly available on their

performance 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 secondary 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 centers 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 both 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 indepth insights in the activities they perform and the components of absorptive capacity.

Table 1 Key figures on collective research centres

Name of Collective research centre	*Sector coverage*	*Year of creation*	*Number of members*	*Employment in FTE in 2005 (b)*	*R&D activity (in % of FTE employ-ment) (b)*	*Tech transfer activity (in % of FTE employ-ment) (b)*	*Ratio tech transfer / 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	Constuction	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

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 whether 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.

In line with Cohen and Levinthal (1990), we distinguish between R&D investments and investments in related activities such as dissimination (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 licence work; policy related studies and routine software development (OECD, 2002). We label the R&D related activities of these centers as “tech transfer” activities as they represent the dissimination 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 in R&D related activities than R&D activities strictu sensu. This means that, to understand absorptive capacity as a construct, it is key 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% of all employees in the packaging industry engaging in these activities up to 100% in paintings and coatings and in welding. As the collective research centres are privately held non profit 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% because of the existence of other activities that are unrelated to R&D at all (f.i. marketing and accounting). In general the centres devote more than twice effort in R&D activities than in 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.

Given the vitality of human capital in both R&D and technology transger activities we take a closer look 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*	*Postsecundary 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%, is 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, 58%, of them have a university degree indicating that the research performed is probably of a more applied nature. Technicians and equivalent staff engage in activities that demand technical knowledge. These activities involve the application of ready made concepts and operational methods (OECD, 2002). Other R&D personnel include skilled and unskilled supporting employees, e.g. secretariat, craftsmen, 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 exist, meaning that the distribution of qualifications differ according to the function that employees perform. The correlation of these attributes, however, show 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 in Belgium (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 these 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.

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 organisational level.

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 beliefs to be their strong and weak points. And, as such, 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 corroborate this: firms mainly lack qualified personnel and technical information to be involved in R&D activities. Besides, the high risk and costs associated to R&D is 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 disposition of collective research centres of qualified personnel 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 less 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 to build absorptive capacity. The services could include activities that either help to build the ability to scan the market for technology or that either help to 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. Besides, the concept of absorptive capacity also suggest that collective research centres will have to build their internal absorptive capacity, and therefore also have to engage in R&D (see Table 1).

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 through 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 collaborate 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. Second, 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 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 performs partly the role as matchmaker. It initiates a collective research project with various members in order to explore new knowledge which 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 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 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 which 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 inter personal (face-to-face contacts, technological advisors) and inter organisational (e.g. number of hits on website) level. The greatest difference with 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 does not take more than half of the time of the staff. In addition to knowledge agency activities, 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. Second, 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 of how collective research centres organise absorptive capacity on behalf of the firms and, at the same time, get an idea how well these activities are thought to serve the member firms.

Table 4 Acivities 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 is 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 to build the ability to identify and monitor technology, which was one of the dimensions of absorptive capacity mentionned 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 prodominantly aimed at providing technological advise and 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 annualy, 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 demonstrated the potential use of specialised new technology. Besides, they are in close contact to 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. Besides, 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 to build the absorptive capacity of the collective research centre. They also play the role of gatekeeper for their member firms that 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 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 from 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 as knowledge agents and knowledge repositories. Looking at the median score in Table 3, collective research centres also provide technology innovation stimulation where 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.

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 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 of 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 that dispose of the background and experience to carry out R&D and to involve in technology transfer activities. This clearly shows that the knowledge intelligence function can not 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) in his study on the building industry 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. He states 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. He shows 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. Our 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.

5. Conclusions, limitations, and avenues for future research

Starting off from the premise that most firms operating in traditional industries 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 strictu 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 new light on the mismeasurement of absorptive capacity if only R&D activities are taken into account and the directions in which absorptive capacity should be expanded.

Second, 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 at the firm internally, we show how technology intermediaries can help to 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 ones (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 the external environment which is adapted to the member firms’ needs. 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.

Third, we show that 'absorptive capapcity' 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 difficult to access without a critical mass of absorptive capacity.

Even though collective research centres are a specific type of intermediaries, we believe that the results on their functioning, knowledge insourcing and drivers for their existence 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 has a number of limitations. This research focussed on the functioning of collective research centres helping firms active in traditional industries to overcome their lack of absorptive capacity. The aim of the paper 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 assessing the client firms' opinions on the role of technology intermediaries is an important avenue for further research.

Another limitation is its focus on the situation within one country, hindering the conclusions 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 of collective research centres in addressing the lack of absorptive capacity.

Appendix

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	Wood products

		repairing of ships and boats	Pulp and paper products Publishing and printing Manufacturing n.e.c.
			Recycling

Source: European Commission, 2006

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References

Acha, V. and Cusmano, L. (2005) *Governance and co-ordination of distributed innovation processes: patterns of R&D co-operation in the upstream petroleum industry*, Economics of Innovation and New Technology, Vol. 14, No. 1-2, pp. 1-21.

Allen, T.J. (1977) *Managing the Flow of Technology. Technology Transfer and the Dissemination of Technological Information within the R&D Organization*, Cambridge: MIT Press.

Arbussa A. and Coenders G. (2007) *Innovation activities, use of appropriation instruments and absorptive capacity: evidence from Spanish firms*, Research Policy, Vol. 36, pp. 1545-1558.

Arora, A., Fosfuri, A. and Gambardella, A. (2001) *Markets for Technology. The Economics of Innovation and Corporate Strategy*, Cambridge (MA), MIT Press.

Berends, H., van der Bij, H., Debackere, K. and Weggeman, M. (2006) *Knowledge sharing mechanisms in industrial research*, R&D Management, Vol. 36, No. 1, pp. 85-95.

Bessant, J. and Rush, H. (1995) *Building bridges for innovation: the role of consultants in technology transfer*, Research Policy, Vol. 24, No. 1, pp. 97-114.

Cassiman B. and Veugelers R. (2000) External technology sources: embodied or disembodied technology acquisition, *Working paper UPF 444*, pp. 1-22

CFS/STAT (2007) Statistics on R&D Activities of Non-Profit Organisations, *Mimeo*, Brussels: Belgian Science Policy.

Chesbrough, H. (2003a) *Open Innovation. The New Imperative for Creating and Profiting from Technology*, Boston (Mass.): Harvard Business School Press

Chesbrough, H. and Crowther, A.K. (2006) *Beyond high tech: early adopters of open innovation in other industries*, R&D Management, Vol. 36, No. 3, pp. 229-236.

Chesbrough, H. W. (2003b) *The era of open innovation*, MIT Sloan Management Review; Vol. 44, No. 3, Spring, pp. 35-41

Cohen, W.M. and Levinthal, D.A. (1990) *Absorptive capacity: a new perspective on learning and innovation*, Administrative Science Quarterly, Vol. 35, pp. 128-152.

Coombs, R., Harvey, M.and Tether, B. (2003) *Analysing distributed processes of provision and innovation*, Industrial and Corporate Change, Vol. 12, pp. 1125-1155.

Dahlander, L. and Gann,, D. (2007) How open is innovation? Paper presented at the DRUID Summer Conference 2007 'Appropriability, Proximity, Routines and Innovatio", Copenhagen, CBS, Denmark, June 18-20.

DGTRE (2006) *Rapport d'activités 2006 de la DGTRE*, Namur : DGTRE.

Dodgson, M., Gann, D., and Salter, A. (2006) *The role of technology in the shift towards open innovation: the case of Procter & Gamble*, R&D Management, Vol. 36, No. 3, pp. 333-346.

Dyer, J.H. and Singh, H. (1998) The relational view: cooperative strategy and sources of interorganizational competitive advantage, Academy of Management Review, Vol. 23, No. 4, pp. 660-679.

European Communities (2006) *High tech industries and knowledge based services*, Statistics in Focus, 13/2006

Gann, D. (2001) *Putting academic ideas into practice: technological progress and the absorptive capacity of construction organizations*, Construction Management and Economics, Vol. 19, pp. 321-330.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P. and Trow, M. (1994) *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*, Londen: Sage.

Giuliani, E. (2005) *Cluster absorptive capacity: why do some clusters forge ahead and others lag behind?*, European Urban and Regional Studies, Vol. 12, No. 3, pp. 269–288.

Howells, J. (2006) *Intermediation and the role of intermediaries in innovation*, Research Policy, Vol. 35, No. 5, pp. 715-728.

Howells, J., James, A. and Malik, K. (2003) *The sourcing of technological knowledge: distributed innovation processes and dynamic change*, R&D Management, Vol. 33, No. 4, pp. 395-409.

Huston, L. and Sakkab, N. (2006) *Connect and Develop: Inside Procter & Gamble's New Model for Innovation*, Harvard Business Review, Vol. 48, No. 3, pp. 58-66.

IWT - Institute for the Promotion of Innovation by Science and Technology in Flanders (2006) *Activity Report 2006 – Open Innovation. Brussels*: IWT.

Lane, P and Lubatkin, M. (1998) *Relative absorptive capacity and interorganizational learning*, Strategic Management Journal, Vol. 19, pp. 461-477.

Lane, P., Koka, B and Pathak, S. (2006) *The reification of absorptive capacity: a critical review and rejuvenation of the construct*, Academy of Management Review, Vol. 31, No. 4, pp. 863-883.

Laursen, K. and Salter, A (2004) *Searching high and low: what types of firms use universities as a source of innovation?*, Research Policy, Vol. 33, No. 8, pp. 1201-1215.

Laursen, K. and Salter, A. (2006) *Open for innovation: the role of openness in explaining innovation performance among U.K. manufacturing firms*, Strategic Management Journal, Vol. 37, pp. 131-150.

Leahy, D. and Neary, J.P. (2007) *Absorptive capacity, R&D spillovers, and public policy*, International Journal of Industrial Organization, Vol. 25, pp. 1089-1108.

Leiponen, A. (2006) *Organization of knowledge exchange: an empirical study of knowledge intensive business service relationships*, Economics of Innovation and New Technology, Vol. 15, No. 4/5, pp. 443-464.

Lennox, M. and King, A. (2004) *Prospects for developing absorptive capacity through internal information provision*, Strategic Management Journal, Vol. 25, No. 4, pp. 331-345.

Lichtenthaler, U. (2008) *Integrated roadmaps for open innovation*, Research & Technology Management, May-June, pp. 45-48.

Lin, B.-W. (2003) *Technology transfer as technological learning: a source of competitive advantage for firms with limited R&D resources*, R&D Management, Vol. 33, No. 3, pp. 327-341.

Mowery, D.C. and Oxley, J.E. (1995) Inward technology transfer and competitiveness: the role of national innovation systems, Cambridge Journal of Economics, Vol. 19, pp. 67-93.

Muller, E. and Zenker, A. (2001) *Business services as actors of knowledge transformation: the role of KIBS in regional and national innovation systems*, Research Policy, Vol. 3., No. 9, pp. 1501-1516

Muscio, A. (2007) *The impact of absorptive capacity on SMEs' collaboration*, Economics of Innovation and New Technology, Vol. 16, No. 8, pp. 653-668.

Nooteboom, B., Coehoorn, C. and Van Der Zwaan, A. (1992) *The purpose and effectiveness of technology transfer to small businesses by government-sponsored innovation centres*, Technology Analysis and Strategic Management, Vol. 4, No. 2, pp. 149-166.

OECD (2002) *Frascati Manual. Proposed Standard Practice for Surveys on Research and Experimental Development*, Paris: OECD.

Oltra, M.J. and Flor, M. (2003) *The impact of technological opportunities and innovative capabilities on firms' output innovation*, Creativity and Innovation Management, Vol. 12, No. 3, pp. 137-145.

Ouyang, H. (2008) *Resources, absorptive cepacity, and technology sourcing*, International Journal of Technology Management, Vol. 41, Nos ½, pp. 183-202.

Ritter, T. and Gemünden, H. G. (2003) *Network competence: its impact on innovation success and its antecedents*, Journal of Business Research, Vol. 56, pp. 745-755.

Sapsed, J.; Grantham, A. and DeFillippi, R. (2007) *A bridge over troubled waters: bridging organisations and entrepreneurial opportunities in emerging sectors*, Research Policy, Vol. 36, No. 9, pp. 1314-1334.

Schmidt, T. (2005) Absorptive capacity – one size fits all? A firm level analysis of absorptive capacity for different kinds of knowledge, *ZEW Discussion papers* 05-72.

Tann, J., Platts, A.E. and Stein, J. (2002) *The roles of independent research and technology organizations in the United Kingdom's technology transfer mechanism to SMEs*, Technology Analysis and Strategic Management, Vol. 14, No. 2, pp. 241-249.

Tether, B. (2002) Who co-operates for innovation, and why. An empirical analysis, Research Policy, Vol. 31, No. 6, pp. 947-967.

Thérin, F. (2007) *Absorptive capacity: an empirical test of Zahra and George's contribution in small business settings*, Gestion 2000, Juillet-Aout, pp. 17-30.

Tidd, J., Bessant, J. and Pavitt, K. (1997) *Managing Innovation. Integrating Technological, Market and Organizational Change*, Chichester: Wiley

Todorova, G. and Durisin, B. (2007), *Absorptive capacity: valuing a reconceptualization*, Academy of Management Review, Vol. 32, No. 3, pp. 774-786.

Trott, P. (1998) *Innovation Management and New Product Development*, Harlow: Financial Times.

Tsai, W. (2001) *Knowledge transfer in intraorganizational networks: effects of network position and absorptive capacity on business unit innovation and performance*, Academy of Management Journal, Vol. 44, No. 5, pp. 996-1004.

Tushmann, M. (1977) *Special boundary roles in the innovation process*, Administrative Science. Quarterly, Vol. 22, pp. 587-605.

Veugelers, R. (1997) *Internal R&D Expenditures and External Technology Sourcing*, Research Policy, Vol. 26, No. 3, pp. 303-315.

von Hippel, E. (1988) *The Sources of Innovation*, New York, Oxford University Press.

von Tunzelmann, G.N. and Acha, V. (2004) Innovation in 'low tech' industries, in: Fagerberg, J., Mowery, D.C. and Nelson, R. R. (eds.), *The Oxford Handbook of Innovation*, New York: Oxford University Press, pp. 407-432.

Zahra, S. and George, G. (2002) *Absorptive capacity: a review, reconceptualisation, and extension*, Academy of Management Review, Vol. 27, No. 2, pp. 185-203.

Zahra, S. and Hayton, J.C. (2008) *The effect of international venturing on firm performance. The moderating influence of absortive capacity*, Journal of Business Venturing, Vol., 23, pp. 195-220.