Financial crisis affects absorptive capacity
Case Raufoss cluster

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Abstract / summary

This paper discusses the impact of the financial crisis, from 2008-2010, on a regional cluster. A cluster of manufacturers, mainly suppliers to the automotive industry and defense and aerospace, is studied at both the outset of the crisis in the autumn 2008 and in the recovery phase in the spring 2010. Looking at absorptive capacity in companies in an instrumental way proves to be inconclusive. A dynamic approach to the same phenomena gives a broader and more accurate picture, but still there are some moderators that need to be incorporated into the definition of absorptive capacity. Moderators need to be research further.

1. Introduction

This paper look at companies at Raufoss Industrial Park, only those how compete in a global market, because they are thought to be "technological leaders" (Giuliani & Bell, 2005) and as such will most probable feel the crisis first. Therefore it is interesting to understand how the crisis affects the individual "technological leaders" and how these spear points in the cluster are affected as a whole. Hagedoorn (Hagedoorn, 2002) pointed out how important of R&D in network has been to the present date. Following this thinking, this paper will investigate how the most R&D intensive companies have managed the crisis. With a strong focus on R&D as indicator of changes due to the crisis, the paper will first provide a brief look at financial crisis and automotive crisis as a context, followed by some problem statements that will lead to a theoretical foundation for researching the problem statements. In the methodology chapter the problem statements are operationalized into specific researchable parts. Context part will give a brief description of the Raufoss Industrial Park and its companies, and followed by the data chapter. The last chapter is discussing the data and a conclusion.

2. Financial crisis

The global financial downturn during the years 2008 to 2010, intensified in the third quarter of 2008 by many collapses and a general loss of confidence in markets, is considered by many economists to be the worst crisis since the "Great depression" of the 1930s (Kirkpatrick, 2009; Reinhart & Rogoff, 2008). As a result the banks around the world cut lending.

Five out of seven of the manufacturers included in this study, representing over 65% of the workforce, are suppliers to the automotive industry. This industry was facing huge challenges prior to the financial crisis in terms of higher oil prices which suppressed demand for larger and more profitable vehicles and stagnating markets in Europe and North America which in turn lead to intensified competition, huge surplus capacity and an ever ongoing drive for cost reduction and improved efficiencies (Gottschalk & Kalmbach, 2007; Hitt, Ireland, & Hoskisson, 2007). This situation culminated with the financial crisis in fall 2008 when the credit market collapsed, leaving consumers without access to credit for the financing of new vehicles (EYG, 2009). Shimokawa and Freyssenet (Freyssenet, 2009; Shimokawa, 2010) predict that the automotive industry must shift from the old paradigm of mass production, mass marketing and mass consumption to a new paradigm where it can coexists with the natural environment. For many of the manufacturers in the Raufoss cluster this situation lead to a decline in production volume as high as 60-70 % during the peak of the crisis. As described in (NI, 2010), 2009 became a dramatic year for the industry in Norway with an 20% decline in export. Compared to European industry this number is not too bad. Large order reserves in general and large investments in the supplier industry to offshore installations and ship building made the impact of the financial crisis less severe in Norway than many other countries (NI, 2010).

3. Research questions

Such crisis, where both lending or the financial side and the market side of the business are affecting the companies at the same time, is rare and the effects are not well documented, yet. This is the reason for this research and hopefully it will bring new insight into how we understand absorptive capacity in companies and at a cluster level. And it can also shed light on what mechanisms can have a positive influence on the robustness of a cluster to resist the aftermath of crisis. Studying a cluster from the inside it was interesting to research mechanisms that determine absorptive capacity stretching from the individual company to the cluster at hand. Motivated by this the following problem statements were formulated:

1. **How is the absorptive capacity in individual firms affected by the crisis?**

2. **How is intra-cluster knowledge system affected by the crisis?**

Problem statement 1 – absorptive capacity:

Cohen and Levinthal who introduced the term "*absorptive capacity*," claimed that utilizing new information in the solution of a problem depends largely on the firm's level of prior related knowledge (Cohen & Levinthal, 1990). The need for new information to challenge existing organizational routines may be triggered by many different situations and information can be derived from many different sources. However, pointing out the relevant information and legitimizing it for further processing towards organizational knowledge is not straightforward. Absorptive capacity plays an essential role, together with the ability to create a context of interaction and socialization, to identify and evaluate the knowledge needed. Time is also a limiting factor, favoring satisfaction rather than optimization. Many times customer requirements serve as the main input to what kind of information and knowledge has to be identified and developed. Time pressure assures that the search for information stops when an alternative proves to satisfy.

Absorptive capacity is often defined as the organization's ability to see the relevance and benefit in new information (Jacobsen & Thorsvik, 2007), and it is divided into potential and realized absorptive capacity. The first describes the organization's ability to acquire information, while the latter relates to the organization's ability to make practical use of the information. In doing this cycle in an efficient manner it is claimed that absorptive capacity accumulates knowledge, which means that the more knowledgeable an organization is, the better suited it is to utilize new knowledge (Jacobsen & Thorsvik, 2007). Efficient accumulation of knowledge enables a firm to predict more accurately changes in the environment where the firm operates, exploiting opportunities independent of current performance. The more objects, patterns, events and concepts that are stored in memory, the more readily is relevant new information (Cohen & Levinthal, 1990). Firms aware of these mechanisms can proactively react to expected changes

and thereby strengthen their position in an uncertain environment. This means that by measuring mechanisms will give some ideas how the crisis has impacted on the companies in the regional cluster.

Problem statement 2 – intra-cluster knowledge system:

The second problem statement in this study is based on the assumption that the financial crisis, the total impact of both the financial crisis starting out in the late fall 2008 and the already ongoing crisis in the automotive market, has reduced the absorptive capacity among *these firms*, due to the massive layoffs.

In a knowledge-based view of the firm, the role of the firm is explored in its way of creating, storing and applying knowledge. Abstracting this firm level of analysis, von Krogh et al. (Krogh, Nonaka, & Nishiguchi, 2000) described how incongruence between product- and knowledge domains of different companies offers opportunities to improve the efficiency of knowledge utilization through collaboration. Such collaboration can be defined as inter-organizational relationships, coalitions, bilateral arrangements and clusters. The merit of a knowledge approach to inter-firm collaboration is a better understanding of the relative efficiencies in creating value. Gulati (Gulati, 2007) refers to value expectations as a function of a firm's network resources, i.e. firms with greater network resources are likely to extract greater value from their partners (alliances) than firms with limited access to such resources. Aligned to this view and the term absorptive capacity, the effect of new ties on the performance of participating firms will be contingent on the amount of existing network resources that they have on the outset of their new relationship. The second problem statement is also based on the assumption that knowledge exchange in a cluster often is asymmetric (Giuliani & Bell, 2005, p. 50). Companies with high absorptive capacity often are net givers of technological information to other companies with lower absorptive capacity. Therefore companies with high absorptive capacity become perceived by the others as "technology leaders". They are often asked for advice, if they are willing to give such. The mechanism can lead to an imbalance in the knowledge interaction inside the cluster (Giuliani & Bell, 2005; Schrader, 1991). But at the same time a company is more likely to ask for technological advice when it knows that it can decode and make use of such information (Carter, 1981). In that way a company with less knowledge but high absorptive capacity, can ask for more knowledge than it gives. This explains a dynamic knowledge exchange inside the cluster, where some are technology leaders and other are able to absorb the knowledge that they ask and are given from the technology leaders. In the long run a company with less knowledge and high absorptive capacity can develop into a technology leader. Following this reasoning a company with very low knowledge base and low absorptive capacity can be isolated in the cluster, but this research will not look into this aspect.

Looking at how the "technology leaders" produce and gain new knowledge, OECD (Aslesen & Isaksen, 2007; OECD, 2004) has pointed towards knowledge-intensive services that some

organizations do in a cluster. In this paper we will use the term KISA (knowledge-intensive service activities), because this is a broader term than KIBS (Knowledge-intensive business services). KISA also include more public organizations like Research Institutes and University Colleges. Of cause there are some businesses sides of a research institute located inside the cluster, projects that are done as a pure market transaction with an arm's length ties, but main activities are characterized by embedded relationships (Uzzi, 1997). Embedded relationships are ongoing systems of relationships that have integrated a high degree of trust in the economic relations. The 'thick' information flows and exchanges tacit knowledge (like skills and experiences) between the companies. Following this KISA approach it focuses on the co-production of knowledge. "Companies supplement their internal knowledge with relevant external knowledge in learning and innovation processes" (Aslesen & Isaksen, 2007, p. 48). Relevant knowledge is produced in a dynamic exchange between the actors where interactive learning and co-production are main features.

In a knowledge exchange there are often something called spill-over effects. Feldman (Feldman, 2000) defines four main ways of spillovers when firms benefit from R&D efforts; mobility of workers, spin-offs of new firms, patents or licenses, and persons acquiring knowledge in informal settings. This can be seen as static knowledge transfers (Aslesen & Isaksen, 2007, p. 49). A more dynamic way of looking at benefits of spillovers can be of redefining the ways in which they occurs. Mobility of workers can also mean that a company gets help on a specific problem from an expert employed in another company in the cluster. This kind of lending of personnel creates also an arena for acquiring knowledge in an informal setting. The person(s) that are the experts on the problem at hand will also bring new things with them back to their own company and informal settings and local buzz (Bathelt, Malmberg, & Maskell, 2004) can be more easily created. And some sort of co-production of knowledge and collecting learning will be the result. In a dynamic picture this lending of personnel will over time go both ways, if company A has got a person on loan from company B to solve a problem and after some time company B need to solve their problem and company A has the right person for the job, this becomes more dynamic. Making this kind mobility of personnel will have a dynamic impact on knowledge exchanges.

4. Methodology

The sample and data collection

The study has been based on both the collection of primary data at firm level and empiric evidences from close collaboration by the authors of the paper on R&D projects with several of the manufacturers in the cluster during the years from 2007. At the firm level data was collected at two different points in time, just at the outset of the financial crisis in October 2008 and in May 2010 when production volumes are sloping upwards again. These two snap shots construct

a time study which captures important states of the crisis and give valuable information about impacts, efforts, decisions and results the companies have gone through. The data from 2008 was originally collected for an European study of regional innovation system policies (CRA - Constructing Regional Advantage), where managing directors and technical directors from 28 companies in the Raufoss regional cluster were interviewed in addition to answering a short web based survey (Isaksen & Karlsen, 2009). The 2010 data is drawn from a more limited population of the regional cluster, focusing on the main manufacturers and local research institutions. The reasons for this selection is that these firms encompass the largest stocks of employees, have their own R&D departments and are considered as first and second tier suppliers to demanding global customers – thus, data from these companies should be sufficient to outline significant generic trends and to answer the problem statements posed in this paper. In total seven manufacturers, including the five largest ones in the study by Isaksen and Karlsen (Isaksen & Karlsen, 2009), were studied.

Key informants in the study from 2008 were mainly managing directors and head of R&D. As far as possible the same people was invited to contribute to the 2010 study for the reason of consistency, but turnover and availability made it impossible to fulfill this criteria. Interview was chosen as the mean to gather rich data, in alignment to the statement; "*Interviews are used to explore the complexity and in-process nature of meanings and interpretations*" (Liamputtong & Ezzy, 2005). We believe that the best data is gathered through conversation, where the interviewer is active during the interview, asking unplanned questions to follow up on interesting comments by the interviewee. Paying attention to what is said is important to let the interviewee feel more like an informant rather than a respondent (Yin, 2003). Hence, all the interviews conducted in this study had structure and guidelines, normally a list of key words that the interviewee was led through – but in a very free form.

The companies' absorptive capacity

In an instrumental view of absorptive capacity, this paper will measure some indicators that can shed light on the changes in the capacities in companies at Raufoss. An important feature of absorptive capacity is how individuals contribute to the knowledge base of the firm. Thus, number of employees and knowledge workers will affect the firm´s ability to search for new information and knowledge and its capability to assimilate and exploit it. The ability to absorb new impulses is here defined to be outside the firm and also outside the regional cluster. Cohen and Levinthal argued that it is firms with higher absorptive capacities in a cluster that are more likely to establish linkages to external sources of relevant knowledge (Cohen & Levinthal, 1990). This is based on the assumption that high absorptive capacity reflects a low cognitive distance to the technological frontier, hence, it also important to specifically measure absorptive capacity at the R&D level in the companies. For instance; technical personnel meets frequently with customers and suppliers, attends conferences, trade fairs and exhibitions, and contributes to external R&D projects. To measure firm's capacity to accumulate relevant and useful knowledge

total number of employees and R&D Human Resource Index is used. The latter, equation [1], is defined as (Giuliani & Bell, 2005):

$$R\&D\ Human\ Resource\ Index = 0.80 \times degrees + 0.05 \times Number\ of\ Master\ degrees + 0.15 \times doctorate \quad [1]$$

The index assumes that the higher degree of education of a person the higher contribution to the economic returns of the firm (Giuliani & Bell, 2005, p. 65).

To gain a deeper insight changes in customer base, product- and project portfolio, patents, and number of public funded R&D project are measured. It is natural to assume that some of these measurements would fall if the R&D Human Resource Index falls. There are fewer qualified people to deal with the customer, develop products, and participate in projects. Patents would be thought to suffer also, but this is a more uncertain measure in Norway, which is a part of, what OECD calls, the Norwegian puzzle. These indicators give a picture of the intensity and nature of the firms' experimentation activities, which may serve as an appropriate proxy for knowledge creation efforts or absorptive capacity.

Intra-cluster knowledge system:

From the measurement of absorptive capacity of the companies, in an instrumental way, a more dynamic and functional study of the regional cluster will, perhaps, give a deeper understanding of the impact of the crisis for the whole cluster. Meeting arenas, participation in R&D projects in the cluster, customer/supplier relations internally, spillovers, and KISA effect can give a more dynamic picture of the aftermaths of the crisis. To make a more manageable research a selection of curtain parts of the variables. Infrastructure, that supports collaboration, is studied at a basic level of co-localization and collaboration. Looking at how these basic levels contribute and create access to common knowledge will be discussed. This will tell something about the climate for knowledge building in the cluster. R&D projects in the cluster will be discussed in light of the Norwegian Center of Expertise (NCE) for light weight materials and automated production that are located at Raufoss. Changes in the total number of R&D linkages are also discussed. There are some customer/supplier linkages internally in the cluster, by examining these and the R&D linkages will give some ideas of the changes in the actual knowledge building. Spillovers will look into some incidents of the crisis and its implications. Inside the cluster there are two research and education organizations. How they have tried to minimize the effects of the crisis for the companies are discussed in the KISA part.

Research model and moderators

The model presented in Figure 2 also introduces the term moderators. Moderators are anticipated to, in most cases, positively affect output in the short run and can be seen as either intentional

actions taken by the firms or as more accidental events. These will be discussed more thoroughly in the result and discussion part of the paper.

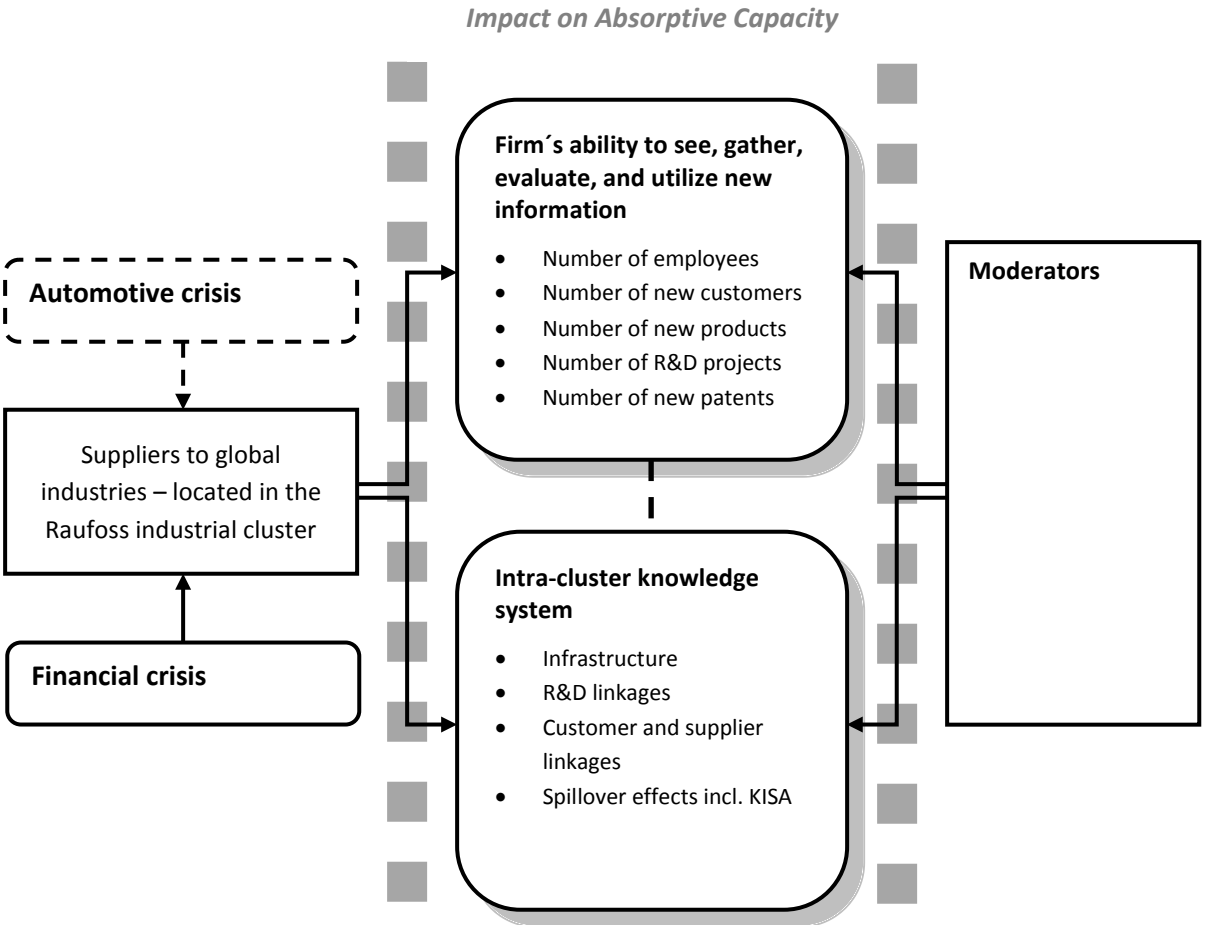

Figure 1: Research model.

5. The Raufoss industrial cluster

During the last 15 years the industry at Raufoss has gone through an extensive change, from a single company towards an regional cluster of between 70-80 companies, included the TotAl-group, of which 35 are located within the Raufoss Industrial Park (Johnstad & Berger, 2008). Despite the turbulence and fragmentation into more specialized companies, there is today a vital regional cluster serving different markets as automotive, defense and aerospace, building construction, pipe couplings and gas containers. Operating in such markets imply that the companies are highly exposed to fluctuations on the global scene, meaning that research and development of new products and processes, and successful commercialization of its outcome, are a necessity to survive. The maintenance of an efficient innovation system through the fission process and the development of a dynamic cluster out of this process can also partly be explained

by the national effort to promote innovation in regional clusters and networks (Finsrud, 2009). Based on the understanding of innovation as an interactive learning process (Lundvall, 1992), and the increased competitiveness in belonging to an regional cluster (Isaksen, Karlsen, & Sæther, 2008; Porter, 1990), national policy makers have supported initiatives to strengthen research and development in such clusters (Finsrud, 2009). Her burde NCE Raufoss, og eventuelt tidligere Arena-prosjekter, nevnes. The seven companies in this study are among the largest in the cluster and comprise approximately 50%, 2 107[1], of all employees in the extended cluster of total 70-80 companies – and these companies are regarded as 1st or 2st tier suppliers to industries as automotive and defense and aerospace. Table 1 gives a brief overview of the case companies and local research institutions.

Companies and R&D institutions	Industry	Ownership	Size – number of employees 2010	Main products
C1	Water and gas distribution	International	49	Couplings, fittings and adapters
C2	Defense and aerospace	Norwegian and Nordic	654	Medium and large caliber ammunition and missile products
C3	Automotive	International	716	Crash management systems
C4	Automotive	Norwegian	280	Air brake couplings
C5	Automotive	International	205	Exterior plastic components
C6	Automotive	International	113	Front and rear control arms
C7	Automotive	International	90	Steering columns
R1	Research and consulting	Industry and national research institutes	80	R&D
R2	Research and education	Public	270	R&D

Table 1: Overview of case companies.

6. Results

This part will present results according to the indicators defined for the two categories; firm-level absorptive capacity and intra-cluster knowledge communication patterns.

[1] Number of employees in 2008.

Firm-level absorptive capacity

To measure firm's capacity to accumulate relevant and useful knowledge total number of employees and R&D Human Resource Index is investigated. The latter, equation [1], is defined as (Giuliani & Bell, 2005):

$$R\&D\ Human\ Resource\ Index = 0.80 \times degrees + 0.05 \times Number\ of\ Master\ degrees + 0.15 \times doctorate \quad [1]$$

From 2008 to 2010 the seven manufacturers have downsized number of employees from 2 107 to 1 655, a reduction of about 21%. As seen from Figure 3 only two companies have maintained or increased number of employees during this period of time, while the remaining, which are automotive suppliers, suffered an over 33% reduction of the workforce. When summarizing the R&D Human Resource Index, which represents the cognitive background of firms' knowledge skilled workers, for all seven companies, this has dropped from 172 to 114 (34%). This is a considerable cut in knowledgeable workers for the cluster as a whole, and according to (Giuliani & Bell, 2005) devastating in the long run due to the assumption that the higher the degree of education the higher is their contribution to the economic returns of the firm. Especially the index for the two companies **C3** and **C5** decreased significant. Reasons for their dramatic reduction of knowledge workers are twofold; first, they had to adjust capacity in accordance to reduced sales volume, and second, both firms faced major restructurings in form of bankruptcy of the holding company (**C5**) and take-over (from a national owned to international owned company, **C3**) during the crisis. These events made huge impacts on the particular R&D departments, but also on the cluster as a whole due to company size and R&D effort. Nevertheless, operations survived at Raufoss and in the cluster, and new linkages are established, so the index may increase when sales volume increases.

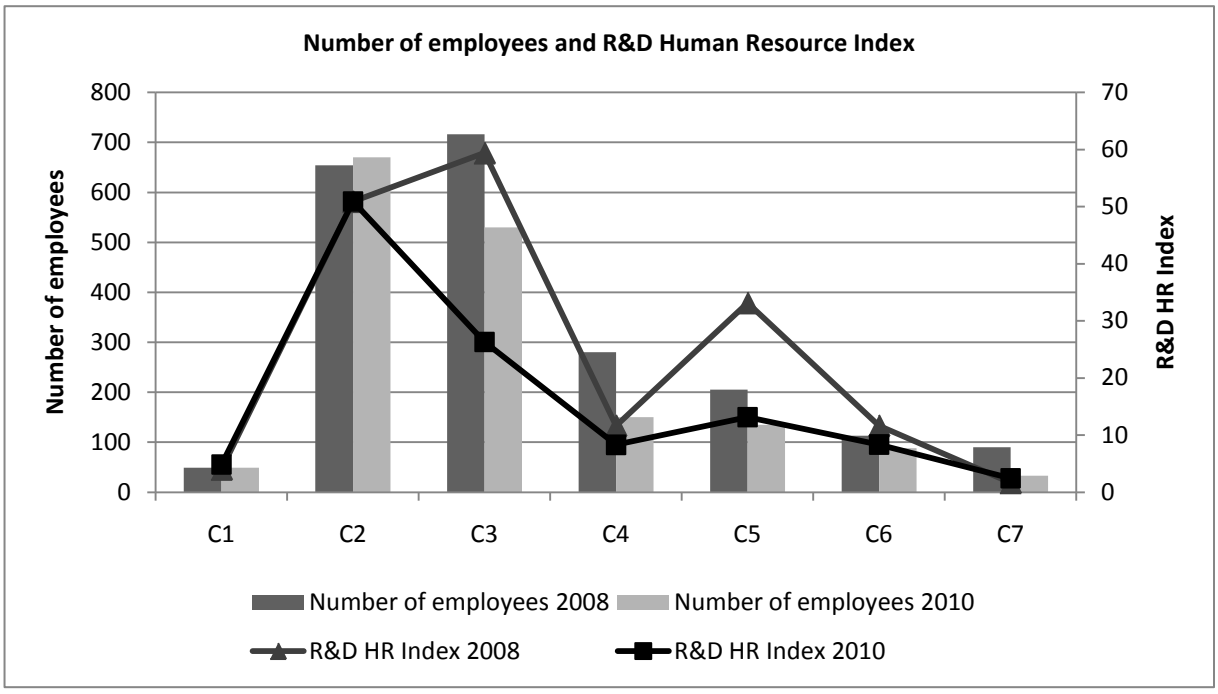

Figure 2: Number of employees and R&D Human Resource Index.

In order to investigate the manufacturers' ability to justify and exploit new information questions were asked with regard to changes to the customer base, product- and project portfolio, participation in external R&D projects and patents. These are indicators of knowledge creation efforts in the companies, which involve collaboration with a broad range of actors – for instance suppliers, customers, R&D partners, investors and funding partners etc. Figure 4 shows that the customer base for all seven companies increased by 17.5% from 2008 to 2010, where positive signs can be reported for five of them and status quo for the remaining. Surprisingly it is the automotive suppliers that contribute the most to the increased customer base. Despite the market turbulence and downsizing processes they have managed to develop new concepts and products that have convinced new customers. This trend is also reflected in changes to each firm's product base, as shown in Figure 5, where all have added products to their portfolio from 2008 to 2010. An overall growth of 8% in number of unique products manufactured by the seven companies is registered. However, when looking at the before mentioned companies **C5** and **C3** there are indications of a threshold for how much activity that can be maintained with regard to new customer projects and product development and degree of downsizing of technical personnel. These two companies report to the lower end of the scale when it comes to adding new customers, projects and products to their existing bases.

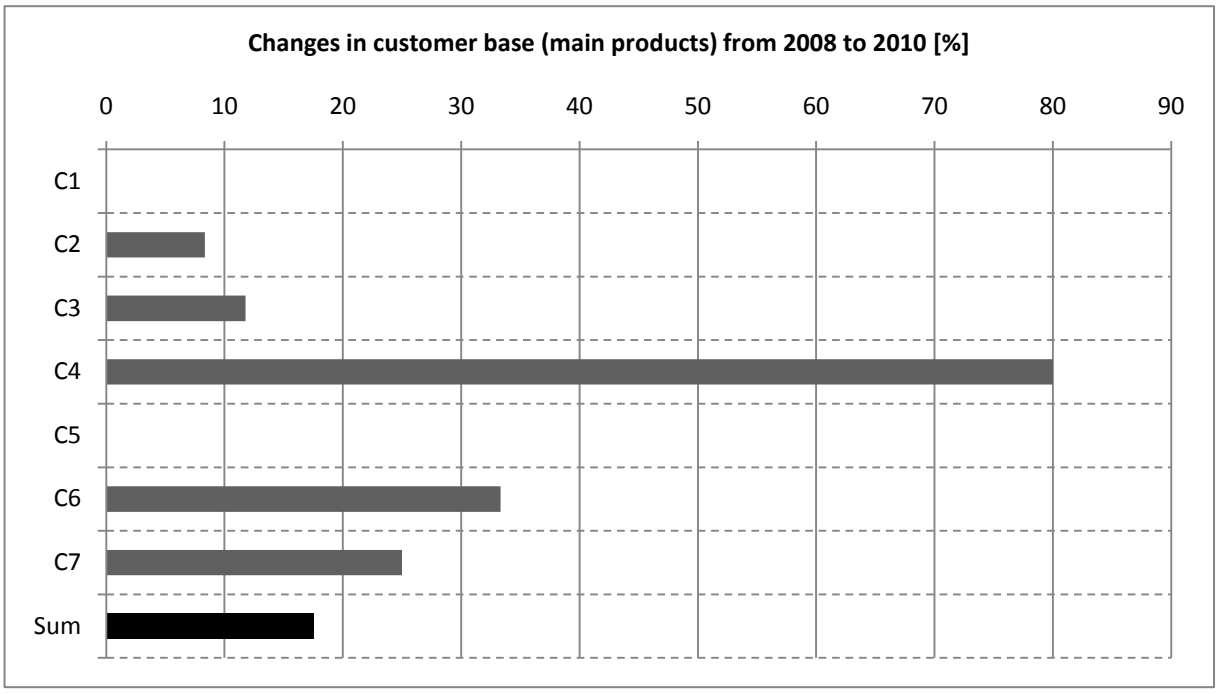

Figure 3: Changes in customer base.

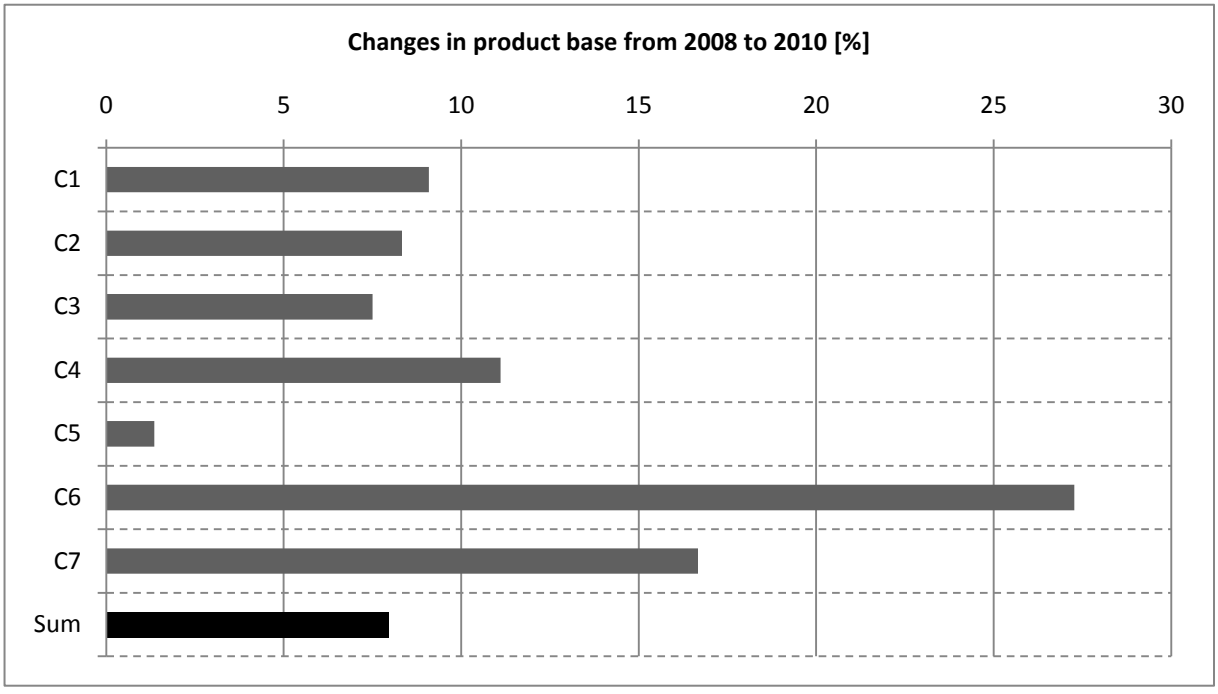

Figure 4: Changes in product base.

Participation in external R&D projects is regarded as an investment in ideas that the firm shall capitalize on in the future. This implies creating new knowledge together with partners showing interest in the same ideas. Thus, such projects are considered as an important arena for companies to invest time and money into long term partnerships that can bring new insight and

knowledge to keep up with, or even lead, the technology development within strategic areas. Figure 6 presents changes in number of R&D projects, which includes governmental funded research projects and programs together with more local network arenas, from 2008 to 2010, where the main trend is positive in the sense that the total number of R&D projects have increased by 14%. Especially **C2** and **C1** have increased their R&D activity, which are also the same companies that best have maintained their R&D Human Resource Index during the same period of time.

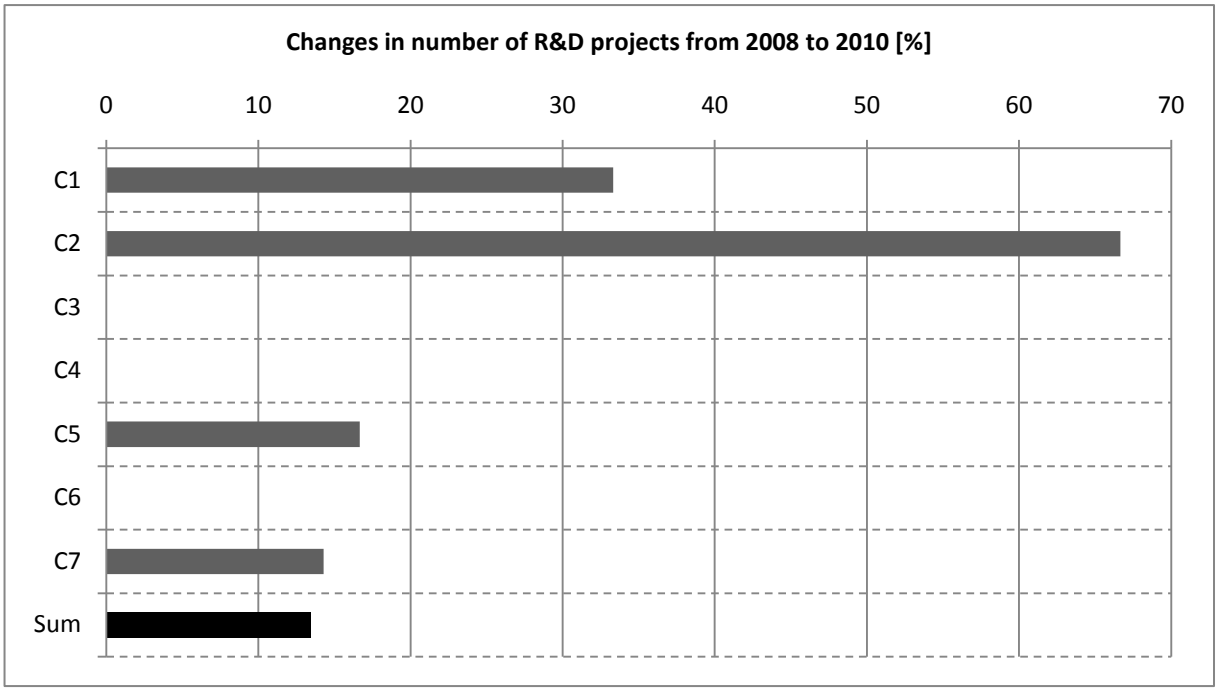

Figure 5: Changes in number of R&D projects.

The last indicator defined for the category firm-level absorptive capacity is patents, i.e., if it is possible to see any trend in patenting during the crisis. All companies report that they have ambitions to patent more than they have used to, but tell that it is costly, time consuming and a long process from describing what is unique to claiming patent rights for a product, process or concept. The interviewees could not tell exactly how many patents their company held at the outset of the crisis, but could report how many which were registered since 2008 – as shown in Table 2. This shows that the manufacturers have registered eight patents the last two years, but it is difficult to say if this number is high or low without anything to compare against. But, on general basis the companies claim that ever increasing customer requirements in global demanding markets force them to rapidly develop new product- and process technology. In that way patenting does not make so much sense as a mean to protect their business concepts. Such policies may contribute to what is defined as the "Norwegian puzzle" by OECD (OECD, 2007), where Norway is rated low on innovation indicators like R&D-intensity, number of patents, high-tech jobs and innovation rate even though Norwegian industry is productive, profitable and competitive (also without the oil and gas sector).

Company	C1	C2	C3	C4	C5	C6	C7	Sum
Number of new patents since 2008	1	1	4	1	0	0	1	**8**

Table 2: New patents since 2008.

Intra-cluster knowledge system

The first indicator, infrastructure collaboration, intends to capture to which degree the actors see the industrial park, in which they are located today, as an important area to maintain and further develop towards a dynamic and competitive cluster. It is assumed that if the actors do not value co-localization and collaboration at the most basic level, it will negatively influence higher levels of collaboration, i.e. contributing, and expecting access, to a common stock of knowledge. When asking the interviewees about infrastructure collaboration several emphasize what they call "Strategic park forum" as an important area for top managers to discuss infrastructure issues (rent, maintenance, access, environment etc). Especially the largest companies, **C2**, **C3** and **C5**, point to the importance of preserving a critical mass in the cluster, herewith optimize the conditions for existing and new businesses. **C2** also claims that the collaboration climate in this forum has never been better than during the crisis. Whether this improved cooperation is owed to an extraordinary effort due to the crisis or to the fact that four out of seven of the companies have changed CEO during the last two years is hard to tell. But, management priority is of course a prerequisite for creating a dynamic and vital strategic park forum. However, it is interesting to note that **C7** now is moving out of the industrial park, establishing new facilities south of Raufoss. Their main arguments for this decision are disagreement on rental costs, maintenance policies and energy prices. These underlying factors are, of course, important for all businesses, but why choosing to move only a few kilometers within a high cost country as Norway? The most obvious reason is the existing and strong linkages to the aluminum forming competence localized at Raufoss, which is important for **C7** in making aluminum steering columns. Since **C7** is owned by a foreign company the decision to stay at Raufoss illustrates uniqueness and quality of the local knowledge. But, also that actors are willing to see how far they can stretch the linkages without losing access to localized and tacit knowledge.

Another indicator of intra-cluster knowledge development is joint network and R&D efforts. There has been a national attempt to promote innovation in regional clusters in Norway, where for instance the program Norwegian Center of Expertise (NCE), partly financed by the Norwegian Research Council and Innovation Norway, provides long term support, ten years, for selected regional clusters with potential for growth. The extended Raufoss regional cluster is among the 12 Norwegian clusters that are appointed this status. One of the main goals of this program is to develop new products, processes and services from the competence network related to light weight materials and automation. Another important focus is also on integration between industry, research institutions, universities and the regional public sector. The supply of

knowledge intensive products to global demanding customers together with the close collaboration between industry and universities and local R&D institutions, facilitated by for instance NCE and other network programs, have resulted in numerous research projects. In 2008 there was reported in total 25 external funded R&D projects where at least two of the seven companies, in addition to the local R&D institutions **R1** and **R2**, were participating. The same number for 2010 was 33 projects, an increase of about 32%. This considerable increase in number of R&D projects can partly be explained by well adapted calls by the Norwegian Research council and well suited projects from the industry.

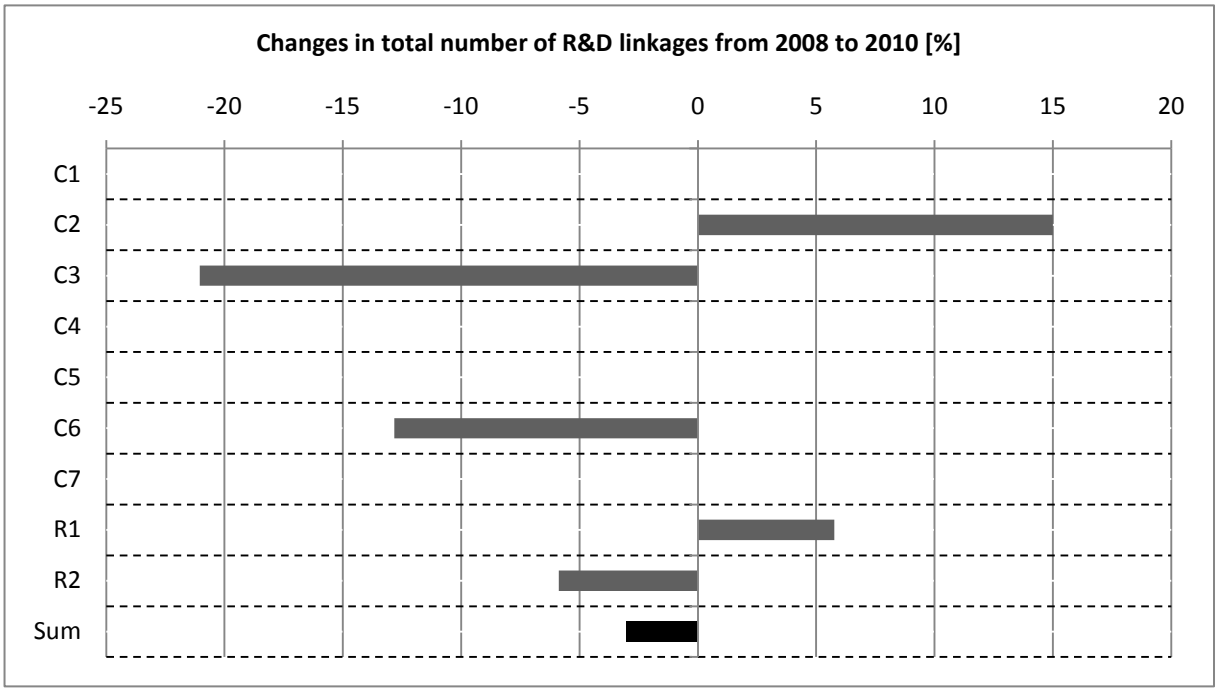

Figure 6: R&D linkages.

Number of R&D linkages, which indicates cluster commonness of the initiated R&D projects, on the other hand, shows a slightly decrease by 3%. As seen from Figure 7 **C3** and **C6** have reduced their number of linkages from 2008 to 2010, although number of projects is maintained (respectively 12 and 9). The main reason for the decrease is therefore a change in R&D projects portfolio, from network projects to more specific R&D projects. **C3**, former Norwegian owned, has also turned their attention to centralized R&D resources and projects within the **C3** Group (German based company with more than 23 000 employees). On the contrary, **C2** has, in accordance to their strategy, involved themselves more in R&D activities together with other cluster companies. Number of projects has increased from four to seven from 2008 to 2010 and number of linkages by 15%. The intra-cluster R&D indicator seems to remain strong during the crisis, but it is important to have in mind that R&D involves long term projects which may not be that affected in the short run.

The third indicator, customer and supplier linkages, reflects the level of business between the companies in the cluster, including products and services. Examples of products are extruded profiles, cast aluminum, tools and components and services (laboratory, testing and validation). This indicator shows degree of intra-cluster dependencies and means to directly impact and improve each other's products and services. Figure 8 shows that number of intra-cluster customer and supplier linkages has decreased by 11.8% from 2008 to 2010.

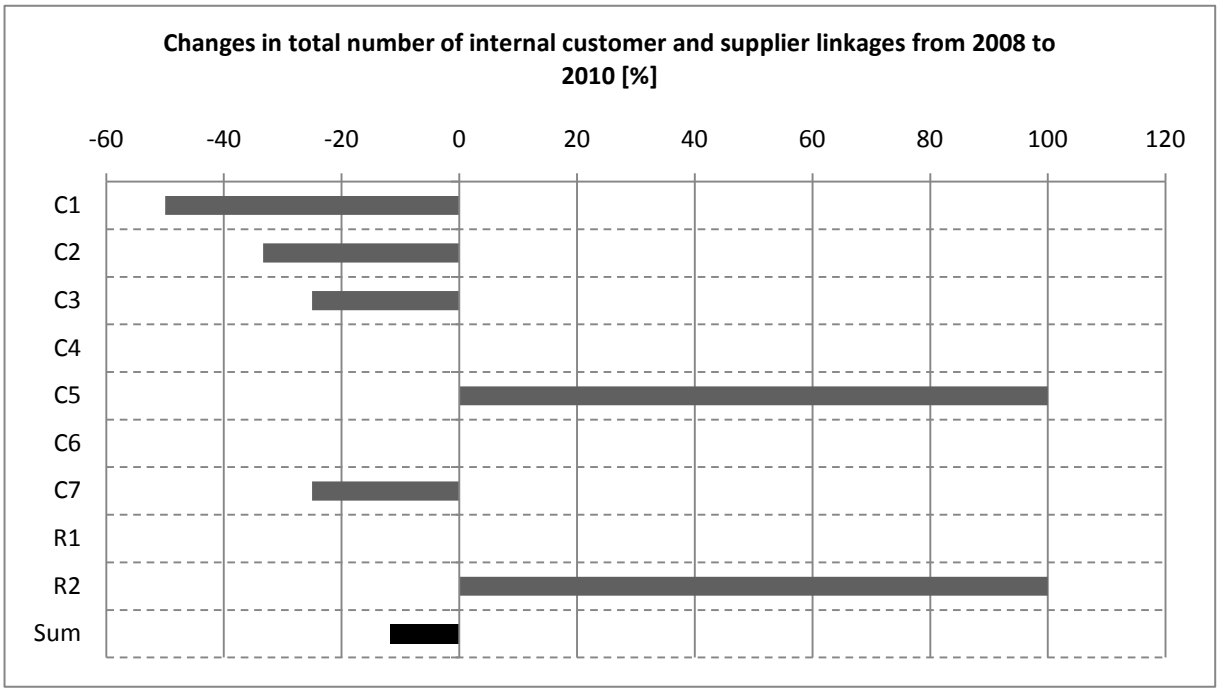

Figure 7: Internal customer and supplier linkages.

It turns out that this reduction is caused by minor changes in supplier bases of the firms **C1**, **C2**, **C3** and **C7**. The apparently huge positive changes by **C5** and **R2** cannot outweigh the trend since the increase by hundred percent means going from one to two linkages due to establishment of laboratory at **R2**.

Figure 9 summarizes number of formal linkages, defined as infrastructure, R&D projects and customer and supplier relations, between actors in the regional cluster, included the seven manufacturing companies and the two local R&D institutions. Line thickness represents number of linkages while node size symbolizes company size in number of employees in 2008. The local R&D institution **R1** constitutes over 19% of all linkages, making it the center of the cluster. As expected, the large companies **C3**, **C6**, **C4** and **C2** come next representing respectively from 15% to 10% of number of linkages. From 2008 to 2010 total number of linkages has slightly decreased by 4%.

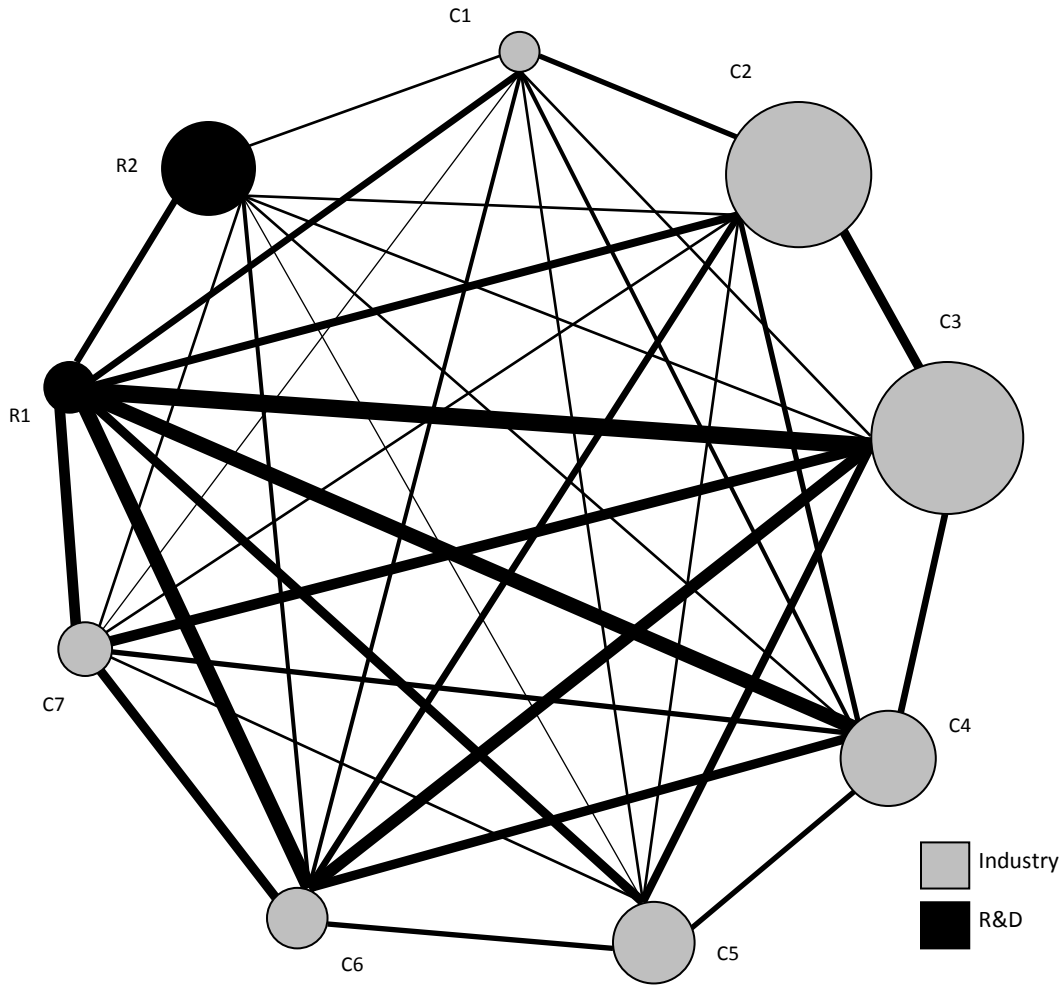

Figure 8: Cluster network, status 2010.

The fourth indicator measures to what degree spillover effects are influenced by the crisis. Spillover effects are agreed upon knowledge flows between companies to strengthen the cluster as a whole. The main interest here is to investigate whether local stocks of contextualized complex knowledge are not only accessible but also eventually absorbed by localized firms. Spillover effects can be found in various configurations, for instance; a. direct support between companies, b. use of local research institutions and c. new product- and process ideas. From the interviews there are extracted a few examples that support the effects like direct support and use of local R&D institutions and possible new ideas during the crisis.

- The first example describes a situation in the beginning of 2009 at **C6** when they were developing a new product for an automotive OEM. This OEM, which was new to **C6**, had stated the importance of frequent "*on-site-evaluations*" during the project in their quality system. However, the crisis led to travel restrictions for both the OEM and **C6**, so in order to get hands-on information about customer drawing specifications **C6** turned to a company in the cluster they knew had much experience with the same OEM for help.

- When the Swedish holding company **C5** went bankruptcy during the crisis the plant and the product development department at Raufoss were heavily affected. The competence developed at **C5** is regarded as the leading edge in Norway when it comes to plastic injection molding. In order to preserve this important knowledge base **R1** and **C5** together with NCE Raufoss and governmental funding sources initiated a program to establish an international competence group on plastic and composite materials. This group now consists of six people who support exiting R&D projects, national industry as consultants and NCE Raufoss in order to industrialize new ideas.
- The spillover effect when it comes to new product- and process ideas is not very present in the cluster according to the interviewees. But the presence of **C3** in the industrial park seems interesting for several of the actors. For instance **C3**'s products for the defense industry attain interest from **C2**, where informal discussions already have taken place. **C3**'s so-called open minded philosophy is in general welcomed at Raufoss, giving hope for new impulses and products.
- As seen in Figure 9 **R1** is assumed to contribute to spillover effects due to the total number of linkages to the other nodes in the network. These linkages provide overview of different needs in the cluster, which in turn can be addressed by contacting the right person(s), consulting, initiating research projects etc. This is possible due to **R1's** extended network consisting of national industry, national and international universities and research institutions. This is in line with findings by Giuliani and Bell (Giuliani & Bell, 2005) who stated that firms with high external openness could be potentially fruitful at local level if they contribute to the diffusion of acquired knowledge to other firms in the cluster.

The examples described above show traces of spillover effects, especially related to advices and use of local R&D institutions. However, the local innovation system in terms of new products, processes and services seems to be exclusively driven by demanding customers. From this study there are few evidences of spillover effects beside friendly support and cooperation in long term R&D projects.

7. Discussion

From the indicators and results presented above the impact of the crisis was not as evident as anticipated with regard to efficient accumulation and adaption of knowledge. Despite the dramatic reduction in number of employees and R&D human resource index there are still considerable activities in attracting new customers, developing new products, participating in R&D projects and patenting of new solutions – as shown in Table 3. When looking at the category intra-cluster knowledge communication patterns the results show a slightly decrease in number of intra-cluster linkages during the crisis, but, in general companies seem to have some focus on helping each other to strengthen the cluster. But the main priority is internally for each company. Thus, at first glance, the reduction in an organization's ability to acquire information

does not give the impression of reduced capability to create knowledge and adapt it into new products. The same seems true for the ability to maintain relations and accumulate knowledge at cluster level, supporting the "likelihood of survival" when embedded in an alliance (Gulati, 2007).

Categories	Indicators	Results
Firm level absorptive capacity		
	Number of employees	Down 21.0%
	R&D human resource index	Down 34.0%
	Number of new customers	Up 17.5%
	Number of new products	Up 8.0%
	Number of new R&D projects	Up 14.0%
	Number of new patents	Increased

Table 3: Summary of results.

This instrumental view of absorptive capacity clearly shows that measuring it is challenging. Absorptive capacity is a simple definition on a very complex and multilateral phenomena. Measuring will, even when measuring at separate time intervals, give a snapshot of a dynamic capability than changes constantly. In this research some moderators have been touched up on. Moderators are anticipated to, in most cases, positively affect output in the short run and can be seen as either intentional actions taken by the firms or as more accidental events. This means that the definition of absorptive capacity holds better when reducing effects of the moderators, claiming that the impacts of the crisis will be more observable in a longer time lag than measured in this analysis. The lack of instantaneous impacts of the crisis upon absorptive capacity can be attributed to the following moderators:

Level of preparedness implies that an organization prior to the crisis had cut fixed costs to minimum, implemented efficient lean processes throughout the enterprise, and introduced extremely professional information acquiring processes to adapt to customer requirements. Streamlining manufacturing processes and global value chains have been part of the automotive industry for decades, making actors in the industry used to survive with a minimum of resources. This attitude, together with an already squeezed market, may have absorbed some of the shock created by the widespread substantial crisis hitting the world in fall 2008. However, there is assumed that it exist a thin line between reducing information to a minimum and actually miss crucial information which in turn may harm product functionality, reliability and quality.

The increase in number of new customers and products may result from work done prior to the crisis. Capture new, and retain existing, customers in aerospace and automotive industries are often long processes, including lots of prototypes and verifications to qualify new products and processes. Consequently, these qualifying processes materialized into contracts at the outset or during the crisis, stacking up projects that have kept the companies busy. As stated by **C6**; during

the crisis, the entire product development department prioritized industrialization of newly won contracts, hence, forfeiting further market and development work. Also **C4** and **C7** have faced similar experiences, which have forced them to keep the R&D human resource index fairly stable. This can be regarded as short term trade-offs and may explain a great deal of the paradox of observed increase in number of project, and a stable cluster activity, at the same time as companies reduce their R&D staff. However, the long term effects of reducing market and development efforts might entail missed customers and contracts, indicating that the crisis will impact businesses for many years to go.

Another explanatory factor is how companies make structural changes when faced with major volume drops. Traditionally have work experience and number of years employed in the same organization been a fundamental principle in Norwegian work life when deciding who to survive a downsizing process (Kjeldsberg, 2009). This is not an unconditional principle but constituted in most employee and employer organizations agreements. Assuming that this principle is compelled, it is also probable that the most experienced personnel, which also hold the most of the linkages to suppliers, customers and R&D institutions, has been preferred over younger and more inexperienced ones. Thus, the companies preserve number of external linkages which is valuable in searching for new and relevant information. Such flexibility is demonstrated in the Raufoss cluster by creating new jobs at **R1** for the skilled workers coming from **C5**. Several of the companies also report job mobility within the industrial park, where for instance **C2** has engaged laid-off people from other actors in the cluster. As a result, this moderator does not give a unilateral answer, but may have affected level of absorptive capacity.

Based on the amount of research results (EEA, 2009) pointing to the effect of CO2 emissions to global warming, and the linear relationship between CO2 emissions and vehicle weight, EU has initiated new regulations. For instance will all cars registered in the EU from 2015 comply to a limit curve set by legislation, stating that a fleet average of 130 grams CO2 per kilometer has to be maintained (ECE, 2010). Such regulations call for new solutions and new performance standards at all levels. To meet these regulations weight reduction is an important factor, which in turn gives opportunities for the regional cluster at Raufoss. The cluster has over four decades of accumulated knowledge on light weight solutions, mainly aluminum, which will be part of future solutions to reduce vehicle weight. Hence, the car manufactures positioning according to new regulations may have positively affected product- and customer bases in the cluster. **C7**, for instance, reports new contracts with existing customers which comprise a broader portion of their model program, than prior contracts. **C7** sees this extension of aluminum products in lineups as a result of new regulations, and that their demonstrated long term expertise and delivery of quality products as main reasons for adding products to their portfolio during the crisis. Aluminum is un-doubtable part of the solution to reduced weight; hence, it can be seen as a moderator with regard to the aluminum intensive industry at Raufoss.

The last moderator which is expected to influence absorptive capacity in the long run is level of external funded research projects. Such projects, mainly government funded, are often estimated

to last for 3-5 years, thus having an appropriate portfolio at the onset of the crisis, and maintaining or improving the hit rate during the crisis, will keep up long term research activities given the condition that resources can be committed. The research project portfolio was considered at a proper level by several of the companies in 2008, and they managed to increase it the successive two years. However, the cancellation of the BIA-program (User Driven Research Projects) by the Norwegian Research Council in 2009 makes the companies concerned. Number of BIA-projects made up over 56% of the cluster's research portfolio in 2010, so they are looking forward to the research councils calls for this particular program in 2010 and 2011. Also government issued short term loans to the industry during the crisis have contributed to keep the pace of ongoing and new projects.

The discussion above shows that explaining absorptive capacity in the light of a fundamental crisis need a set of moderators. This set may be added to "prerequisites and concerns related to absorptive capacity" as introduced in the literature part of this paper.

Categories	Indicators	Results
Intra-cluster knowledge system		
	Infrastructure collaboration	Improved climate for infrastructure discussions
	R&D linkages	Down 3.0%
	Internal customer and supplier linkages	Down 11.8%
	Spillover effects	Observable, but limited with regard to new product- and process ideas

Table 4: Summary of results.

8. Conclusion

This paper investigates how the financial crisis has impacted absorptive capacity, at both firm and cluster level, in a regional cluster. The instrumental view of absorptive capacity on a company level did not give satisfactory answers. Absorptive capacity is by nature a dynamic feature that is in constant change, and it is highly complex. Theory assumes that this is something that occurs rationally in a company, but people's ability to absorb new knowledge is not only determines by rational choices. And according to this measuring it will always face problems.

Taking a more dynamic approach to the absorptive capacity a clearer and more interesting picture can be revealed. But also this has it limits due to the underdeveloped definition of absorptive capacity. Moderators for such a dynamic view of absorptive capacity have been discussed and needs to be researched further.

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