NETWORKING INNOVATION IN THE EUROPEAN CAR INDUSTRY: DOES THE OPEN INNOVATION MODEL FIT?[1]

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ABSTRACT

The demands of transportation have driven the automobile industry into an innovation race. Uncertain technological trends, long development cycles, highly capital-intensive product development, saturated markets, and environmental and safety regulations have subjected the sector to major transformations. The technological and organisational innovations related to these transformations necessitate research that can enhance our understanding of the characteristics of the new systems. The study investigates the applicability of the Open Innovation concept to a mature capital-intensive asset-based industry - the European automobile industry, which is preparing for a radical technological discontinuity. Purposely selected knowledgeable respondents were interviewed across seven European countries. The findings contribute to the understanding of the OI concept by identifying key obstacles to the wider adoption of the OI model in the European car industry, and signalling the importance of intermediaries and large incumbents for driving network development and OI practices as well as the need of new competencies to be developed by all players.

Key words: open innovation, networks, car industry, SMEs

1. INTRODUCTION

The car industry has a major influence on transportation developments in general and on the wider concerns about climate change. Transportation policies and innovation in the car industry are critical to the radical change necessitated by the demands of climate concerns.

With huge development costs, long development cycles and fierce global competition, the car industry is a traditionally closed industry. Costs must be contained, and yet customers in nearly saturated markets still desire new, cutting-edge products (Ili et al, 2010, Lazzarotti et al, 2013). Moreover, significant amounts of resources have been spent in recent years on lowering emissions and on the development of environmentally-friendly vehicles. The transition to such vehicles requires a radical and costly technological and organisational shift in automobile operations.

Under growing pressures from increasingly demanding customers, safety and environmental regulations worldwide, the automotive sector has entered an innovation race. Sustained competitive advantage increasingly depends on the ability to improve and accelerate innovation output continuously (Fallah and Lechler, 2008). Innovation has become largely dependent on the ability to monitor all the latest market and technological developments and integrate various complex technologies.

The constraints of the monolithic, vertically integrated firm in scanning the environment and identifying relevant technological breakthroughs and market changes have given rise to the networked organisation characterised by porous boundaries and numerous linkages with other organisations. In the car industry, large manufacturers, also known as Original Equipment Manufacturers (OEMs), form clusters and wider networks driving a deep restructuring of the supply chains and transforming them into supply networks (Karlsson and Sköld, 2013, Dilk et al, 2008). The number of participants and interdependences within and between these networks, coupled with a turbulent business environment and shortening product life cycles generate high complexity of innovation tasks and decision-making. The question that arises is how and why networks are formed in an industry preparing for a radical technological shift, which requires a major rethink of its approach to innovation.

Indeed, Open Innovation appears in policy advice as the way forward for the industry (MacNeill and Bailey, 2010) and the involvement of Small to Medium sized Enterprises, SMEs, as providers of new technologies to OI ecosystems is seen as particularly suited to electric vehicle development (Parker and Parry-Jones, 2013). However, the application of the Open Innovation model has been little investigated in the context of mature asset-based industries (e.g. Chiaroni, 2010), like the car industry.

Against this background, our study aims to explore the application of the OI model to a mature asset-based industry – the European car industry - in the light of the radical technological discontinuity taking place in the sector.

More specifically, we aim to investigate:

- How and why networks are formed;
- What inflows and outflows of knowledge circulate within the networks and how companies make use of them;
- What is the role of different size enterprises in the generation of innovation and how they interact in the process;
- How intermediate markets and institutions facilitate interorganisational interactions.

The paper is divided into five main sections. It begins with theoretical background of the study and review of the existing research on OI in the car industry. A methodology section follows, with the description of the investigation protocol. Then, the paper presents the findings of the semi-structured interviews conducted in seven countries. The following section is focused on discussion proposing a large-scale innovation model of innovation in the car industry. Finally, the conclusions and limitations of the study are reported.

2. THEORETICAL BACKGROUND

2.1. *OPEN INNOVATION*

The Open Innovation (OI) model has become popular through providing a different perspective on how companies can create and profit from innovation (Chesbrough, 2006, Gassmann, 2006). OI has been defined as ‘the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and to expand the markets for external use of innovation’ (Chesbrough et al., 2006, p.1). Outbound knowledge flows are defined as unused technologies that can be sold or licensed to organisations with better suited for their commercialization business models (Chesbrough and Crowther, 2006). Hence, in contrast to the traditional model where innovation is internally generated and marketed, the OI model recommends utilization of both internal and external sources of ideas. OI is all about leveraging and utilising knowledge inside as well as outside the organisation in order to exploit innovation opportunities.

The idea of sourcing knowledge externally is not new (e.g. Nelson and Winter, 1982, Von Hippel, 1988, Cohen and Levinthal, 1990) but Chesbrough's work provides an overarching concept encompassing various research streams. The basic assumption behind the OI model is that even large enterprises can no longer possess all the capabilities and resources to generate innovation by themselves and need to capitalize on external knowledge (Gassmann, 2006). Indeed, in the car industry the increasing complexity of cars as products reflects the growing number of technical fields that provide opportunities for new developments and problem-solving. The growing importance of deep specialized knowledge in these fields necessitates an upsurge of R&D investment and need for organisational capabilities that allow absorption and integration of external knowledge. To deal with the tension between cost pressures and the need for diverse specialized knowledge , car manufacturers focus on their core competences and outsource other activities thus forming networks of suppliers (e.g. Ward, 2014, Schmitt and Biesebroeck, 2013, Frigant, 2011).

Thus the role of OEMs in the increasingly distributed value networks is seen as system integrators who must possess capabilities to specify and test externally produced components, and to coordinate the integration of new technologies. Integrative competencies, however, are not as strongly associated with particular areas of technological knowledge but relate to application-specific knowledge and adaptability to environmental changes such as emergence of new technologies. Hence, for large organisations the adoption of the OI model necessitates organisational innovation and adoption of structures that allow adaptability and flexibility for optimal combination of internal competencies and external knowledge (Christensen, 2006, Chiaroni, 2010).

It is less clear, however, what is the role of SMEs in the generation of innovation in the distributed value networks in a mature industry preparing for a radical technological change. The ability of SMEs to innovate has become increasingly important in the light of deepening trends for specialisation. Yet, while some studies report that entrepreneurs and SMEs are great idea hunters because they are skilled at opportunity recognition (O'Connor, 2006), it is also argued that many SMEs lack the capability to innovate (e.g. Vermeulen, 2005). Lack of resources and limited access to qualified labour are often cited as the main obstacles to SMEs' ability to innovate (Amini, 2004).

One way to overcome these deficiencies is through engaging in interorganisational networks, which reinforce SMEs' innovative ability by providing them with a window on technological and market change, and sources of technical assistance and potentially available resource flows (Vermeulen, 2005, O'Regan and Kling, 2011). However, existing research is inconclusive about the ability of SMEs to engage in networks and exploit effectively external scientific and technical knowledge to support their innovation. Some authors argue that SMEs have a good ability to create and make use of network relationships due to their size (Massa and Testa, 2008) while others claim that SMEs have weak external contacts precisely because of their size (Srinivasan et al., 2002). Moreover, SMEs are generally short of managerial resources and find it difficult to manage a broad network due to a very high opportunity cost of management time (Srinivasan et al., 2002, Lowik et al., 2012).

To reap the benefits of OI, thus offsetting the limitations of resource shortages, SMEs need to build a strong regime of appropriability in the early stages of the technology life cycle through establishing a combination of patents and deep and complex technology knowledge base, generally unrelated to the knowledge bases of the large players

(Christensen, 2006). Moreover, SMEs should make this technology base attractive to incumbents through codification, documentation, and communication, and engage in cooperation with incumbents to create functional solutions and test market potential (ibid.) or sell the technology to complete its commercialisation (O'Connor, 2006). Thus, one way or another, entrepreneurs and SMEs are bound to become involved with large incumbents (Christensen, 2006, Teece, 1986).

In sum, this perspective suggests that SMEs deliver innovative ideas and technologies, which large enterprises integrate in product architecture in exchange for complementary assets (Christensen, 2006). While SMEs and entrepreneurs concentrate on exploration and perhaps some experimentation, large incumbents step into the final stage and take over experimentation and exploitation, instituting repeatable processes such as manufacturing, delivery and customer contact and support (O'Connor, 2006). Such symbiotic relationship, theoretically at least, can compensate for the cumbersome structures of large enterprises as well as for the resource shortages of SMEs.

However, do SMEs possess the managerial and organisational capabilities to secure rents from the technological knowledge when collaborating with large incumbents? Shortage of managerial resources (Lowik et al., 2012) combined with asymmetric information, insufficient bargaining power, economic incentive conflicts and associated opportunistic behavior, and differences in norms and procedures are likely to result in SMEs being squeezed in the negotiation rounds and exit, or be acquired (Christensen, 2006, Christensen et al, 2005).

Last but not least, the OI model is highly dependent upon intermediate markets where entrepreneurs supply new discoveries and highly specialised technological capabilities, possibly in collaboration with research institutions, to large companies, like OEMs, who in turn provide integrative capabilities, transform technologies into application-specific use, and complementary assets for large scale commercialisation of innovation (West and Bogers, 2014, Lee et al., 2010, Sieg et al, 2010, Spithoven et al., 2010, Chesbrough, 2006a, Teece, 1986). Thus the OI model highlights the prominence of market-supporting institutions in promoting technological entrepreneurship as well as the importance of multiple ties among organisations and various types of institutions, e.g. universities, research centres, government and regional institutions (Simard and West, 2006). It is important to explore to what extent intermediate markets and institutions facilitate interorganisational interactions in the car industry.

2.2. *OPEN INNOVATION IN THE CAR INDUSTRY*

To have external validity, a paradigm must explain evidence beyond its initial area of enquiry (Yin, 1988). However, the evidence to support the OI concept is taken almost exclusively from evidence in the context of high-paced industries, such as computers, software industry and pharmaceuticals (e.g. Chesbrough, 2003a, 2003b, 2003c, 2003d, West and Gallagher, 2006, Gardet and Fraiha, 2012). Whether the OI concept can be applied in lower tech or more mature industries, remains an open question. Mature industries display very different characteristics in terms of types of innovation, handling of intellectual property rights (IP), patterns of innovation diffusion, risk management as well as strategies for exploiting innovation. Hence it is important to examine whether the OI model is appropriate in other industry settings and what obstacles prevent the wider adoption of the model.

As in many other industries (e.g. Coombs & Richards, 1993, Christensen, 2002), in the 1980s, the car industry witnessed a move from the prevalent central-R&D-lab model towards a more distributed R&D model through supplier involvement in new product development. While this may be seen as a move towards OI, suppliers were still working under strict guidelines and specifications provided by OEMs. Although specifications vary in the level of detail (Ge and Fujimoto, 2006), their prescriptive nature make it problematic to see the resulting output as purposive knowledge inflows intended to accelerate internal innovation in OEMs. OEMs still maintained powerful central laboratories while experimenting with ways of coordinating R&D at different levels (Tidd et al., 2005, Argyres, 1995). The move in the 80s has been branded 'a dismal failure' by industry practitioners and resulted in transferring the design control and product validation back to OEMs in the 90's.

Whilst there are examples of Open Innovation in the automotive industry, some of which have been studied (e.g. De Massis et al, 2012; Lazzarotti et al, 2013), the industry as a whole remains conservative. An early study by Ili et al (2010) examines OI and demonstrates that the car industry displays all the relevant properties suggesting that the OI model would be appropriate, i.e. it is highly globalised, technology intensive, characterised by high levels of technology fusion and open to identifying and implementing new business models. The one idiosyncrasy that does not fit the OI model is the observed low level of knowledge leveraging. The authors conclude that the closed innovation paradigm still dominates the industry and recommend that the car industry should consider the OI model despite the remaining barriers.

Di Minin et al (2010) develop a case study of Fiat and conclude that OI is a bifocal strategy, in the sense that it balances the need to stay focused when only meager resources are available and continue investing in the company's future thus strengthening operational efficiency while preserving and enhancing R&D effectiveness.

Stating that there are few studies about the topic, Lazzarotti et al (2013) explore whether, why and how OI is adopted in the automotive field. Based on three case studies, the authors agree with Ili et al (2010) in confirming the automotive industry as 'being trapped by cost and innovation pressure by customers' (Lazzarotti et al, 2013:53). The authors see partnerships as a manifestation of OI in the automotive industry, conclude that Tier 1 suppliers are more likely to engage with a wider knowledge base to pull new technologies. OI is seen as the way ahead and further investigation of OI practices of SMEs in the industry is recommended.

Depicting the network as a more relevant level of analysis than the firm, Karlsson and Sköld (2013) examine OI practices in the car industry through focusing on the various collaborations and relationships of a single large global automotive OEM. The authors distinguish between vertical and horizontal relationships and find that large enterprises developing and manufacturing complex products may use many different forms of OI resulting in the concurrent existence of combined openness and closedness in innovation for different purposes. The paper concludes that patterns of OI are primarily found in vertical relationships but even in those, 'closed' signatures are found in relation to large influential suppliers owning scarce technology or prescribing technological content. Such relationships are nevertheless seen as OI because the innovation activities were performed outside of the firm boundaries. Horizontal relationships are found to be dominated by closed innovation.

In sum, despite extant research pointing to the relatively closed nature of the interorganisational relationships in the car industry, we still know little about the 'how' and 'why' of OI in this conservative industrial setting. Little attention has been devoted to the question whether OEMs possess the capabilities needed to become the leaders of OI ecosystems, i.e. supporting and accelerating inflows and outflows of knowledge to facilitate innovation and efficiency. For mature traditional companies like car manufacturers, OI is a marked departure from previous integrated 'industrial' models. OI necessitates competencies in identifying and exploring unexpected opportunities that emerge from technological breakthroughs outside of the firm.

3. RESEARCH METHOD

We applied a qualitative inductive approach as the variable-oriented techniques would not allow us, for example, to address questions about motivation or to observe causal processes (Rueschemeyer & Stephens, 1997), particularly with regard to sensitive issues such as interorganisational relationships, interaction problems, intellectual property (IP) rights, and perceived risks. Moreover, the use of OI in a mature industry preparing for a radical technological shift is a complex, novel, and little studied phenomenon, and we wanted to capture the details and iteractions that were making the story.

3.1. *SELECTION OF RESPONDENTS*

The study applies the principle of data source triangulation, whereby the phenomenon of interest is studied at different places (Stake, 1995), e.g. across organisations, which vary in terms of size, locality, or industrial background, in order to achieve validity of interpretation, explanation and generalization. The respondents in our study come from seven European countries - Germany, Hungary, Italy, Romania, Slovenia, Spain, and UK.

It is often problematic for the researcher to identity key informants who can provide the most relevant information (Fontana & Frey, 1994). Consistent with the logic of Huber and Power (1985), who argue for selecting knowledgeable informants, the respondents for this study were purposely selected to represent car industry stakeholders from one of the following groups: OEMs, large suppliers also known as Tier 1 suppliers, SMEs, regional authorities, cluster management, regional universities or research institutes involved with the automotive industry, and regional support agencies (description of the respondents in Appendix A).

This approach allowed examination of the experiences and perspectives of a diverse selection of individuals who were directly involved with the studied phenomena hence ensuring the research problem was approached 'in a rounded and multi-faceted way' (Mason, 1996, pp. 149).

3.2. *DATA COLLECTION*

The employed research instrument was semi-structured, open-ended interview for its potential to generate rich and detailed accounts of the interviewed individuals' experience. This research instrument allows the discussion to lead into areas which may not have been considered prior to the interview but may be potentially relevant. This flexibility was particularly important in our study due to the different professional background of the respondents and the need to make full use of their individual experiences, while ensuring consistency and comparability across the interviews.

A set of directional topics (Appendix B) was prepared, reflecting the insights gained from the review of the relevant existing literature. The questions were designed in most general terms to allow multiple site research and collection of data comparable across country boundaries and organisational settings. The specific questions and their order varied between interviews depending on the conversational flow while the common topics ensured comparability across interviews.

The data collection was completed over a three-month period (January – March 2012). Each interview began with a brief professional history of the interviewee. These narratives lasted approximately 5-10 minutes and were used as the basis for follow-up questions for the remainder of each interview. The interviews ranged in length from 50 to 90 minutes. All interviews were taped and transcribed.

The interviewees were encouraged to develop their views around the open-ended questions. The interviews captured a broad picture of the automobile industry and the processes taking place in the sector because most of the respondents had occupied different positions or worked in different companies in the industry over a number of years. These individuals were able to reflect on their experiences and provided valuable insights into the studied problems.

Thirty interviews were conducted until it was felt that theoretical saturation was reached and we felt confident about the meaning and importance of the findings (Bryman and Burgess, 1994).

3.3. *DATA ANALYSIS*

In qualitative research, theory and concepts tend to emerge from the inquiry, coming after data collection rather than before (Robson, 2002). Following this logic, the study adopted a holistic unstructured approach to the data analysis, allowing themes to emerge from a close reading of the interview transcripts rather than using preconceived categories (Dey, 1995, Charmaz, 2014). This approach is underpinned by Kolb's learning cycle model (Colombo et al., 2012, Kolb, 1985), which consists of four stages: data collection, reflective observation, abstract conceptualisation and active experimentation, as set out with the research method in Fig 1.

The data were initially broken down into categories (nodes) corresponding to the directional interview topics (Appendix B). To ensure respondents' anonymity as well as links to the original files, all the data were coded and cross-referenced. In those cases where the respondent's reply addressed more than one node, the data were coded into both categories. The data were then searched for patterns and reoccurring events in order to identify emerging themes (Gephart, 1993, Miles and Huberman, 1994). A theme was defined as a recurring topic of discussion that captured an interview's central ideas (Dutton and Dukerich, 1991). Continuous comparison across the interviews ensured that all reoccurring events were accounted for and grouped together (Glaser

1978, Gephart, 1993). The data were then reordered to reflect the research objectives of the study. NVivo9 software package was used to assist the organisation of the data.

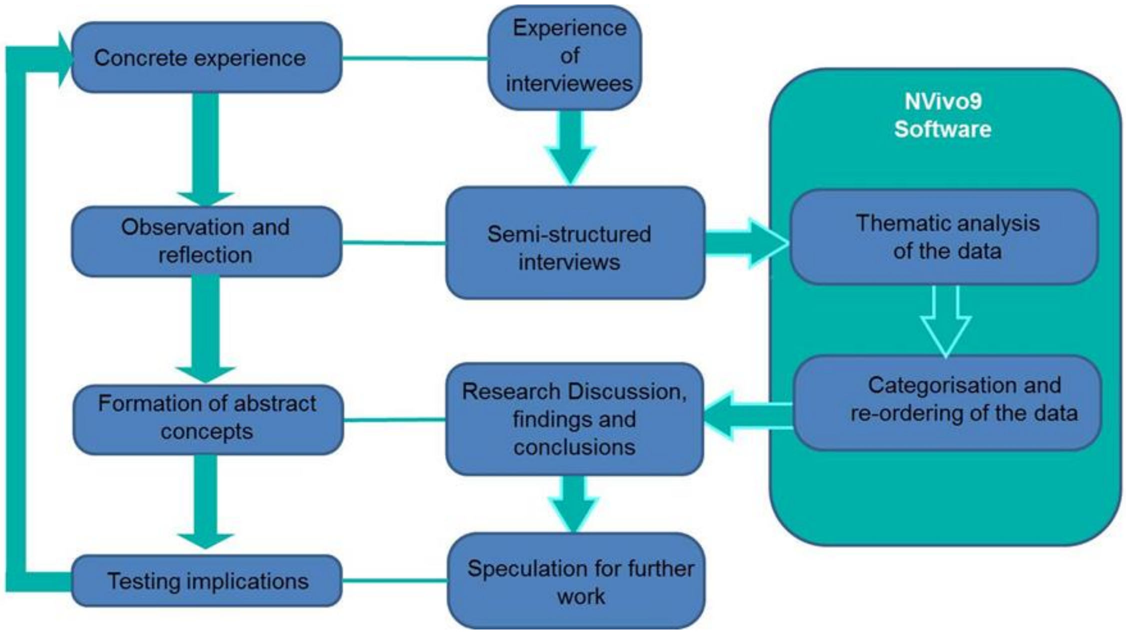

Fig. 1 The research method set out as four stages to mirror Kolb (1985)

Finally, the identified patterns were checked for a fit with existing models and concepts. This grounding in the existing knowledge corresponds to the final stage of Kolb's learning cycle model and provides conceptual leverage to the significance of the emerged concepts and models (Glaser, 1978).

3.4. *VALIDITY AND RELIABILITY*

To ensure reliability of the findings, all the interviews and consequent comments were tape-recorded and transcribed, and consistent data coding and sorting were deployed and documented.

In qualitative research, the primary checks on validity are internal checks on the validity of the data (Kirk and Miller, 1986). Hence, the emerging categories were continuously refined in parallel with the process of interviewing. As the research progressed and new or inconsistent data were collected, the categories were constantly compared and modified. Moreover, all the interviewees agreed to follow-up calls and emails and, where necessary, elaborated on unclear points. To assist the validation of the findings, the interviewer summarised the key points for each section of the questionnaire and asked the respondents to comment on the truthfulness of the interpretation. The identified inconsistencies were recorded and used to support the data analysis.

4. FINDINGS

In this section the key findings of the study are summarised. First, we discuss some general findings about the formation of different types of networks in the car industry. After that, the findings concerning knowledge flows and exchanges are presented followed by findings describing the role of different size enterprises in the generation of innovation. Finally, the role of intermediaries in supporting innovation are discussed. The anonymised respondents are listed by type in Appendix A and referenced in the text by R1, R2 to R30. Appendix C contains some key evidence in support of our findings.

4.1. *NETWORK FORMATION IN THE EUROPEAN CAR INDUSTRY*

Our findings show that two types of networks can be distinguished in the EU car industry: formal networks, known as 'clusters', and informal networks. The latter can be project-based networks, typically initiated by research centres, or free networks, strictly based on trust and credibility. These were termed 'informal' to indicate the temporary, project-based, problem-oriented character of such networks. The clusters, on the other hand, are formal networks, typically established and funded by the industry and the regional authorities. We found such regional industry networks in all the countries covered by this study.

The cluster networks differ between countries in a number of characteristics, e.g. size, variety of membership, method of funding, level of organisation, level of support and type of services for member companies. However, the better-developed clusters typically involve 'a cross-section of the industry' (R20) as well as research organisations and universities.

Large incumbents participate in clusters mainly to secure a window on potentially innovative developments. While the evidence shows that OEMs may not necessarily see benefits in network membership, it also shows that large enterprises are interested in networking *per se* as a source of new ideas.

In the less developed clusters, the member base is typically limited to SMEs, universities and support institutions. The clusters, in which large incumbents are absent, tend to be under-resourced and often dissolve over the course of several years. SMEs participate in the clusters to gain bargaining power, access to technology and expertise, managerial and administrative support. Most importantly, the clusters support the regional automotive SMEs through facilitating their relationships with the large OEMs, Tier 1s, public authorities and research institutions.

Interactions between SMEs and larger incumbents are seen as having a strong positive effect on SMEs' technological and organisational capabilities. While in the less-developed clusters SMEs work together to increase their buying power and bid for work on larger and more complex projects, SMEs in the well-developed clusters have the opportunity to work on advanced R&D projects in cooperation with OEMs and Tier 1 suppliers as well as with universities and research institutes.

> 'The OEM is a nucleus for this kind of companies [SMEs]' R13[4]

[4] Respondents are referenced by number.

The regional clusters are seen as important platforms for developing ties between organisations of different sizes, providing a platform for exchange of ideas, facilitating interorganisational communication, nurturing fostering trust, as well as supporting the development of managerial and R&D capabilities in SMEs. The spatial proximity of the member organisations within the clusters is seen as important due to the uncertainty and multidisciplinary nature of large complex development projects.

4.2. Knowledge Flows in the Networks

The key characteristics of a network are the participating actors, the relationships between them, and the resources exchanged through these relationships. In the context of OI, the existence, intensity and direction of the knowledge flows circulating between the participating actors in the network indicate to what extent OI practices are employed. We distinguish three types of purposive knowledge flows in the industry: (i) between OEMs/Tier 1s and knowledge institutions, (ii) between OEMs/Tier 1s and SMEs, and (iii) between SMEs and knowledge institutions. Our findings strongly indicate that problems and barriers exist at all levels and knowledge flows in the car industry are, although to a different degree, largely restricted.

In the traditional industrial segments, the incoming knowledge flows of car manufacturers are strictly limited to large suppliers and research institutes. As noted in the previous section, a key feature of the better-developed clusters is the presence of OEMs and good working, yet narrow in scope, relationships between the OEMs and the member universities, including ‘involvement of students into production for training purposes’ (R25) and contribution to research development.

OEMs work much more intensively with research institutes and outsource R&D, ‘or rather D’ (R17). The key considerations underpinning the use of research centres by OEMs are costs, time to market, the progressive complexity of cars as products, the corresponding necessary diverse knowledge base and increasingly shortening technology life cycles. While OEMs do outsource development projects to research organisations, they also retain key capabilities internally. The adopted approach is twofold. Internally, large manufacturers create the structure and the specifications, while externally they task R&D organisations with the development of the necessary subsystems. Such approach ensures that internal capabilities are maintained to allow successful integration of the sourced components and systems. Indeed, research institutes as well as suppliers work to OEMs’ strict specifications. The dominant approach of OEMs appears to be sourcing of external technology as a ‘black box’ component for modular systems integration (Jaspers and van de Ende, 2010).

The data strongly indicate that both the incoming and the outgoing knowledge flows of OEMs are strictly controlled and restricted to the relationships with trusted Tier 1 suppliers. Notable exceptions are the fewer relationships with research organisations as discussed above. Relationships between OEMs and SMEs are indirect and only possible through the mediation of Tier 1 suppliers or regional clusters. The key barrier to the use of external knowledge by OEMs appears to be the lack of trust rooted in the capital intensity of the industry and the related momentum of production, credibility, cost, risk aversion and responsibility considerations. As one of the respondents noted:

> ‘You have to trust in others’ knowledge, that is a learning process.’R16

The data also points to mindset of R&D staff as being a big part of the resistance to external ideas. The cultural and organisational barriers to OI identified by Ili et al. (2010) in the German car industry, including the ‘not-invented-here’ syndrome, lack of appropriate processes, and top-down integration, were found to hold in all the national settings in our study.

In addition, the very size of OEMs creates challenges of accessibility and transparency due to lack of efficient communication interface between OEMs and the rest of the industry, hence further restricting knowledge exchanges with organisations that do not belong to the close trusted circle of suppliers. Last but not least, the transaction costs associated with coordinating a large supply network were pointed out as an important consideration behind the small number of relationships that OEMs are willing to be closely involved in.

An interesting distinction was made between the types of OEMs. It was pointed out that luxury car manufacturers tended to be ‘very open to new ideas. This is one of their sales points. But the volume manufacturers are not open.’ R25

In contrast, Tier 1 suppliers appear to be well connected both upwards with the OEMs and downwards with the SMEs. They are also the ones who appear to be most open – not only they actively scan and select external ideas and knowledge, but they also attempt to maximise the exploitation of their own innovations by offering them to other industries.

SMEs, on the other hand, find it next to impossible to exchange knowledge flows with OEMs and difficult to work with large suppliers due to the reasons discussed above. Hence, the paths for taking advantage of OI and making their technology base attractive to incumbents (Christensen, 2006), boil down to two: via Tier 1 suppliers or via the regional clusters. However, SMEs, engaging in collaborative work with large incumbents typically lack the managerial and organisational capabilities to secure rents from their technological knowledge, e.g. ‘resource management, project management, quality management’ R6. Cluster membership offers better chances of benefiting from own innovations. All in all, while SMEs may reap great benefits from OI in dynamic, knowledge-based, labour-intensive industries like the software industry, in mature capital-intensive asset-based industries like the car industry, they have limited options.

SMEs themselves are very cautious in their interactions with other organisations due to appropriability concerns. The result is anxiety, closedness and reluctance to engage in even in cluster initiatives and work with universities. A comparison is made between SMEs and OEMs, pointing out that the latter had the organisational capabilities and resources to separate R&D projects and ensure that ‘inside knowledge that is very sensitive, they do not let out’ R13. In addition, universities are seen by SMEs as having a different agenda reflected by their approach to knowledge generation and project management. The challenge of inefficient use of external knowledge by SMEs is observed even in the most developed clusters.

In concert with previous research, our findings show that the car industry is still a closed industry in a pressing need of cultural change if it is to accelerate innovation rate and adaptability. At present, the sector uses mainly its own direct environment as a trigger for innovation: the handling of IP is defence-oriented (Ili et al., 2010), while the most important drivers of innovation are legislation and regulations, followed by customer demand. Ultimately, the intensity and quality of participation and knowledge exchange are contingent upon the beliefs and drive of the individuals involved. Existing mindsets and lack of trust in both OEMs and SMEs are cited as key communication barriers rooted in risk aversion, cost, and appropriability concerns.

4.3. The Role of Enterprises of Different Size in Innovation

The data strongly indicate that key product innovations are driven by OEMs and executed by Tier 1 suppliers. The importance of OEM's willingness and ability to lead innovation in the networks is highlighted beyond doubt by the respondents. As highlighted in the previous section, the progressive complexity of cars as products and the corresponding diverse knowledge base combined with increasingly shortening technology life cycles necessitate deep specialisation of tasks in the industry and underpin OEMs' 'black box' approach to sourcing technology. However, OEMs are highly regarded for their knowledge and understanding of customer needs. The role of car manufacturers is seen as innovation architects, technology selectors and integrators, responsible for the capital-intensive commercialisation of the end product.

Tier 1 suppliers are regarded as powerful players, productive innovators as well as innovation selectors and integrators on a par with OEMs. They are expected not only to generate most innovation but also to 'manage' the rest of the suppliers hence reducing risk and transaction costs for OEMs. In other words, OEMs and Tier 1 suppliers possess the power and the competences to select the technologies and products that will reach mass commercialisation. Smaller suppliers are provided technical specifications and aggressive cost targets within which they must deliver.

While most of the respondents shared the view that smaller suppliers contribute significantly to the innovation and expertise of large incumbents, in conventional automotive markets resource constraints and lack of credibility prevent SMEs from taking their inventions to the market and capitalising on them. Typically, the owners of worthy innovations are bought by Tier 1 suppliers. The dominant view is that rarely, if ever, an SME can capitalize on its own IP and grow to 'a self-sustaining company because that is really serious capitalization' R20. In other words, SMEs typically lack the complementary assets to scale innovation.

However, opportunities are emerging and spaces are opening up for innovative SMEs in the new segments around environmentally friendly vehicles, e.g. in IT, electronics, software and mobility services, telematics, car entertainment, as well as the development of relevant infrastructure. While the car industry is still very much closed in its traditional segments, the expected shift to electrical vehicles is giving rise to OI practices in the emerging sustainable segments, where SMEs incubate radical innovations. These segments display all the signs of an emerging industry, e.g. lack of dominant design, low rate of market penetration, focus on technology and design, etc., hence creating space for innovation-potent SMEs.

While large enterprises are proficient in managing existing markets and exploiting existing knowledge, SMEs act as explorers and engines of radical innovation because they do not suffer the bureaucracy of incumbents and can be flexible in structuring appropriate business models (Leifer et al, 2000, O'Connor and Rice, 2005). The new sustainable mobility paradigm opens up niches for SMEs to identify new needs and satisfy these through innovative adaptation of deep specialised knowledge, including from cross-industry linkages.

Yet, it was pointed out that the opportunities in the emerging sectors are limited in terms of potential market success in the short run due to insufficient demand. This limitation is very significant in the context of SMEs who typically suffer low survival rate in the first five years after establishment. In other words, in the face of insufficient demand in the short run, SMEs will not have the resources to sustain themselves until the new markets grow to a size that will allow them to capitalize on their inventions. Once again, they will have to negotiate with the large incumbents.

4.4. THE FACILITATING ROLE OF INTERMEDIARIES

In the context of OI, intermediate market-supporting institutions can promote entrepreneurship through reducing coordinating costs, increasing the scope for secure IP, and developing ties among the various players. They are the critical drivers of enhanced effectiveness in technological markets that help companies experiment with OI processes (West and Lakhani, 2008).

Although there were differences in the level of development, we have observed attempts to establish intermediate institutions across all the countries in our study. The key role of intermediaries in the OI model is linking highly specialised suppliers of technology and technological capabilities. Different types of intermediaries have emerged to serve the technology markets in the car industry. Some provide managerial and administrative support, link enterprises according to their needs, coordinate the innovation efforts, assist interorganisational communication and dissemination of information, e.g. clusters. Others link universities to enterprises, fundamental research to applied research, and become directly involved with the innovation processes, e.g. research centres. Clusters play an important role in connecting smaller suppliers of technology with the OEMs and Tier 1s who possess the integrative capabilities and complementary assets needed for large-scale commercialisation.

The examples of the well-developed regional clusters illustrate the importance of close interaction and exchange between the smaller and the larger players in the industry. As highlighted earlier, the absence of OEMs and Tier 1 suppliers from some of the clusters has negative impact upon the realised potential of the cluster. In contrast, where healthily-funded clusters assist the establishment of robust links between the players, SMEs demonstrate marked development in terms of technological and managerial capabilities.

Last but not least, the clusters are seen as a sound solution to the problem of trust, which was identified as a major impediment to the wider adoption of OI practices in the industry.

> ‘It is all about trust and the intermediary organizations could plant the seed of this trust, feed it, water it and try to be the gardener of it. They can ensure that all the frictions that exist in the networks are managed.’ R17

In large development projects, clusters assume responsibility for their members and for project management thus removing to a great extent the element of risk and reducing the transaction costs associated with the coordination of numerous enterprises. Together with the larger industry incumbents, well-resourced clusters have the potential to drive innovation in the industry.

5. Discussion

Extant studies have argued that SMEs can counteract the liability of size and enhance their ability to innovate by engaging in networks and OI practices (e.g. Vermeulen, 2005, Keupp and Gassmann, 2007, O'Regan and Kling, 2011). However, our analysis suggests that SMEs in the car industry are slow to engage in networks and OI practices due to appropriability concerns and resource limitations. Beyond financial and human resources, SMEs are also short of managerial resources and capabilities and find it difficult to engage in broad networks due to high opportunity cost of management time. Knowledge flows between SMEs and knowledge-generating institutions are obstructed by resource limitations as well as differences in management style and priorities.

While SMEs concentrate on the selection and exploration of knowledge, large incumbents take over experimentation and exploitation (O'Connor, 2006). This is not a linear process because diversity of knowledge drives innovation and necessitates dense networks (Cowan et al, 2004). However, this study strongly suggests that, from the viewpoint of the network leader, a network that combines strong dense ties at the centre, e.g. around the OEM, and weak dispersed ties in the more peripheral sections of the network, could achieve controlled diversity of knowledge while minimizing risks and costs. Yet, the insufficient and irregular development of links in the networks may result in underutilisation of their potential.

The data suggest pyramid-shaped networks, stratified according to organisational size, with large enterprises – OEMs and Tier 1s – occupying the top strata and organisational size decreasing as the pyramid widens downwards. This large-scale structure consists of horizontal and vertical sub-networks with limited scope, the links within and between which are mediated by research centres, cluster management and support institutions. Cluster management occupies central position in the regional networks. The need of close simultaneous interdisciplinary development is what glues these smaller networks. This visualisation has implications for decision making and suggests that the management of innovation in the sector needs to be built on an integrative system along the innovation processes rather than on isolated players if it is to reap the benefits of continuous innovation and minimise knowledge spillovers.

The network structure suggested by the data resembles 'fishing nets' (Burt, 1992), also referred to as networks with structural holes, i.e. lower-density structures with many relatively weak ties. The bases of the pyramidal structures consist of SMEs providing absorptive capacity to larger incumbents by identifying and implementing new technologies, including from other industries, in their products and processes. By doing this, SMEs facilitate technological innovation in client companies (Wood, 2006), and enhance their adaptability to the rapidly changing environment, including technological change and increasing knowledge diversity.

The Tier 1 suppliers act as a filter between the top of the pyramidal structure and the strata, i.e. between the OEM and the lower tier suppliers, by selecting the most viable innovative ideas and technologies, developing them to a marketable stage, perhaps integrating with own developments, and passing the resulting products/systems on to the OEMs, often in the form of 'black boxes' (Jaspers and van de Ende, 2010). While the ties at the top - between Tier 1s and the OEM - are strong and dense, the ties between and within the strata become weaker and more dispersed further down the network structure. Higher density of ties exists at locations around regional clusters, which may involve Tier 1s, the OEM, universities and research centres.

This network model, in which OEMs are central nodes, seems to fit really well with the concepts found in small world research. The latter integrates the research on tie strength and structural holes in networks. Small world researchers assert that structural holes and network cohesion need to coexist to impact positively on innovation and creativity. Small world network structure has both a high level of local tie strength and a large number of weak bridging ties at the periphery (Fleming and Marx, 2006, Uzzi and Spiro, 2005). Capaldo (2007) found that a network structure characterized by a large periphery of heterogeneous ties and a core of strong ties around a focal firm brought about substantial competitive advantage. Conversely, Rowley et al (2000) concluded that a combination of strong ties and high density in a firm's network undermines exploration-centered performance. What sets the networks found in the car industry apart from the networks described by small world researchers is the lack of weak ties in the top sections of the network, i.e. around OEMs, which ultimately results in lower levels of exploration but also in reduced transaction costs.

The large scale innovation model, which we propose, extends previous research on OI in the car industry, which has depicted that patterns of OI are primarily found in vertical relationships and that large enterprises developing and manufacturing complex products may use different forms of OI resulting in the concurrent existence of combined openness and closedness in innovation for different purposes (Karlsson and Sköld, 2013). The model provides fresh paths for future research on the network relationships in the car industry as well as on innovation as complex patterns of interactions between individuals, organisations and institutions.

The proposed model also complies with the suggestion that many different degrees of openness may be equally successful depending on the internal and external environment and that instead of looking for a general answer, a firm's particular situation needs to be considered, especially its corporate strategy, culture, industry appropriability regime and potential risks of implementing OI (Lichtenthaler, 2011, Di Minin et al, 2010, Chesbrough, 2003). All of these factors appear to be particularly relevant in the case of the car industry.

While we agree that large enterprises may use many different forms of OI (Karlsson and Sköld, 2013), we support the view that OI does not merely require a firm to intensify its relationships with external organizations throughout its innovation processes but requires the use of a business model through which decisions about innovation are evaluated and taken (Chesbrough, 2006b, Chiaroni et al, 2010).

Last but not least, integrative competencies, efficient management of IP and radical cultural change are needed to support the wider adoption of OI in the car industry. The issue of trust and the relevant appropriability and credibility issues deserve special attention in future research.

6. Conclusions and Practical Implications

Perhaps the most important deficiency that surface from our analysis is the weak ties of SMEs with other organisations and the lack of ties between SMEs and larger incumbents. Despite evident attempts by regional authorities, the desired robust ties have been slow to develop. Further efforts in this direction can improve the performance of the automobile clusters and networks.

The research identifies network leadership as a key to driving innovation and points to the critical importance of the IP regime and support infrastructure for realising the full innovation potential of networks. It also highlights the important role that intermediary institutions play in facilitating interorganisational exchanges, creating accommodating environment, facilitating joint problem-solving between different stakeholders, nurturing trust and credibility, and supporting and motivating the innovation efforts of SMEs. Regions that seek to participate in global technology networks must devote as much attention to expanding training, disseminating information, creating institutions to support SMEs, and assisting communication, as to attempting to attract investment.

The study strongly suggests that the identified problems of accessibility and disrupted knowledge flows can be only resolved if an appropriate mindset exists. OEMs have the technological competencies to evaluate and integrate breakthroughs emerging outside of the firm. However, they have not yet developed capabilities to support and accelerate inflows and outflows of knowledge in the networks thus facilitating innovation and efficiency. More specifically, they lack the organisational capabilities to identify, coordinate and benefit from emerging, unplanned external developments.

We contribute to the understanding of the OI concept by examining its applicability in a mature capital-intensive asset-based industry, which is preparing for a radical technological discontinuity. Such industries may be less dynamic but with more momentum, thus manifesting very different characteristics in terms of patterns of innovation diffusion, risk management and strategies for exploiting innovation. We identify key obstacles to the wider adoption of the OI model in the car industry and demonstrate that the OI model, although very attractive, may be not be equally applicable to all industry settings. The importance of IP management and intermediate markets for the generation of innovation in the car industry deserve more attention from scholars as well as from policy makers.

Finally, the study identifies an interesting pattern of “closedness” in the established mature segments of the car industry and tendency for openness in the emerging sustainable segments around the design and development of electrical vehicles. Cyclical adoption of OI practices appears a plausible proposition for mature asset-based industries. Consistent with the idea of OI as a bifocal strategy (Di Minin et al, 2010), incumbents may adopt OI strategy in the beginning of the technology life cycle to deal with a radical technological discontinuity, followed by internalisation of the consecutive innovations as the technology matures, and then by re-externalisation (outsourcing) of components as interfaces become standardised (Chesbrough & Kusonoki, 2001, Christensen, 2006). This proposition provides an interesting line of enquiry for future research.

Our study is not without limitations. Although a thorough inductive research approach to studying OI is important for developing deeper understanding of the process and its implications in different settings, we also recognise the limitations of this approach. Although we were very careful to avoid bias, as in any qualitative study this concern remains. However, we believe that, although not generalizable at this stage, the processes, relationships and dependencies that have emerged from our study provide fruitful avenues for future research.

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APPENDIX A: DESCRIPTION OF THE RESPONDENTS

Respondents' job title, education & experience	Organisation
Professor, and Founder and Manager	SME, spin-off of a cluster member university
Technical coordinator	Intermediary providing foreign buyers with support in outsourcing activities through linking them with suppliers, selected on the strength of their technical, qualitative and logistic capabilities. The member companies are together potentially able to manufacture a vehicle from the drawing board to mass production
[Dr] Head of the Secretariat of the regional financial institution; an Engineer, Ph.D. In Economics and the Management of Technology	The regional financial institution is the bank of the regional government devoted to policy operations. The institution takes care of the car sector with specific instruments.
[Dr] researcher in material engineering, working on power sources	University - a cluster member
Founder and General Manager	An engineering SME (40 staff), focused on R&D in the field of Electronics. The company provides highly specialised engineering services in different sectors: automotive, railway and military.
Managing Director of a regional automotive cluster	The cluster is a business interest association of automotive industry suppliers.
HVEC cluster manager, and project manager and partner	An engineering SME (micro – under 10 staff) originally providing services in the field of CAD/CAE, dedicated as a supplier partner to support engineering activities in development of vehicles mostly in designing of passenger cars; offers

	services in BIW design and simulation]. The cluster deals with national and international R&D projects in the vehicle sector, from bicycles up to buses and trucks
[Dr] Partner; an engineer and an entrepreneur for about 15 years	An SME (40 staff) developing innovative technical development and background services; construction of prototypes of alternative and hybrid vehicle models, preparations for manufacturing, series production
Innovation Manager	Regional innovation agency
Project and PR manager in the Regional Knowledge Centre for Vehicle Industry,	University - a cluster member
Manager	A large supplier providing a broad range of services to the automotive industry in mechanical engineering
Project Manager in the Competence Centre for Mobility Technologies	Research institute
[Dr] a researcher and Project Manager	Research institute
Project Manager for development projects; mechanical engineer; 10 years experience in the current consulting company, 10 years in another company providing engineering services to the automotive industry	A large (over 600 employees) specialized engineering and consulting company in the fields of electronics and information technology, developing software and hardware for electronic car units
Manager Infrastructure Development for Fuel-Cell and Battery-Electric Vehicles; Previously ‘started in the production of condenser powertrain, then worked on hybrid vehicles in the development centre in Michigan, US, then worked on software development for production vehicle which is now sold in US’	Major car manufacturer
[Dr] Cluster manager for two organizations	Regional automotive clusters
[Dr] Project Manager; background in mechanical engineering and software services for the automotive industry, experience with the Regional Economic European Cooperation	A large (over 600 employees) specialized engineering and consulting company in the fields of electronics and information technology, developing software and hardware for electronic car units
Head of Powertrain Engineering and Advanced Propulsion; 28 years experience in the current company; background in automotive test and development particularly powertrain emissions and fuel consumption.	A large service provider, operating as an independent test development facility for the whole of the automotive and related industries
Founder and Managing Director; 41 years experience in the industry, started at 16 on a mechanical apprenticeship, worked for Lotus for 19 years managing a project team with more than 36 people, introducing 8 engines, which have resulted in 8 million cars in and around Europe and America.	An engineering design SME (42 employees) working closely with clients (oems globally) to develop new products and technologies in all areas of mechanical engineering; clients span aerospace, automotive, industrial, marine, renewables and oil & gas and others; active in the renewable energy sector through anaerobic digesting, solar PV and wind energy.
Technical Director; also working as a consultant on some automotive based programs; technical lead on a major EV infrastructure development project; formerly Chief Electrical Engineer at	An SME providing consultancy and project management for electric vehicle and infrastructure projects; focus on integrating transport and infrastructure (incl. Infrastructure design and implementation), managing a very large scheme for electric plugging

Lotus for a period of 18 years; in the automotive business for a period of 32 years; also worked on some energy storage projects; Chair of the EDITC of the Institute of Engineering and Technology	for hybrid vehicles and running a fleet of 45 vehicles on behalf and in close cooperation with a number of vehicle manufacturers.
Director of Mergers and Acquisitions	Tier 1 Supplier, delivering climate systems, electronics, interiors, lighting, engine induction, powertrain controls, mobile applications; origin: 'the components manufacturing segment of Ford Motor Company'
Manager Environmental Strategy; worked for another major car manufacturer in a variety of roles in Europe and around the world for 21 years	Major car manufacturer
Professor, specialist in the programming and operation of CNC machine tools	University - a cluster member
Process Improvement Consultant; 16 years experience in the automotive industry (multinational corporation environment) working as process engineer, production manager, plant manager. Participated in the cluster establishment and development.	Consultancy (SME) in the automotive industry for projects improvement or training for lean manufacturing, six sigma, quality, ISO/TS 16949
General Manager	An SME (36 people); provides engineering services to oems in a variety of engineering disciplines in the development of electronic automotive products
Project Consultant and Project Coordinator	Regional Development Agency and Regional Center for Innovation and Technology Transfer
General Manager	A regional foundation – part of the regional cluster - that governs all the regional automotive industry and brings together all of the sector: the manufacturer; the components and support services companies; and the technological centre.
Coordinator	Corporate university of the regional automotive foundation (see above); provides 'a more specific training, not only to respond to the needs of the present, but also to the future needs'; 'we do not only hire people, who are professionals in training, but who are professionals in the clusters, so that they could bring all their knowledge and experience'; the training is 100% adapted to the needs of the industry.
Director of the Research Department at Automotive Technological Centre	[Automotive Technological Centre] (more than 300 people) is an initiative launched by the automotive sector. It provides local automotive companies with technological support for their activities. It has been established to bridge the gap between universities and industry.
Partner and COO in an SME, many years of experience in the automobile industry	SME developing and installing the infrastructure for evs

APPENDIX B: DIRECTIONAL INTERVIEW TOPICS

- Type of organisation
- Respondents' experience

- What is innovation
- Innovation in the car industry
  - Who innovates in the car industry
  - Drivers of innovation
  - Innovation in SMEs
  - Expectations for the future

- Opportunities for SMEs in the emerging sustainable transport
- Outsourcing
  - Role of suppliers
  - Role of SMEs

- Collaboration
  - Suppliers-clients relationships
  - Problems
  - SMEs
  - Sharing of ideas

- Relationships or collaboration with other sectors (outside of the car industry)

- Relationships or collaboration with universities or research centres or other institutions
  - Benefits
  - Problems

- Ideas that come from outside the company

- External support (incl. funding)

- Need of further support

APPENDIX C: EMERGENT CATEGORIES & EXEMPLARY QUOTATIONS

Research objective	Code	Exemplary Quotation
Network formation	Innovation	'I think a network is critical. Otherwise your horizons for innovation are going to be very limited.' R 21
	Informal network, Industrial network Credibility	'We have other innovation networks, a broad network of partners, and if we develop an interesting project, we approach them and show them our approach and normally they are like between 8 and 25 industrial enterprises that have an interest in joining the innovation network and developing innovations and future solutions, and this is how we come together and start working.' R12
	Cluster, Industrial network	'Normally you get a couple of universities in the cluster, some key stakeholders from the Tier 1s, and the SMEs. The mainstream car manufacturers are also involved in clusters.' R20

	Size, Industrial network	'We have around 100 companies in the cluster as well as research institutions, universities, labs, public authorities.' R16
	Capabilities, Networking	'Bigger enterprises tend to underestimate the potential of innovation networks. They have big research departments on their own and do not need any research from us. The interesting aspect for them is establishing interesting contacts with suppliers. So the networking aspect is for OEMs much more important than the actual innovation.' R12
	Stratification (of network)	'I really think this is going to be a network, it is not anymore going to be one single player who is innovating. I see really a stratification of research and innovation in networks.' R12
	Multidisciplinary, simultaneous (engineering), Collaboration	'The teams are multidisciplinary teams and the work is based on simultaneous engineering.' R29
	Proximity, Communication, Uncertainty	'Especially for the most cutting edge technology, it is important to have proximity because projects can be very unpredictable. New questions appear every day and you need to talk about them before you start thinking about solutions. This requires intensive communication that you can hardly do over electronic media.' R17
	Centrality, Leadership	'The OEM is a nucleus for this kind of companies' R13
Knowledge flows	Collaboration	'Large companies not only work in universities, but they partner with them and contribute. So it is not just doing research together but also taking responsibility to develop research.' R16
	Integration	'They develop some functions themselves and we develop additional functions. Then we integrate.' R14
	'Black box' (approach to innovation)	'OEMs have the architecture, they have certain things coming from other suppliers, and they need us to develop basic modules and components into that whole system. You have a specific task, so tactically you are replacing an internal department.' R17
	Technology life cycles, Modularity, Creativity	'You have a task which requires specific knowledge, you need someone to work on it for 3 months and have it done. So you buy the skills that you need just for the time frame that you need and keep your organization lean, which is probably the main reason why OEMs work with a lot of suppliers. Technology is another reason because things are changing really fast. If you have employees, you would have to

		retrain them every couple of years. But in the creative areas they are covered by employees.' R17
	Credibility, Risk, Cost	'The situation is different from an IT company where you can move from one thing to another more dynamically but with less momentum. The companies stick to who they know.' R17
	Trust, Mindset, Culture	'They [OEMs] try to open their minds but it goes top down so the management board decides but the engineers do not open their business. You have to trust in others' knowledge, that is a learning process. You need to change the mindsets of the guys doing the actual R&D within the company to see that they add value if they make use of external knowledge.' R16
	Openness, Closedness	'The luxury car manufacturers, they are very open to new ideas. That is one of their sales points. But the volume car manufacturers are not open' R25
	Size, Accessibility, Transparency, Idea sourcing	'In many ways, it is down to the size of the corporations. If an SME came to me and said "we have a telematics idea", I wouldn't know who to direct them to. Somebody who is sitting over in [another country] may be responsible for the development of telematics. We do not have direct knowledge of where a project like that would find its target. So, it is accessibility, which needs to be made easier and more transparent. In many ways, the pool has to come from the manufacturer, because there might be ideas out there that we as big manufacturers are missing.' R22
	Accessibility, Closedness, Outsourcing	'I think one of the big challenges [to knowledge exchange] is for the innovative SMEs to actually access the big OEMs. And I think the route for that is often through the Tier 1s. It is very difficult to get directly into an OEM, they tend to work very closely with their major Tier 1 suppliers and we are seeing the Tier 1s taking more responsibility for subsystems and aspects of the vehicle.' R18
	Accessibility	'So the dominant industrial companies have actually picked up quite a lot of innovative ideas that have been raised and developed through the SMEs but OEMs are not set up to deal with the SMEs, they deal with much bigger companies.' R20
	Transaction costs, Credibility	'If you are a small company, the Tier 1s do not care about you because it is an additional support activity. It means that to coordinate a small company takes the same effort as to coordinate a middle size and bigger company. So the Tier 1 suppliers and the OEMs do not

		like working with small companies. Only if they are very innovative in a particular product or service area.' R7
	Closedness	'You come across people who have the attitude ['not-invented-here'?], and that is something that can really slow down the development process. We just founded a little organization within our organization and these folks are looking at new ideas.' R15
	Closedness	'It is a very strong cluster: we have OEMs and mega suppliers, and there is a good R&D infrastructure, universities, companies who do R&D, then we have regional support for the SMEs, and informal cluster initiatives. There are many networks and opportunities for networking for the SMEs, but they could use it better. Some SMEs use it, but the majority do not use these opportunities. They are not opening up to see the benefits of such instruments.' R13
	Closedness, Appropriation regime	'Most SMEs do not look at new undertakings due to anxiety of knowledge appropriation. It is not easy to overcome their reluctance.' R13
	Closedness, Appropriability regime	'Often the SMEs say they have problems that the university departments are more theoretical. The thing is, the SMEs do not want to let outsiders in. They are anxious that other companies might get hold of their knowledge. This is not easy for them. The OEMs have the resources to protect their knowledge, and they can differentiate the things they do with universities and the things they do themselves. They do some research with universities but the inside knowledge that is very sensitive, they do not let out.' R13
	Appropriability regime, Resources	'A small company very hardly could fight for their intellectual property rights.' R16
	Appropriability regime, Resources	'It is not easy for SMEs to work with research centres and universities because usually they do not have so much resources, skilled people and also financial resources for innovation.' R2
	Priorities, Commercialisation	'The timeframe of the academia seems to break up the project into small elements. Maybe it is ok for research, but if you are looking for product development, we have struggled to get those guys to work in the same timeframe that we are expected to serve that customer base.' R19, SME
	Priorities	'If there is a specific want from the industry, a vehicle manufacturer will approach the university and ask whether they have got an interest in doing the work. But it is very much

	Commercialisation	down to whether the problem fits what some PhD student wants to do. So you can put a problem to a university, and it may not be one that is picked up.' R20
	Closedness	'Companies do not really trust universities because they cannot do anything with the research done by the university.' R7
	Mindset	'At the moment we are a part of a mainstream industrial network but we are thinking of going out because we think that this kind of network cannot give us anything, only something to pay.' R5, SME
	Mindset	'I would say it really depends upon the chances and possibilities that partners see within this network. If the people who are involved are enthusiastic about a topic, they can push a lot, and if they do not, certain topics just stay untouched.' R12
		'I would not necessarily say it is something that an organizational change would improve, it is more like the mindset, what people think, how open they are. It is easy to say the company has to do that. You have to do it yourself, you have to be open and encourage people around you to be open and that is the only way you can make a difference. The people are the company and you cannot change the people by simply giving a department a new name or setting up procedures. If those people do not want to do that, if they are not open, nothing will change.' R15 OEM
	Trust	'A lot of trust was lost during the last 20 years due to very heavy procurement rules along the value-chain. Now maybe we have a kind of recovery.' R16
	Communication, Accessibility, Mindset	'So the main question is how we can remove these barriers in the communication and enable companies to have steady contacts with the right people because it really comes down to who you know.' R17
The role of different size enterprises in innovation	Leadership, Innovation	'I think most innovations will be driven by the car manufacturers and will be executed by the Tier 1 suppliers.' R15
	Leadership, Innovation	'Tier 1s are the most expected to innovate. And they manage all the other suppliers with their innovations.' R24
	Credibility, Accessibility	'Smaller innovative companies cannot break into the market of supplying the OEMs because they do not have the credibility. So they sell to the Tier 1 suppliers.' R19

	Innovation, Commercialisation, Leadership	‘OEMs work very close together with Tier 1 suppliers because Tier 1 suppliers are the companies that develop the new technologies. But the final decision to introduce the innovative technology in a product is the OEM’s. The OEMs have R&D departments where they try to identify the best innovation to be introduced.’ R29
	Innovation, Capabilities	‘Not to my knowledge. From my perspective, we have a strong engineering organization and also a technical development centre.’ R22
	Leadership, Innovation, Modularity, Product complexity	‘Collaboration between car manufacturers and suppliers is very important in terms of accessing and forecasting what is going to be coming in the future and how that can be integrated into vehicles. So I guess we do rely on our suppliers to bring new ideas to us about things that are going to be happening. You know we are experts in building and selling cars, and we are not necessarily experts in things like telematics for example.’ R22
	Commercialisation, Leadership, “Black box”, Capabilities, Integration, Coordination	‘OEMs do not have the deep understanding of what is inside or the factors that are influencing from the design side of the process, and then probably we as do not understand exactly what the customers want. In other cases, it could be that the customer wants two things at the same time that are technically not possible. And then we need to discuss and find compromise.’ R25
	Innovation, Integration, Coordination, Exploration/exploitation	‘I do not think so [SMEs are good at innovation]. It is not simply a matter of resources. That is a matter of the functioning of the value-chain. In the past innovation was done by OEMs and Tier 1 suppliers. Now things are changing so OEMs and Tier 1s require innovation from tier 2, 3 and 4. But it makes no sense if tier 3 or 4 companies are innovating but there is no idea at the OEM at the end of the value-chain.’ R16
	Innovation, Resources	‘Most of the new car innovations come from other [smaller] companies but it is very complicated for them to get finance, and to get investment, and therefore a lot of innovations could not reach the right phase where they could go into production.’ R8
	Innovation, Exploration/exploitation, Rents	‘I have seen a number of them, technologies that have been developed in a small organization, which have then been bought up by the Tier 1 suppliers going into the OEMs. […] This small organization is then bought up by the bigger Tier 1 suppliers to get access to their technology. I think you would find out that the likes of […] have had many acquisitions in the last 20 years where they have bought into expertise that they did not have in their own

		portfolio, expertise that gives them a stronger place in the market.' R19
	Rents, Resources, Credibility	'There is a company or an individual with a specific IP, which then gets the interest of a major company. The major company in many cases then buys out the SME. It is very rare that an SME capitalizes on its IP and grows to where it becomes a self-sustaining company because that is really serious capitalization. Vehicle manufacturers do not purchase equipment from SME's because of viability.' R20
	Opportunity, Openness	'There is still a quite broad field [around eMobility] which is not so much defined and could develop into a big market in the future. By having a smart idea, SMEs could really enter and position themselves in a quite new market, and it is pretty open still.' R12
	Opportunity, Specialisation,	'Technology accelerates at such a speed that there is a constant increase in the call for specializations and therefore opportunities for the SMEs.' R22
	Rents	'SMEs could bring fresh ideas to all these areas but at they will be taken over by an OEM or by a tier 1 if they are successful.' R16
	Opportunity, Competencies, Resources	'I do not see that many opportunities, basically because they [electrical vehicles] are not important in the market today. If the SMEs develop core competencies based on the future of the electrical vehicles, I think it would be a failure in the short term because the market is not buying those parts.' R27
The facilitating role of intermediaries	Trust, Credibility	'If someone has an idea and go to the bank for money, often the banks say "you have to talk to the cluster because we are not experts in the automotive industry". And the same happens with the government when they look for public funds.' R27
	Managerial capabilities	'We have also an area devoted to innovation management. We support the companies in getting support from public institutions, or identifying possible partners to share technologies.' R29
	Managerial capabilities	'SMEs perform similar to large companies [in terms of innovation] but need much more management support to establish the project structures, to facilitate the activities. Large companies are able to do it on their own.' R16
	Networking, Ties, Managerial	'We do common marketing and push innovation and research. We work consistently on upgrading R&D competencies and buy equipment for our technology centres, which the companies use

	competencies, R&D competencies	together. Another field is education and training. We support SMEs with training that is not available but is needed for the suppliers, especially resource management, project management, quality management.' R6
	Networking, Ties	'We push SMEs to work together, horizontally and vertically.' R2
	Leadership	'Unfortunately, the big players from this region are not present in the cluster. The activity would improve and grow if the big players were in the cluster. But this is not happening even though the guys from the [regional support] agency put a lot of effort in that.' R25
	Information, Communication Closedness, Leadership, Centrality	'You have to give more information [to SMEs] about the mutual benefits they can draw from collaboration. Many SMEs do not know about these possibilities. I see research institutes like us, and also organizations like the state agencies, who are facilitators in this process, doing the management of information. It is very helpful when there is one actor who brings the actors together and coordinates the activities, and helps them shape and define the projects so they can play well together.' R12
	Information, Communication, Closedness	'It may be the case that universities do not know what projects are out there, and sometimes I guess industry might not know the facilities that could be implemented at universities.' R22
	Information, Communication, Closedness	'The real problem is to find the match, trigger the need. How do you get this company to offer their services to, let's say, Porsche, or how can Porsche find this company? Somehow the networks are limited.' R17
	Trust, Credibility	'The cluster could be a solution because you have to find the trust at some level. You need to have a number of companies willing to say "that is how it could work, and our bundle will act as a partner to Daimler, and this is who will do the job, but if he fails we are going to jump in and save the game." It is all about trust and the intermediary organizations could plant the seed of this trust, feed it, water it and try to be the gardener of it. They can ensure that all the frictions that exist in the networks are managed.' R17
	Trust, Credibility	'The clusters should invest into know-how. You cannot do it as an outsider. You do actually need to have at least a basic understanding of the technologies in order to be trusted so that the rest follow you.' R17
	Capabilities, Commercialisation	'We can provide them with support in all the phases of the development of products. Not basic

		research, but we can analyse the new technologies and try to adapt them to a complete application, we can collaborate with the company in applied research phase of the project, also in the conceptual phase, we can even give support in the production phase.' R29
	Openness, Collaboration	'So our [research] institute has a very close relationship with the university. Some of my team are employed by the university, others are employed by the research institute but we work together on the same projects. So it is just a matter of administrative separation, but that was the intention. We can draw a lot of resources from the university and do also basic research.' R12
	Credibility, Closedness	'I have seen people here or in the premises who are independent employees but who cannot work as independent employees for Daimler. So they work for a services supplier who watches over them and deliver the goods with the promised quality and cost. So they just give a part of their profit share to these companies who act as a contact and a security buffer between them and the customer.' R17
	Communication, Information, Ties	'Traditionally the universities are not very close to the real needs of the industry, and this is the reason why the model for a technological centre was proposed. It was just to bridge the gap between research from the university, and the needs of the industry.' R29