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Transformation Networks in Innovation Alliances – The Development of Volvo C70

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ABSTRACT This paper addresses an important gap in the literature intersection between network theory and networked innovation by developing a theoretical framework on how to leverage learning alliances across extra- and intra-corporate levels to support both exploration and exploitation of innovation to secure its creation *and* its implementation. A detailed case of the Volvo C70 development is analysed with focus on how the full innovation from exploration to exploitation of innovation seem to rely on fundamentally different types and structures of networks. Our detailed description and analysis of how a 'transformation network' was established and operated across different organizational levels to secure not only transfer, but also transformation and integration of knowledge into commercialized innovation makes an important contribution to extant theory on inter-organizational knowledge transfer and networking.

INTRODUCTION

Networked innovation is becoming increasingly important for organizations as they attempt to respond to rapidly changing environments by acquiring and integrating interdependent and complex bundles of knowledge (Geisler, 2007; Hardy et al., 2003; Hellström and Malmquist, 2000; Hobday et al., 2005). As a consequence, the 'ideal' models of and processes for innovation have experienced a linear evolution from a traditionally closed system towards more or less exclusively open and strategically networked systems of complementary resources (Berthon et al., 1999; Chesbrough, 2003; Easterby-Smith et al., 2000; Nyström, 1990; Pisano, 1990, 1991; Salford, 1995; Sawhney, 2002; Shenkar and Li, 1999; Teece, 1986).

Although there is a wealth of literature on open and networked innovation, this does not address how to leverage learning alliances across extra- and intra-corporate levels to

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support both exploration and exploitation of innovation. In particular, current literature pays little attention to how these two consecutive phases of the innovation process seem to rely on fundamentally different types and structures of networks. In response to these gaps, our paper explores how to manage external creativity networks both for steering of direction during exploration, and for transformation and internalization of the results so as to secure exploitation of innovation. In particular, we describe the role of transformation networks and analyse through which types of ties and relationships these networks contribute, respectively, to creation, transfer and transformation of knowledge.

We develop and illustrate a new theoretical framework for knowledge transformation by examining how Volvo Cars created a network of partnerships to make a new car development possible. Our detailed description and analysis of how a 'transformation network' was established and operated across different organizational levels to secure not only transfer, but also transformation and integration of knowledge into innovation makes an important contribution to extant theory on inter-organizational knowledge transfer and networking.

THEORETICAL FRAMEWORK

The Dilemma of Technological Leadership

To secure long-term survival, companies must not only address the requirements of existing customers, but simultaneously innovate to ensure the identification of new customers and the means of delivering a value proposition – an ability that has been termed 'organizational ambidexterity' (Duncan, 1976; Grant and Baden-Fuller, 2004; He and Wong, 2004; Tushman and O'Reilly, 1996). The essence of the innovative firm is the ability of an organization to adapt to market change and is influenced by the organizational integration of a skill base and the speed at which new competencies and skills can be developed to match the demands of the new technologies (Verdu-Jover et al., 2005). Various forms of inter-organizational partnerships are now core elements of corporate strategy and act as means by which organizations can pool or exchange resources, and jointly develop new ideas and skills (Powell and Grodal, 2005).

When the knowledge base of an industry is characterized by a high level of complexity and widely dispersed pools of expertise, the locus of innovation will be more likely centred in networks of learning rather than in individual firms (Powell et al., 1996). In this context, Abraham (2005, p. 11) introduces the term *co-creation* and holds that 'the challenge in strategic thinking is to find innovative ways of co-creating value with customers, a technique for finding unique competitive advantage'. Eric von Hippel (1988) pioneered this thinking through his argument that market risks associated with new, or enhanced, product, process or service development can be minimized through specific lead-user integration in new product development. His concept has been developed further by a number of authors who claim that direct lead-user involvement in the innovation process enhances the company's innovation capabilities and reduces the innovation-related market risk (Berthon et al., 1999; Brockhoff, 2003; Dolan and Matthews, 1993; Lüthje and Herstatt, 2004; Murphy and Kumar, 1997; Ulwick, 2002).

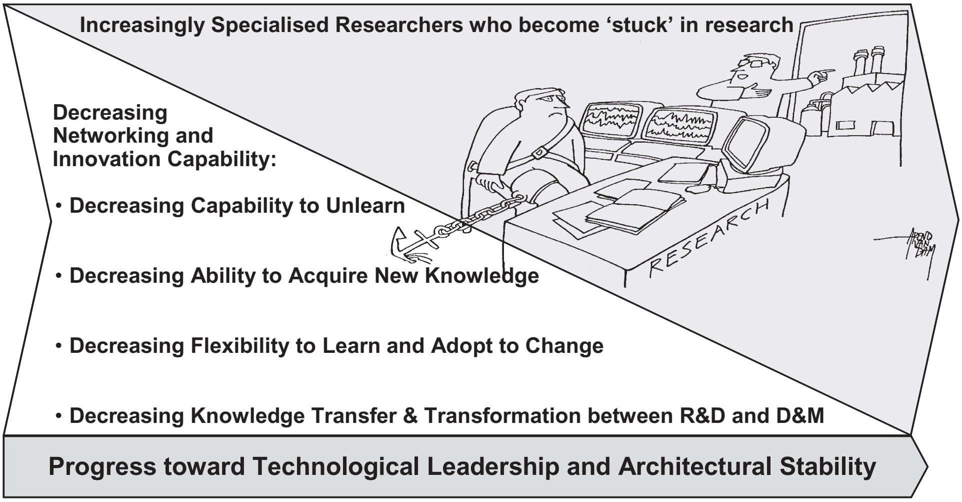

Figure 1. The dilemma of technological leadership
Source: Own adoptions from Harryson (2002).

The greater ability to identify and bring in external ideas and technologies enhances a company's flexibility to respond to changing customer needs. Conversely, the pursuit of specialization for internally generated technological leadership requires a very stable and deeply rooted architecture, or architectural stability, in its technology problem-solving process (Harryson, 2002; Kline et al., 1991; Leonard-Barton, 1992, 1995; Levitt and March, 1988; Sidhu et al., 2004). This seems to make it ill prepared to deal with the equally increasing knowledge extensity, i.e. the geographical and organizational dispersion of knowledge important to competitiveness (Hedlund, 1995). As a result of these two contradictory dynamics, it seems reasonable to claim that the real challenge is not simply to advance technological know-how, but to strike the right balance between internal technology depth (knowledge intensity) on the one hand, and customer-driven speed of delivery through concrete market applications with global reach (knowledge extensity) on the other hand.

A strong focus on internal specialization can leave many people in marketing, R&D and design and manufacturing short of the cross-functional learning skills they need to manage the transfer and transformation of scientific knowledge into product innovation (Harryson, 1997; Hedlund, 1992, 1994; Leonard-Barton, 1995; McGill and Slocum, 1993). Therefore, the so critical and mainly tacit technological knowledge remains stuck in research – rather than being transferred into manufacturing – as suggested by Figure 1.

Our conclusion is that many companies have reached an inner limit in terms of flexibility and innovation ability due to excessive internal technological development. The dilemma of technological leadership resides in the fact that successful pursuit of innovation path tends to focus firms on intra-corporate activities. This in turn, cripples their sensitivity and responsiveness to external technological and market factors that ought to guide innovation.

Consequently, new forms of organizational flexibility and learning alliances are required to adapt to substantial and uncertain changes in the environment (Brusoni and Prencipe, 2001; Lorange, 1996). Firms tap the potential of external sourcing strategies and learning partnerships to acquire new knowledge and reduce uncertainty in R&D. Complementarity of resources or differences in skills and knowledge provide the catalyst for learning by the alliance parents (Inkpen, 2000). Grant and Baden-Fuller (2004) further highlight the role of strategic alliances as a vehicle to access a partner's knowledge base in order to exploit complementarities while maintaining a distinctive base of specialized knowledge. According to leading literature (Badaracco, 1991; Contractor and Lorange, 1988; Hagedoorn and Schakenraad, 1994; Inkpen and Pien, 2006), the essential factors contributing to this trend include the growth in cross-technology and field interdisciplinarity, the globalization of technology and proliferation of sources, and the necessity for rapid commercialization at reduced risk and cost.

An interesting finding from the research on a selection of technology innovation leadership companies in Japan and Europe (Harryson, 1998, 2006; Harryson and Lorange, 2005) is that external sourcing of technologies and skills does not have to result in a phasing out of internal R&D capabilities. On the contrary, it seems to stimulate and create a unique flexibility to network tacit knowledge and disruptive technologies into innovation. This flexibility does not seem to have been covered extensively so far in the current literature on the topic – nor does how to leverage learning alliances across extra- and intra-corporate levels to support both exploration and exploitation of innovation. Exploration includes search, discovery and experimentation for generation of new knowledge, while exploitation relates to selection, refinement and utilization for application of existing knowledge (Benner and Tushman, 2003; Grant and Baden-Fuller, 2004; March, 1999). It is interesting to note that current literature pays little attention to how these two consecutive phases of the innovation process seem to rely on fundamentally different types and structures of networks. We address this important gap in the following section by combining theories on networking, organization of innovation and creation, transfer and transformation of knowledge.

Open and Closed Networks

Along the connectivity dimension of the social network, a distinction is made between open and closed social networks. The open network is mainly about resource exchange of information, while the closed network focuses on social exchange, trust and shared norms (Jack, 2005; Walker et al., 1997). An example of an open network is one in which firms have direct social contacts with all their partners, but these partners do not have any direct contacts with each other. A high number of such non-connected parties, or structural holes, means that the network consists of few redundant contacts and is information rich, since people on either side of the hole have access to different flows of information (Burt, 1992, 1993). This kind of innovation network stresses the indirect linkage, has mainly weak relationships and is loosely coupled. The opposite is the tightly coupled closed network, where all partners have direct and strong ties with each other. Embeddedness in dense networks supports effective knowledge transfer and interfirm cooperation (Coleman, 1988; Granovetter, 1985; Gulati, 1999; Walker et al., 1997). We

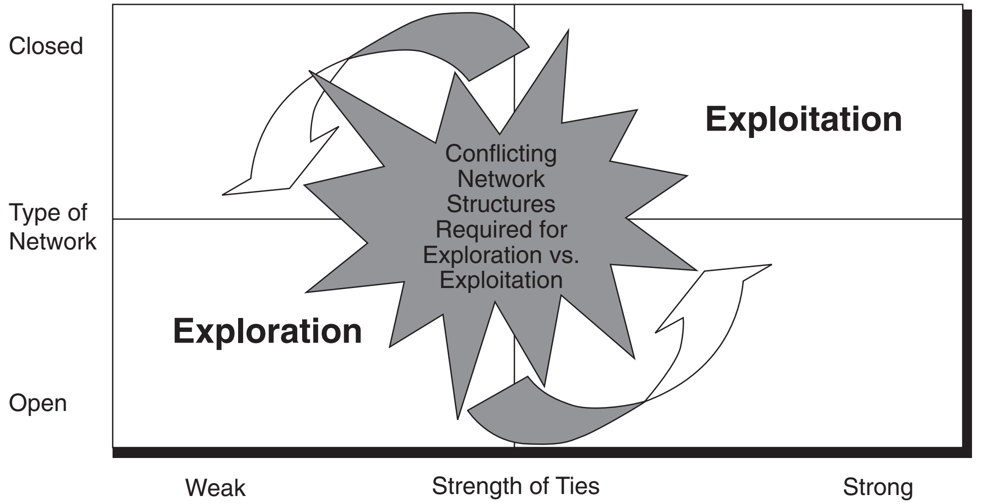

Figure 2. Conflicting network structures required for exploration vs. exploitation of innovation

believe that this type of network is required for exploitation, but not suited for exploration. This argument is partly addressed by Ahuja (2000), who proposes that the larger the number of structural holes spanned by a firm, the greater its innovation output.

A study by Soda et al. (2004) regarding the organization of project teams found that the best performing teams are those with strong ties among the project members based on past joint-experience, but with a multitude of current weak ties to complementary (non-redundant) resources.

If we summarize the complementary networking theories in a model, it would seem that the network structure required for exploration is the absolute opposite of the one required to support exploitation. We can also conclude from the literature that a project team should have its nucleus in the North-Eastern corner of Figure 2, but also have a multitude of current weak ties into the open networks – as represented by the opposing South-Western corner. However, we have not found any advice in the literature on how to secure learning within, or how to transfer the knowledge from one network structure to another. The perhaps most uncovered aspect in this context seems to be how to transform the results generated in a network structure supporting creation into a network structure supporting exploitation.

Our case will illustrate and analyse how Volvo has established distinct models for collaboration with external partners that enable learning and knowledge creation within and across both opposing corners of Figure 2. The transformation from exploration to exploitation also seems to imply a shift from initially weak to increasingly strong ties – both in the external collaborative relationships, and internally within the increasingly large company units. This is why we also include the dimensions of strength of ties and size of the units in our theoretical models.

Granovetter (1973) pioneered the argument that novel ideas more often emanate through weak ties from the margins of a specific network rather than through strong ties from its core. Accordingly, the relative strength of weak ties can transform marginal idea creating networks into a new nucleus of innovation. Research findings by Hansen (1999), Uzzi (1996), Rowley et al. (2000) and Van Wijk et al. (2004) confirm that strong ties are positively related to firm performance when the environment demands a relatively high degree of exploitation, and weak ties are beneficial for exploration purposes and to prevent the network's insulation from market imperatives.

Based on the arguments outlined above, it seems reasonable to assume that strong and weak ties are complementary from the perspective of time, and that the structure of an ideal network should maximize the yield per primary contact. We also learn that weak ties are likely to accelerate development speed in early phases of exploration when the required knowledge is not complex, but may slow down speed in situations of high knowledge complexity where strong ties are required to support exploitation of innovation. It seems that radical innovation requires management of both weak and strong ties, cutting across both peripheral and core networks, with a strong focus on developing and managing relationships for transfer and transformation of information into innovation across multiple levels. In this context and based mainly on such arguments, Harryson (2002, 2006) makes a distinction between three interrelated network levels with different foci: extracorporate *creativity networks* with weak ties as primary sources of specialized knowledge and technology focused on exploration through collaboration with external partners; intracorporate *process networks* with strong ties focused on exploitation of innovation through strong linkages between R&D and marketing & sales (M&S) for market alignment, and from R&D to design & manufacturing (D&M) for commercialization; and *transformation networks* focused on interlinking the complementary creativity networks and process networks. This is where and how cross-level interaction seems to happen for transfer and transformation of knowledge into innovation.

As gradually introduced in this section and summarized in Figure 3, creativity networks tend to be relatively small in size and organically managed across open network structures – to fulfil the by now well-known requirements for creativity in exploration. By

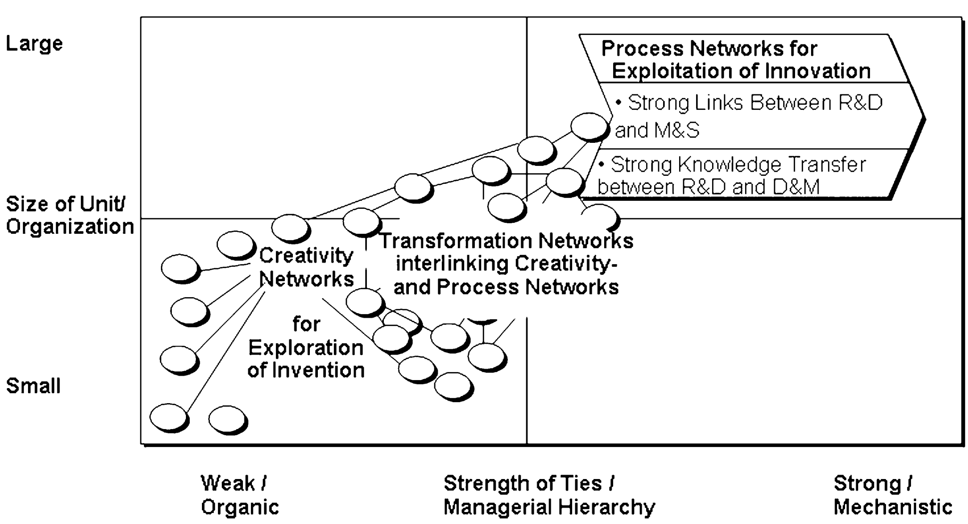

Figure 3. Cross-level networks for exploration and exploitation of innovation

contrast, process networks are typically found in large organizations with closed network structures – focused on strong ties for efficiency in exploitation. Our model serves as a starting point of the theoretical framework and guides the empirical as well as the theoretical analysis. The perhaps less well-explored challenge seems to be how to manage external creativity networks both for steering of direction during exploration, and for transformation and internalization of the results so as to secure exploitation of innovation. In this context, we see a strong need to understand the role of transformation networks and analyse through which types of ties and relationships these networks contribute, respectively, to creation, transfer and transformation of knowledge.

Creation of Knowledge

For effective knowledge creation through assimilation of extracorporate knowledge, Hedlund (1992) recommends high quality of involvement with deep understanding of the tacit components and the local context. These knowledge creation processes are closed into continual cycles through the activity of acquiring and assimilating extracorporate knowledge, as this activity both is driven by, and is a driver of, the development of a broad portfolio of different competencies – *multicompetency* (Harryson, 2002, 2006). Multicompetency supports the creation of redundancy by sharing additional information. This, in turn, helps individuals to recognize their part and location in the larger context of the organization, by clarifying the meaning of 'the specific requisite information held by distinct individuals and groups' (Nonaka, 1990, p. 28). Accordingly, individuals' sense of control is increased and provides purposeful direction to their individual thoughts and behaviour, which enrich and accelerate the collective knowledge creation.

Transfer of Knowledge

The *scope* of knowledge transfer is determined by where in the organization the knowledge resides. It could be embedded into tools, tasks and members (Argote and Ingram, 2000). The *content* of the transfer regards the characteristics of knowledge. Essentially, the more tacit the knowledge, the greater the additional costs required for transferring it (Martin and Salomon, 2003). As tacit knowledge cannot be codified, it typically cannot be transferred without transferring the knowing actor in person (Allen, 1977; Gooderham and Ulset, 2002; Polanyi, 1966; Roberts, 2002). Another critical enabler in this context is to facilitate the creation of social ties between the transferor and the recipient – so as to prepare channels for tacit knowledge flows (Coleman, 1988; Polanyi, 1966). In this sense, human agents acting as boundary crossers have an important role to play, because they can internalize new elements, such as new modes of thinking and acting from one group of practitioners into another one – thereby intensifying the bond between different practices (Wenger, 1998).

Other factors that support the transfer of tacit knowledge are: similarities across knowledge bases, skills, organizational structures and incentive systems (Brown and Duguid, 2000; Davenport and Prusak, 1998; Hardy et al., 2003; Lane and Lubatkin; 1998, Simonin, 1999; Szulanski, 1996, 2000; Szulanski and Cappetta, 2003; Wang et al., 2004).

Transformation of Knowledge

Whereas transfer is usually dominant in the exploitation of given knowledge (Nelson and Winter, 1982), transformation through its combination with other knowledge within or beyond the firm, is more critical to support exploration and radical change (Hedlund, 1992, 1994; Kogut and Zander, 1992; Teece, 2001). We also believe it is important to distinguish between transformation and integration of knowledge. Systems integration is mainly concerned with the integration of skills and knowledge from external organizations (Cohen and Levinthal, 1990; Hobday et al., 2005). As opposed to buying different well-defined pieces of Lego and putting them together into a car, the transformation of knowledge requires all of creation, transfer, adaptation and integration. This is why different network structures, sizes of units and types of individuals often need to come together to jointly create, transfer and transform knowledge for final integration and exploitation of innovation. An in-house capability for systems integration can be observed at automotive original equipment manufacturers (OEMs), which are linked with their supplier network (Brusoni and Prencipe, 2001). However, phenomena such as the case presented in this paper, go beyond the mere notion of systems integration since the car development project represents a range of different boundaries with often high novelty of knowledge and high levels of complexity. Under such circumstances, 'the common knowledge used and/or the interests and knowledge of the actors involved must be transformed to effectively share and assess knowledge' (Carlile, 2003). Our concept of knowledge transformation also expands on the organizational learning framework put forward by Crossan et al. (1999), which distinguishes four succinct stages of organizational learning, namely intuiting, interpreting, integrating and institutionalizing. We nevertheless conform to the distinction of Crossan's framework between organizational levels, which ascends from individual to group and organization.

In this context, we believe that the examination of transformation networks will improve on current literature, by first establishing who the actors in the respective networks are, second, understanding what their unique roles and responsibilities are, and third, identifying what the motivations of the actors are. This should enable us to draw theoretical and practical conclusions regarding the dynamic nature of transformation networks.

METHODOLOGY

In our study we have used a qualitative in-depth case study method since a large extent of information was to be collected from a limited number of research units to gain a deeper understanding of 'how' a highly networked and complex new product development project managed external collaborations to enhance impact and speed of innovation (Yin, 2003). The primary instruments in the data collection were semi-structured interviews with audio recording and transcribing, including several types of documentation. The methodological strategy behind this research is mainly abductive, being a mix of deduction and induction (Alvesson and Sköldberg, 1994; Dubois and Gadde, 2002). There has been a continuous interchange between empirical data and theory, as empirical findings initiated the search for further theories. The purpose is theoretical development with a final stage of theory validation rather than theory generation based on grounded theory approaches.

The theoretical model is a further development of earlier work by Harryson (1998, 2002, 2006). While Harryson's model describes how companies can obtain ambidexterity by creating and interconnecting creativity and process networks through project networks, we make a more detailed analysis of not only how the interconnection takes place but, more importantly, how the knowledge is transferred and transformed into innovation – hence our choice to introduce the term 'transformation networks'. We contribute to his model both by adding new theory and by applying the enriched framework to a new case with more details on the transformation process than in any of his own case studies. To enhance the internal validity of our case, we have had the case reviewed by the companies involved (Volvo, Pininfarina, OASys/Webasto) in several iterations. To enhance the generalizability of our theoretical framework, we have also organized four seminars in which we have jointly reviewed and tested the applicability of the framework to Volvo and nine additional European companies[1] involved in a large research project on best practices regarding knowledge transfer in external collaborations. While our total sample in the larger benchmarking project amounts to ten high-tech companies, this paper presents the case with the highest amount of detail across multiple organizational levels. Of the 120 interviews that were conducted between 2002 and early 2006 in this research context, six were made with Volvo C70 related interviewees for the first version of this paper. In addition, we ran three master theses projects (in particular, Altshuler and Stern, 2006) and two PhD projects – all following different parts of the C70 development over an extended period of time. Based on suggestions by the Editor and our reviewers, we made five additional interviews during Spring 2007 with the C70 Project Director, the Technical Director, the Head of Volvo Design in California, and the C70 project manager from OASys/Webasto. The purpose of these interviews was to add verisimilitude and represent a wider network of the different actors across multiple levels in the case.[2]

CASE STUDY – THE NEW VOLVO C70 DEVELOPMENT

By examining the development project of the new Volvo C70 conducted in a highly networked way, we will present an example of complex multilayered knowledge transfer within and across the main actors involved in the complete vehicle development collaboration. We approach the case by first looking at how a creativity network was formed to deliver the exploration part of the innovation, in a relatively open network with loose ties between smaller actors. The case then shows how exploitation of the creative input from the exploration network took place within the context of a more controlled and larger organization in a relatively closed network based primarily on strong ties. The final part of the case describes how a transformation network emerged to transform the innovative concept into a complete vehicle by transforming the concept from the creativity network into pre-series cars, and how the whole transformation network then transferred from Italy to Sweden to move from 20 pre-series cars to 20,000 commercial cars per year.

The new C70, which is the world's first convertible with a three-piece retractable roof structure, was well received by the media and immediately started selling far beyond the forecasts.

Background of the Case

With the development of the Volvo C70, Volvo Cars Corporation needed to rely on a highly networked form of project organization in order to reduce time to market, enhance the degree of innovation and ensure a profitable business case. Unit volumes of the C70 had been set to just 16,000 units per year, and Volvo did not possess the expertise to manage such a small run of units themselves. Furthermore, development capacity had been consumed by other models planned for launch in the same period. Building up development capacity internally was not an option considering the low volumes and the unpredictable market impact of a niche model. Volvo's only option was to leverage a network of new partners in order to outsource the entire development and production of the complete vehicle project.

Central to the overall success of the consecutive exploitation phase of the project, Volvo intended to integrate the knowledge created in an initially open network by transferring it into their existing plant in Uddevalla, which had been producing the first generation C70. This was achieved through a joint venture, with responsibilities split 60 per cent for the main strategic partner, Pininfarina, and 40 per cent for Volvo. The partner Pininfarina was assigned clear responsibility while Volvo was retaining a major share in the venture, and the incentive for successful project completion was mutual. The choice of Pininfarina may have been influenced by the fact that – at a dinner organized around the Detroit Motor show in January 2002 – the CEO of Volvo sat next to Andrea Pininfarina and started to discuss the idea of a possible joint innovation project. The Technical Director of the C70 project, Olle Odsell, explains the rationale behind the collaboration model that may have been born over the dinner in Detroit:

> By giving Pininfarina 60 per cent of our joint manufacturing plant, it was clear from the very beginning of the development phase that Pininfarina would have the main responsibility for transforming the development results into a lean and efficient manufacturing process. I have seen examples of other companies outsourcing only the design and development, but without making the same partner responsible for the manufacturing. This has resulted in designs that caused significant problems in manufacturing and partners ending up blaming each other, respectively, for making poor designs and having poor skills in manufacturing. (Interview, 23 March 2007)

After development at the Pininfarina development centre in Turin, production was located in Uddevalla, a former Volvo plant which had been acquired by the Volvo/Pininfarina joint venture called Pininfarina Sverige AB. The supplier of the retractable hard top (RHT) for the car was also integrated at the Uddevalla plant. This was a small company called OASys, which re-integrated into its mother company, Webasto, as the C70 project reached its full focus on production ramp-up. Thus, Volvo managed the balance between exploration and exploitation through a highly networked organizational setup, which will be described in more detail below.

Creating the Concept in Creativity Networks

Volvo retained full responsibility for the development of the car concept. This included target market, sales projections, commercial viability (business case), technical specifications and design. Defining the concept and developing exact specifications were essential procedures in order to ensure that the requirements set initially by Volvo could be implemented in the loose network structure of the creativity network. A strong and detailed concept was also necessary in order to facilitate the knowledge transfer of explicit knowledge from Volvo to the creativity network. The knowledge transfer was further consolidated through a series of hand-over workshops and co-location teams of Volvo engineers and designers in Turin – with engineers from the roof supplier, as well as the designers. A key carrier of knowledge was the overall Volvo C70 project director Patrik Widerstrand, who was constantly travelling back and forth between Gothenburg and Turin in order to coordinate and steer the project. He shuttled knowledge from inside Volvo out to the main partner in order to activate the creativity network. As illustrated below, not only the project director, but also the head of design, was instrumental in facilitating the transfer of knowledge from creativity to transformation and later, on to the process network.

Volvo design. As part of the concept phase, in a process common among automotive OEMs, Volvo initiated an internal design competition which was battled out between the Volvo design offices in Barcelona, Spain, Gothenburg, Sweden and Camarillo, California. After three months, a winning concept emerged – the Californian design team was chosen with its idea for the design of the new C70. The choice was made by a team of six executives, including Volvo's overall Head of Design, Peter Horbuery from the UK (now Global Head of Design of the Ford Group), the Project Director and the CEO – both from Sweden. Upon winning the internal design contest, John immediately moved to Gothenburg – both to identify further creativity networks, and to start preparing the transformation network:

> Immediately upon winning the design contest, I moved to Sweden in August 2001 and stayed one year to get networked with the local design engineers and to search for new partners. This is when we identified Pininfarina and evaluated a few possible options for the very advanced roof structure that this model would need. (Interview, John Kinsey, Head of the Volvo California Design Office, 29 March 2007)

After one year of collaborative design work and network building in Sweden, John Kinsey left for Turin together with four colleagues, where they formed part of the Volvo on-site team overseeing the serial development of the new C70 with Pininfarina. The role of John and his team can be regarded as one of the most important shapers of the final product and one of the most important success factors, consistent design application being one of the core competences retained by Volvo and representing the major unique selling point of the final project. It was also through John that design knowledge was carried from early development into the final process network. Once the whole project moved to Gothenburg after two and a half years in Turin, the designers were also integrated into the closed network which would be responsible for the final production of the vehicle:

> We need to be intimately involved on a daily basis to secure that the design is fully transformed into reality without making the many small compromises that engineers will ask for based on practical manufacturability issues. In the end, this is what is going to decide if a car looks simply good, or really great. (Interview, John Kinsey, Head of the Volvo California Design Office, 29 March 2006)

OASys/Webasto. One of the specifications of the car concept had been a retractable hard top (RHT), in order to create a 'two-in-one' coupé/convertible. Volvo had identified several RHT partnering options, including Webasto, but delegated the responsibility for the development and production of the RHT to Pininfarina. The German roof concept specialist Webasto possessed the relevant expertise for such a roof system and in order to pool resources and access their partner's knowledge, Pininfarina formed a 50/50 joint venture with Webasto called Open Air Systems – OASys. In the long run, Pininfarina hoped to be able to permanently add the knowledge acquired through the joint venture to expand their service offering. However, in the course of the serial development phase in Turin, Pininfarina decided instead to re-focus on their core competences and discarded their plans to extend their services to RHT development. Webasto in turn acquired Pininfarina's 50 per cent stake in the venture.

The OASys development team had been in Turin since the autumn of 2003 and stayed there for slightly more than one year. Initially there were only two resident engineers inside the Pininfarina facilities, but the team grew rapidly and was backed up by some 20 OASys development engineers in Stockdorf. The OASys Project Manager, Jörg Wandler, and his Technical Director, Horst Schmidhuber, distributed their time equally between Turin and Stockdorf to secure timely creation of a revolutionary three-piece roof structure and support its seamless integration into the pre-series cars that were developed in Turin. Through extensive socializing, the OASys engineers became a fully integrated team within Pininfarina:

> We usually met our Pininfarina colleagues in the evenings. The perhaps most intensive evening together was when we watched the semi final in the football championship with Germany playing against Italy. We agreed to switch channel every five minutes to follow the game, equally, in German and Italian languages. The next day at work, some of our Swedish colleagues feared that the team spirit between Webasto and Pininfarina would be damaged, but we were still an equally strong team – although Germany lost against Italy. By watching the game together, their combined joy and compassion compensated largely for our disappointment. (Interview, Jörg Wandler, OASys/Webasto C70 Project Manager, 29 March 2007)

Dynaudio/Alpine. Dynaudio had already been involved in collaboration with Volvo for the integration of its speakers and amplification technology in the first-generation C70.

Gradually, realizing the potential of premium car audio and co-branding possibilities, the collaboration with Dynaudio assumed a more strategic character, whereby in later models, the Dynaudio logo was featured prominently in Volvo cars. For more super premium sound, Volvo required that Dynaudio use the Bang & Olufsen (B&O) ICE-power amplification technology. As a consequence, Alpine, that had the overall responsibility for amplifiers, made an agreement with B&O ICEpower to use their unique power conversion technology. This was the first time that the breakthrough technology from B&O was used in a sound system for cars (Harryson et al., 2008).

Transformation Network

The Transformation Network consisted of four nodes: Pininfarina Development, Volvo On-Site Development Team in Turin, Volvo Project Management in Gothenburg, and OASys/Webasto. As stated by the Head of Design, this network was more strongly interconnected through co-location of the core functions and their corresponding strategic partners than what he had experienced in other companies:

> The way in which Volvo interconnected design, engineering and manufacturing in the C70 project was unique. There are many companies in which the designer just makes a sketch that a director likes and then he never sees the sketch again – nor the people who are supposed to implement it. In such companies, the sketch is never transformed into the reality that the designer envisioned. We felt that if we were to be away from the action in Turin for a week or more, the transformation process could be deviated into more engineering driven pathways. This is why we stayed intimately connected to the development engineers. For example, in Turin, we were based less than 30 metres from the mixed Pininfarina, Volvo, OASys Team. (Interview, John Kinsey, Head of the Volvo California Design Office, 29 March 2006)

Pininfarina development. The central node of the entire transformation network was spanning both creativity and implementation. The Pininfarina/Volvo joint venture was organized through a comprehensive contractual framework specifying all eventualities of the project in detail and moving development and manufacturing risk clearly towards Pininfarina. The Italian partner was incentivized through the clear responsibility split of the 60/40 joint venture. The strength of the ties created by this framework still allowed for enough room for the partner to leverage its smaller size and mobility during the exploration phase, since it removed the need for close scrutiny and geographical proximity of Volvo. With lean coordination from Volvo, which was achieved through bi-weekly and later, weekly meetings on-site in Turin as well as web meetings, Pininfarina still succeeded in applying the flexibility and speed of change adjustment required for this phase of the project.

While a variety of sources contributed to the creativity network, the critical part of the project would be the effective use of skills and knowledge of the various actors. The fact that Pininfarina took on the entire scope of skills of an automotive OEM, underlines the fact that it was faced with a steep learning curve. Naturally, the larger OEM was able to step in and add their competences when required, e.g. leveraging bargaining power with suppliers. Especially considering the highly complex nature of the development project, it was only through transforming knowledge and breaking it down into meaningful subsets, that Pininfarina succeeded in integrating the separate systems.

Following codified communication of specifications and contractual arrangements, co-location of Volvo staff and the roof system supplier, knowledge was effectively transformed through strong vertical channels of the Pininfarina hierarchy. The agility of the organization was a key enabler of knowledge transformation. 'We were amazed at the speed with which changes were implemented' (Interview, Olle Odsell, Technical Director Volvo, 17 March 2006). In a more recent interview, he confirmed that:

> It wouldn't have been possible to run such a project as fast within a big organization. The project team was small and dedicated, the decision-making was faster. Additionally the project team was highly flexible, during the prototype phases, as it was supported by different small suppliers, responsible for the different elements of the prototypes. (Interview, Olle Odsell, Technical Director Volvo, 23 March 2007)

In similar terms, the Head of Design views the networked organization – located outside of the main company – as the most important driver of speed and creativity:

> The key success factor was to have a small team of designers outside of the mother company ship, which allows you to really focus on the job and be in the centre of the action instead of being in bureaucracy. We were empowered to do the job that designers really should do. By being outside of our traditional comfort zones we had to think on our feet and always meet the people involved rather than sitting in our home offices and trying to develop solutions without interacting with those responsible for their translation into reality. (Interview, John Kinsey, Head of Volvo California Design Team, 29 March 2007)

The larger OEM from Sweden relied mostly on collaboration in horizontal teams to form decisions, whereas the Italian Pininfarina displayed a much more vertical hierarchy. At the beginning, Volvo was missing concrete reporting processes; over-the-desk discussions and delegation at Pininfarina produced the desired results when changes had been requested. However, as complexity rose over time, Volvo Project Management realized a need to implement regular design reviews as a basis for decisions – followed up by a sophisticated IT error tracking system – rather than relying on Pininfarina's Head of Engineering going around to each individual engineer to make undocumented and non-communicated decisions. As stated by the OASys project leader, this IT system supported full transparency among all members of the transformation network:

> All of us – OASys, Pininfarina and the different Volvo units – applied the Volvo Quality Tracking system so that we were all on line and on the same page in terms of problems, parties involved, and the progress of verification, analysis and solution. The one who reported a problem had to confirm that it was solved before it is removed from the system. (Interview, Jörg Wandler, OASys/Webasto C70 Project Manager, 30 March 2007)

Volvo on-site development team in Turin. The on-site team, including engineers and designers, oversaw the development at Pininfarina in Turin. The role of Volvo designers was to add clarity for engineers to secure transformation from the tacit vision of designers to a tangible reality. 'Our job was to protect the design and secure its transformation into reality. We may want a certain appearance and have to fight with engineers who may suggest more manufacturable but less distinct solutions' (Interview, John Kinsey, Head of the Volvo California Design Office, 29 March 2006).

The fourth node in the transformation network consisted of the C70 project management team in Gothenburg. At this critical transformation step, the head designer John Kinsey proved essential for the meaningful application of the knowledge gathered into a fine-tuned product, monitoring design specifications down to the correct colour of the paint. Without the co-location, successful transformation of knowledge would not have been possible without a great deal of close coordination from Volvo:

> The physical proximity is critical, but some of the project members still had a language barrier that added to some confusion. Luckily, I had worked for Fiat for three years in the same town, so I knew the language and could better understand the minds of the Torinese before returning there with the C70 project. This helped me a lot in terms of building respect, trust and mutual understanding. We simply understood each other more easily and I could go straight to the right people . . . Rather than just going to an overseer of engineering, we could use the proximity and the well-oiled network to go straight to the engineer directly responsible for the specific part. This really makes the difference – not because engineers do not want to cooperate, but because their minds are too different to collaborate across distance. To be there in person bridges the differences and adds clarity to the transformation. (Interview, John Kinsey, Head of the Volvo California Design Office, 29 March 2007)

Volvo project management Gothenburg. As with the Volvo on-site team, the Volvo project organization in Gothenburg depended largely on a central carrier or knowledge shuttle, personified by the Project Director Patrik Widerstrand. In addition to the intensive steering during the transformation phase by the project director, the Technical Director Olle Odsell gained importance as technical integration of the various sub-systems reached critical stages. Those two individual actors were able to leverage the key nodes of the network efficiently. To a certain extent, the dispersed actors could also be steered by Volvo project management through net meetings. 'Through our net conferencing, it was possible to work simultaneously on content with a variety of actors involved in development. . . . This allowed us to secure early preparation for integration of the results' (Interviews, Olle Odsell, Technical Director Volvo, 17 March 2006; 23 March 2007).

OASys/Webasto. OASys' role in the transformation process intensified from fine-tuning concepts to pre-styling and trials focused on how to stack the three piece roof in the most space-efficient way. Making sure that the solution for the roof met the requirements of the transformation quartet – Volvo development, Pininfarina development, Volvo project management and OASys – the OASys engineers travelled frequently back and forth between Turin and their headquarters in Germany. Volvo's technical director also went to OASys/Webasto on a regular basis to ensure that the roof structure they developed offered a good fit. The project leader from OASys/Webasto notes how the smaller OASys organization allowed for more speed and creativity in the first half of the project than what would have been possible in a large organization:

> I always reported directly to our Managing Director, which was key to supporting the immediate decision making and flexible resource allocation that were required to develop the unique roof structure in such a short timeframe. It was clear that our relatively small OASys JV company with approximately 120 employees – supported by the mother companies Pinninfarina and Webasto – could act in a faster and more organic way than a large company would normally do. Towards the end of the project, we were re-integrated into the Webasto Group with a total of 5,000 people worldwide. Especially at this stage of the project, where our goal is to enhance efficiency and capacity in production, it feels good to be part of a resourceful organization. (Interview, Jörg Wandler, OASys/Webasto C70 Project Manager, 29 March 2007)

End customers. Towards the end of the serial development, Volvo conducted a car clinic, presenting a first prototype, a full-scale functional model to lead users in the USA and Germany. 'In the market for premium convertibles, the US accounts for 50 per cent of convertibles sales worldwide, and Germany and the UK account for 25 per cent more, thus the clinics in the US and Germany covered most of the potential client base' (Interview, Patrik Widerstrand, Project Director Volvo C70, 17 March 2006). Car clinics are commonplace in the automotive industry and are a key tool for testing customer feedback on new concepts and models. During these 'automotive focus groups', 100 customers each in Los Angeles, Munich and Stuttgart were presented with the models and were able to provide feedback, both unprompted, without the Volvo logo showing, and prompted, with the Volvo logo displayed. The customer feedback served both as a consolidation of what had so far been developed, and also provided knowledge essential for the transformation into the network. In addition to the potential customers, selected dealers saw the rolling mock-up during 2004. Significant feedback was provided from two dealers in Spain and Sweden and from two dealers based in Florida and California. The main partners Pininfarina and OASys/Webasto were always invited to join both the car clinics and the final test drives – as if they had been company internal collaboration partners.

Implementing Creativity Network Results in the Process Network

Following the completion of serial development of the new Volvo C70, the project was transferred to the Uddevalla plant, whereby the most central knowledge transfer during the project occurred. The move to the Uddevalla plant further consolidated the ties between Pininfarina and the Volvo headquarters. Pininfarina took over existing resources and capabilities from the Uddevalla plant, which consisted of 800 staff, equipment and tools. This acquisition made it possible for Pininfarina to absorb the Volvo production processes.

Pininfarina manufacturing. Pininfarina took on the entire responsibility of the Volvo/ Pininfarina plant which was owned by the 'Pininfarina Sverige AB' joint venture. Both the Pininfarina project management and the Volvo on-site team moved to Gothenburg in order to further coordinate the whole production process as well as organizing the adjustments of the existing assembly line of the first C70 model to be able to produce the next-generation C70. As already implied, Pininfarina benefited from considerable knowledge transfers as a result of the acquisition of the plant. For example, Pininfarina took over the quality-gate system extant at the plant, enabling the supplier to draw on one of the key core competences of Volvo – more rigorous quality management than ever practiced by Pininfarina.

OASys/Webasto. The RHT supplier, OASys, also moved to Uddevalla for immediate integration of the roof system module into the production process. This way, the supplier's knowledge was transferred directly into the plant – combining the benefits of smallness at the start, with a growing organization at the exploitation phase – as witnessed by the OASys/Webasto C70 Project Manager:

> Initially, we planned to have just a handful of resident engineers in Sweden, but we soon realized that a massive transfer would be required. We ended up sending the whole Turin based team and several additional C70 engineers from Stockdorf, which meant a transfer of close to 20 of our engineers to Sweden for at least 9 months. We lived there on a permanent basis five days per week and also stayed some weekends in Uddevalla. Most of us were living in flats that were co-located with the flats of our Pininfarina colleagues. Also some Volvo engineers, normally working in the Torslanda plant, relocated their daily office living base to Uddevalla – although their homes and families of course remained in Gothenburg. We had a growing joint office with all team members from Volvo and Pininfarina within less than 10 metres reach. (Interview, Jörg Wandler, OASys/Webasto C70 Project Manager, 29 March 2007)

Volvo management. While Pininfarina underwent considerable learning effects by taking over the Uddevalla plant, Volvo also absorbed some of Pininfarina's capabilities, which mainly consisted of speedier implementation of specification changes and adjustments. Further, during supervision of the production of the vehicle, Volvo was exposed to Pininfarina's excellence in integration of the various systems. With the commencement of production, the Volvo on-site team could be relocated back to Gothenburg. At this stage, the members of the initial design team would still be fully involved with the supervision of production, representing a consistent transfer of very critical concept knowledge from beginning to end. Continuous supervision and accompaniment of the project was critical since the design was core to the final product, representing the key means for Volvo to retain control of development and shape the full creation, transformation *and* final integration of the results in full accordance with the premium brand intent.

Placing Pininfarina in a Volvo plant also ensured that the design could be effectively transformed into a lean manufacturing process. Also, Uddevalla, situated just outside Gothenburg, was close to the Volvo headquarters, enabling comfortable control over the continued implementation part of the project, including systematic quality improvement. In addition, the project was also linked to existing logistics and other functions required for the commercialization of the car.

Controlling all software development to secure smooth system integration. While Volvo pursued strategic alliances and outsourced many strategic activities to collaborative networks of development partners, all software development for the entire vehicle was made by Volvo. Software development that had to be done during the Turin-based vehicle development, or was required for controlling the roof structure, was still made by Volvo software engineers, who worked as consultants for Pininfarina and other external partners.

> The overall IT brain power participating in the transformation phase consisted of some ten Volvo software engineers responsible for the software development of the vehicle. Additionally, there was one IT person responsible for each area (electrical, interior, exterior, body, and chassis). These people were also responsible for finding the necessary resources in their respective areas. They were constantly travelling between Italy and Sweden – and also went to Stockdorf to develop the software of the roof structure. By having full control over all software development, we could save a lot of time when integrating the different modules into a complete vehicle. (Interview, Olle Odsell, Technical Director Volvo, 23 March 2007)

Building trust through social networking. As a preparation for the transfer of Volvo engineers and designers to Turin, several full-day exercises were run with mixed teams of mainly Swedes and Italians to create a dialogue around important differences in culture, ways of working, ways of communicating and decision making routines. The exercises served the purpose of creating awareness of the differences rather than finding solutions or trying to eliminate the differences.

Formal dinner events and barbecues were organized every six months, but the informal networking was much more frequent. For example, football matches between the Swedes and the Italians – followed by joint wine tasting – were popular events that strengthened the social ties among the collaboration partners. One engineer deserves special mention in this context:

> Hans Persson was a critical engineer across the entire project. Prior to the design contest, he came to my office in California working as a studio engineer. After the contest, he joined my transfers to Sweden, Italy and then Uddevalla. He is a great engineer with a unique ability to interact with designers as he can think like us. Moreover, he regularly organized soccer games between the Swedes and the Italians. He always demonstrated passion and never took 'good enough' for an answer. What we did had to be great. Hans also wrote a newsletter with continuous updates on who did what in the C70 football games. Actually, he just did this as an informal thing for fun, but it played a critical role in bringing Swedes and Italians together. (Interview, John Kinsey, Head of the Volvo California Design Office, 29 March 2007)

Most interviewees mention frequent examples of socialization. The head of design stated: 'I mainly hang out with a large group of Italian Pininfarina engineers, and my own designers: Dave Bishop, Dave Wilkinson, Tony Patman, Partik Lundgren and Hans Reuters. In the week, we would go to town for dinner and in the weekends, we went snowboarding'.

DISCUSSION AND MANAGERIAL IMPLICATIONS

Similarities and Differences Between Creativity and Transformation Networks

As suggested by our theoretical framework and illustrated by the Volvo C70 development case, the relatively high degree of innovation in this new RHT convertible was accomplished by first identifying, selecting and engaging a number of external creativity networks. These creativity networks included large companies like Pininfarina and OASys/Webasto, but also smaller companies like Bang & Olufsen ICEpower and Dynaudio for modular innovation in the sound system. While the first two creativity networks migrated fully into the transformation network, the two latter creativity networks did not. A possible conclusion is that creativity networks will consist of external partners – typically smaller than the main company in question. We can also conclude that having the role of a creativity network does not guarantee a role in the transformation network. This will depend on the relative need for transfer of tacit knowledge and pressure for speed of integration. Finally, we can conclude that parts of the main company can be (temporarily) transformed into a creativity network through spin off into a smaller and more organically managed unit, or through transfer to a more organic company structure.

The transformation network is far more complex than the creativity networks, which often constitute parts of the transformation network. The latter often also includes units or individuals from units that are normally nodes in process networks. The reason for this is that transformation networks not only interconnect creativity and process networks, but 'free' selected members in these networks from their formal organizational/subunit contexts to prioritize the project agenda in such ways that the inventive results created by the creativity networks are effectively transformed into commercialized innovations.

The strong ties of the transformation team members to their respective organizations/subunits enable them to draw out and combine the relevant knowledge and resources required to implement the vision of the project – as orchestrated and reinforced by the transformation network. In this sense, the transformation network orchestrates the shift of levels from organization to individual to team. The members of the transformation network maintain and continually leverage their strong past ties to their respective home organizations/subunits, while gradually also building up strong ties within the transformation network. Once a concept has been created and validated, the transformation network implements it through the process network, which gradually 'takes over' the concept to merge it back at the level of the home organization. This process of integrating knowledge and ownership at home organization level is facilitated by the fact that the transformation network also includes important members from the home organization's process network with the potential knowledge and resources to take the concept/prototype into production. Transformation networks build cross-level ties across organizations and units with different size, managerial hierarchy, strength of ties and types of networks to make transfer, transition and transformation from exploration to exploitation possible. The transfer, transition and transformation are phased in time – starting with a focus on creativity networks for creation of new knowledge, transformation networks for transfer and integration of the relevant knowledge and process networks for implementation of the results.

Our theoretical framework and its case illustration suggest that the dilemma of technological leadership can be avoided by building ties to external creativity networks with the required specialized skills – rather than developing these in house. Instead, several key people can build multicompetency and global networks of know-who for access to relevant know-how. By acting as 'spidermen' building networks across multiple levels, they secure creation, transfer and integration of the relevant knowledge for implementation and commercialization.[3]

It seems that the transfer of people and whole teams into new network structures can be required to build a transformation network. It also seems that multicompetence, frequent professional interaction, co-location, social networking and good communication tools are vital cornerstones in the establishment of transformation networks, the roles of which are summarized below.

Roles, Responsibilities and Functions of Transformation Networks and their Members

If traditional gatekeepers and boundary spanners gather external information from various actors and translate this into the specific contextual information meaningful to the locally oriented actors (Allen, 1977; Allen and Cohen, 1969; Tushman and Katz, 1980; Wenger, 1998), the project leader and key members of transformation networks have the wider roles and responsibilities of transfer, integration/transformation and implementation of knowledge. In addition to performing information transfer tasks, they establish a common communication structure. This seems to be a vital mechanism in helping to align the various actors in order to transfer information using shared norms, values and language. Finally, by moving into the process networks and by creating direct links between members in creativity networks and the process network, the knowledge transfer and transformation is secured. As illustrated in the case, the very first step towards a transformation network happened when the designer, John Kinsey, and his Swedish colleague, Hans Persson, transferred to Sweden to team up with the Project Director, Patrik Widerstrand, and his core team of designers and engineers. The first formal transformation network emerged through the Turin centred quartet of Volvo designers from California, Volvo engineers from Gothenburg, Pininfarina engineers from Turin and Webasto engineers from Stockdorf, Germany.

Organizational Contexts that Make Transformation Networks Effective

The fact that development was managed in a very lean way outside of the more structured and process-driven main organization turned out to be an additional asset.

Freed from organizational bureaucracy, and outside the Volvo main routines, Pininfarina and the other innovation partners proved highly efficient in implementing specification changes and in integrating the complex sub-systems into the car.

During the whole of the project, multicompetent key members of the project teams from both suppliers and OEM displayed high mobility, adjusting their location in order to be able to add value to the project directly. Especially considering the dispersion of actors in the creativity network, mobility and circulation of actors was critical in order to ensure success of the project. A highly representative example was provided by the design team which was first moved from California to Turin and later to Gothenburg. This mechanism was central for such an important OEM competence. Car design is a crucial competence of Volvo, thus transferring design knowledge by circulating staff was a vital mechanism for the overall success of the project. Socialization also played an important role in intensifying the bond between members of the networks, as it regularly surpassed the boundary of the office and extended into evenings and weekends.

Once exploration had been successfully completed, co-location of all actors involved in the development followed. The different actors were placed within a closed network made up of an existing Volvo plant, which entails a high degree of embeddedness and facilitates control/coordination and close information exchange from Volvo and is based on Volvo processes. It can be strongly attributed to this mechanism that the supplier Pininfarina was able to successfully produce a vehicle of the quality required by Volvo. Alternatively, transferring premium production knowledge to the existing Pininfarina production plants would otherwise have been a costly and time-consuming process of teaching Pininfarina under constant close supervision of Volvo. An important managerial implication of our paper is that co-location seems conditional for transfer of complex and tacit knowledge. 'Rather than just going to an overseer of engineering, we could use the proximity and the well-oiled network to go straight to the engineer directly responsible for the specific part. This really makes the difference – not because engineers do not want to cooperate, but because their minds are too different to collaborate across distance. To be there in person bridges the differences and adds clarity to the transformation' (Interview, Head of the Volvo California Design Office, 29 March 2007).

Thus, the lean structure of Pininfarina and their track record of similar projects requiring a vast set of competences and knowledge, proved a key enabler for the effective transformation and later exploitation of the knowledge created in the creativity networks. Secondly, the Volvo on-site team assisted the full transformation of knowledge.

This is not to say that all project members transfer from one network to another. For example, OASys had only between two and four resident engineers in the Turin-centred transformation – out of a total development team of 20 engineers. Later, OASys transferred 20 dedicated C70 engineers to the Uddevalla plant, which ended up hosting a total of 800 employees.

Our analysis of the dynamics of the different networks represented in the Volvo C70 development is not suggesting that geographically and organizationally dispersed networks have to cease. A large majority of the project members remained geographically dispersed across main locations like Gothenburg, Uddevalla, Turin and Stockdorf, but instead certain members of these networks were co-located, in one or even several of these main locations, depending on the phase of the project – creation, transformation, or exploitation. These phases and their respective network dynamics are analysed in more detail below.

Analysing Dynamics Within and Across Creativity, Transformation and Process Networks

John Kinsey first went to Gothenburg to spend one year building a local network and understanding the local context in which his design would be implemented. He was also deeply involved in assessing, selecting and getting connected to the external partners that would support the transformation of his design into a premium convertible. As many as five different suppliers of retractable hard-tops were involved in developing initial concepts before the project director, the head of design and the chief engineer selected OASys (which reintegrated with the larger mother company, Webasto), as the project reached the stage of commercial production. The dynamics were also stimulated and coordinated by Hans Persson, who was a multicompetent designer-engineer – supporting the C70 project across all networks and phases.

Our analysis substantiates the arguments outlined in our presented theory, namely that the deployment of strong and weak ties was complementary from the perspective of time, being mediated through transformation networks. The case also supports the proposition that weak ties are likely to accelerate development speed in early phases of exploration when the required knowledge is not complex. Conversely, strong ties turned out to be more productive in situations of high knowledge complexity to support exploitation of innovation.

Another key mechanism for successful knowledge transfer during the project was created through the right choice of ties. Despite losing some strength due to geographical distance during exploration, the tie between lead actor Volvo and supplier Pininfarina seemed to provide the right degree of strength for leaving sufficient space for creative exploration. Conversely, abandoning the joint venture alliance with Webasto for the development and production of the RHT proved to be an important choice of tie since Pininfarina was thereby enabled to fully concentrate on core competence and expansion of production capabilities, rather than also expanding expertise into hard top manufacturing.

As illustrated in Figure 4, the knowledge transfer and transformation process happened across the two opposing networks: exploration in open creativity networks and exploitation in closed process networks. The project teams working across transformation networks secured both transfer and transformation of the knowledge required to bring the new C70 to market.

In all cases except for the ICEpower technology from B&O, a certain transfer of human knowledge carriers was required to secure the necessary knowledge transfer from creation to integration and implementation. The ICEpower technology was incorporated in a chip that could be integrated into the Alpine/Dynaudio system without bringing a human knowledge carrier from B&O to secure the knowledge transfer. All other knowledge transfer examples mentioned in this case required transfer of human knowledge carriers from knowledge creation to knowledge integration for exploitation, as the knowledge was both tacit and complex – not stored in a small power amplification chip.

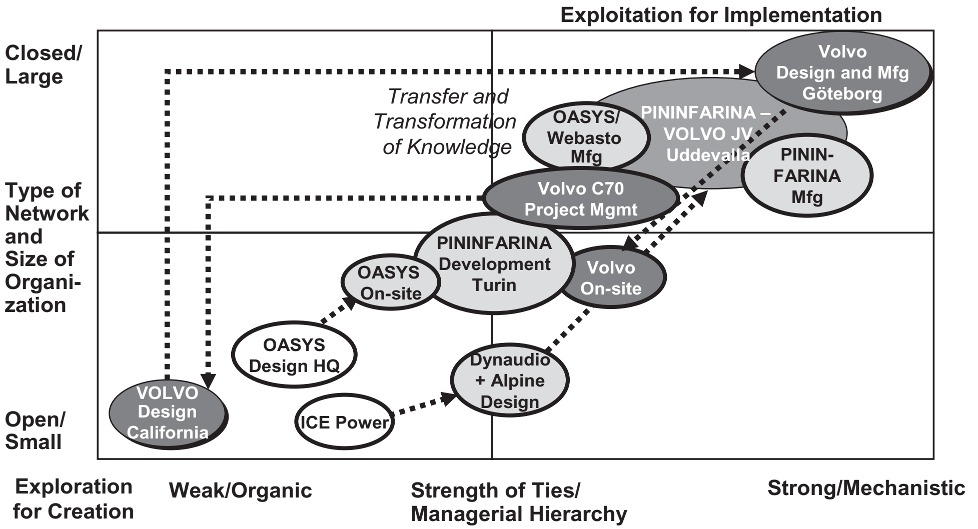

Figure 4. Knowledge transfer for creation and integration of knowledge

Volvo leveraged the internal network of decentralized design units for optimal creativity, speed and flexibility in exploration. By placing the Volvo designers, the OASys engineers and the Volvo software engineers at the premises of the strategic partner, tacit knowledge was effectively transferred. Further, by transferring the entire quartet from Turin to Uddevalla to support exploitation of results, loss of knowledge could be reduced and misinterpretation and misunderstanding be avoided.

Similarly to the integration of a chip into an amplifier, there are other industries in which the role of transformation networks is equally unimportant. For example, the transformation from exploration to exploitation of a new drug can usually be made without transfer of human beings, because the required mix of ingredients is easily documented and replicated in production.

Avoiding the Dilemma of Technological Leadership by Acquiring it from External Partners

For managers it is interesting to learn how Volvo managed to strike a good balance between technology depth (knowledge intensity) on the one hand, and customer-driven speed of delivery through concrete market applications with global reach (knowledge extensity) on the other hand. The example of Volvo illustrates, across multiple levels, how exploration can be transferred from partly open and informal networks into exploitation and implementation through a more formal and closed network with strong ties.

Creativity networks with weak ties were adopted to source specialized knowledge and technology focused on exploration through collaboration with external partners; process networks with strong ties were focused on exploitation of innovation through strong linkages between partners for accelerated commercialization; transformation networks focused on bridging the creativity networks and process networks, while integrating and transforming their complementary resources and skills for implementation of innovation. As a result of these arrangements, both external and internal networking abilities were creatively employed, and the dilemma of technological leadership was avoided.

Accordingly, it would seem that creation and implementation of innovative designs need two types of people:[4] The first are the 'spidermen' who both have a larger vision (big picture) and also have the ties and power to bring the entire network structure together. The second type of people are the transformation network members who have three characteristics: (1) necessary experience, insight, and relevant knowledge; (2) strong past ties and credibility within their parent organizations; and (3) enjoy a challenge, value innovative thinking, thrive in an independent environment, and like being a part of something larger than their normal functions in the organization. Both types of people have strong social skills.

To wrap up our discussion and summarize the key elements of our study, the different actors involved in the Volvo C70 innovation project are listed in Table I, including their functions/roles and their motivations/objectives.

Limitations of our Study, Generalizability and Suggestions for Further Research

Our case illustrates how Volvo created a seemingly unique capability to flexibly network tacit knowledge and disruptive technologies into innovation and tap the potential of learning alliances to support both exploration and exploitation of innovation. We chose a single case study design based on 11 interviews and five Volvo C70 related Masters and PhD research projects to allow for detailed analysis across multiple levels. The generalizability of our theoretical framework goes beyond the single case – as we have organized four seminars in which we have jointly reviewed and tested the applicability of the framework to Volvo and nine additional European companies involved in a large research project on best practices regarding knowledge transfer in external collaborations. Future detailed case studies – ideally of different industries – will need to explore when and why knowledge transfer depends so heavily on the transfer of human knowledge carriers across multiple organizational levels, and also better understand the rare exceptions in which the transfer of human knowledge carriers is not necessary to the same extent (for example, in process industries).

NOTES

[1] The other nine members of our research project are/were: Anoto, Bang & Olufsen, BMW, Gambro, Nordic Mobile Company, Porsche, SCA, Stora Enso, Tetra Pak.

[2] We would like to thank two anonymous reviewers and the Editors for giving us this idea and for making many additional suggestions that helped us improve this article significantly.

[3] Hans Persson was mentioned as such a person, who built competence in several of the disciplines involved in designing, engineering and manufacturing a car. He also transferred to and worked within all of these functions to serve as one of those who kept the transformation network together. Other crucial individuals, who drove the creation and transformation from decentralized exploration to global exploitation, were the Head of Design, John Kinsey, the Director of Technology, Olle Odsell, and the Project Director, Patrik Widerstrand.

[4] We would like to thank Reviewer A for giving us this idea and for her/his helpful comments on our section on 'Similarities and differences between creativity and transformation networks'.

Table I. Actors in the Volvo C70 development and their motivations to contribute to the project

Actor	*Function/role*	*Motivation/objectives*
Volvo Concept Development	Creating a premium concept based on clearly customer-driven specifications. Overseeing entire project from concept through to production.	Efficient development and production of a new model to enter the premium segment through a profitable business case. Effective leveraging of external partners to offset skill and capacity deficits.
Californian Volvo Design Division	Car design/concept, models and prototypes. Supporting selection of the right partners. Overseeing development of complete car at Pininfarina and ensuring that design requirements are respected.	Competitiveness-competition triggered and steered passion for desired progress. Implementation of a unique Volvo design with more premium feeling than ever before. Supervise and collaborate with all partners to secure transformation of a premium design into the first RHT commercial convertible in the history of Volvo.
Webasto/OASys	Joint venture for the development and implementation of a retractable hard top.	Economic gains through innovation leadership – developing the first three piece system in the world.
Dynaudio/Alpine/ICEPower	Integrating a unique technology into an automotive sound system. Integrating superpremium loudspeakers into a convertible.	Finding a new application for a revolutionary technology. Innovation leadership and economic gains.
Pininfarina Development project organization	Integrator for sub-suppliers, development of complete vehicle. Selecting sub-suppliers. Securing manufacturability.	Integration of input from creativity network. Meeting quality requirements. Developing pre-series that are manufacturable. Meeting deadlines.
Volvo on-site development team	Supervision of Pininfarina, collaboration in developing vehicle according to specifications. Providing expertise to Pininfarina.	Meeting specifications. Learning from Pininfarina. Leave the mother organization for an exciting venture in Italy as part of a dynamic network.
Volvo Project Management Gothenburg	Steering and management of project in collaboration with Pininfarina.	Ensuring successful transformation of concept into commercial vehicle. Reporting to CEO and getting media attention.
Lead customers	Confirming market viability.	Being able to contribute to a car concept.
Pininfarina Production Management	Adjusting plant to production of new C70. Managing production process and implementation of development.	Meeting deadlines for start of production. Meeting volumes with quality and on time. Increasing production capacity to be able to supply to the superior market demand.
Volvo Production/Uddevalla plant	Provides facilities, capabilities for complete vehicle production.	Plant utilization. Enhancing capacity for enhanced revenues.
OASys/Webasto Production	Integration and production of roof system.	Developing the first three piece roof structure. Economic gains.

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