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Innovation Processes in the Car Industry: New Challenges for Management and Research

Giulia Trombini and Francesco Zirpoli

ABSTRACT *Over the past decades the development of a car has become a complex activity involving skills and resources from a variety of industries and actors, and requiring the accomplishment of tight regulatory norms and market needs. Technological and market forces have led incumbent firms to radically change the organization of their innovative activities, shifting from a closed vertically innovation model to a distributed one. The aim of this study is to review the main challenges carmakers are currently facing and the organizational and strategic solutions adopted to perform innovative and development activities within vertically fragmented networks. The chapter casts light on the organizational and strategic challenges of downstream development activities, then it also tries to overview the strategic role of up-front research activities, namely the research activities leading to patenting. The main changes brought by the distributed innovation model on new product development activities are discussed, focusing on the principles guiding outsourcing decisions and the governance mechanisms carmakers use to manage networks of external suppliers. The study, then, reviews the role of patenting in the industry as a means for carmakers to appropriate value from innovation in vertically fragmented networks. Finally, it discusses the changes on the organization of innovation activities that the emergence of the electric car-standard may imply for carmakers' innovation strategy.*

1 Introduction

Over the past decades, the development of a car has become a complex activity requiring skills and resources from a wide variety of actors and industries. Due to the enlargement of the car's technological components (e.g. electronics components) and the rise of new technological trajectories (e.g. the «electrification» trend), carmakers have been increasingly needing to master a wide variety of technological fields in order to stay at the forefront of technological developments (Maxton, Wormald 2004). Moreover, market pressures and tight competition have

pushed carmakers to speed up their product development process while constantly reducing costs and improve quality (Clark, Fujimoto 1991).

In order to respond to such twofold (technological and market) challenge, carmakers have revolutionized their product development process. In the first place, they have changed the new product development organization. Starting from the beginning of the 1990s, they implemented solutions such as (1) the *heavyweight* project manager (Wheelwright, Clark 1992), emphasizing the role of the project leader in integrating knowledge and development efforts within teams, (2) multi-project management tools, for reaping the benefit of sharing components across projects (Cusumano, Nobeoka, 1992), and (3) the integrated development of product families, in order to reap economies of scope and scale by leveraging common product platforms (Meyer, Utterback 1993). As a consequence, from an organizational point of view, new managerial roles diffused such as the product manager, platform and program managers (Clark, Fujimoto 1991).

In the second place, carmakers started establishing a large number of external ties with suppliers. Such move not only allowed carmakers to quickly access specialized knowledge, thus facing technological novelty and uncertainty, but also contributed to reduce the development time and costs of new product development activities (Clark 1989; Cusumano, Takeishi 1991; Nishiguchi 1994). The central role of external sources of innovation contributed to complicate integration and coordination problems in new product development process. The most common solution to address such problems was the use of *guest engineering* and new product development teams that involved also suppliers' engineers (Nishiguchi 1994).

On the whole, technological and market pressures have made the process of developing a new car an extremely complex organizational task. Thousands of different parts, often developed and manufactured by suppliers, have to be integrated into a product that must be both highly reliable, e.g. complying with strict regulations, and performing, e.g. matching sophisticated customers' expectations. In this respect, market segmentation and customers' preference volatility have made investments in new product development very risky: time to market reduction, quality improvements and cost cutting have become key variables for reducing the sunk costs related to launching a product that once on the market may not be well accepted by customers.

In light of the rising product development complexity, the aim of this chapter is to provide an overview of the current challenges that carmakers face, taking both the carmakers as well as the broader industry level (i.e. suppliers' networks) as units of analysis. The aim is to describe the

organizational solutions adopted by carmakers to carry out both upfront research as well as new product development activity and to understand their link. The chapter, unlike the usual take on innovation processes in the automotive industry, not only casts light on the organizational and strategic challenges of downstream development activities (i.e. the development process of new car models), but also tries to overview the strategic role of up-front research activities (i.e. the research activities leading to patenting). These ones, with few exceptions (Antonelli, Calderini 2008) have not been investigated in the literature. This leaves a gap in our understanding of the contribution of up-front research activity in explaining carmakers' innovative performance.

The chapter is organized as follows. First, we highlight the major challenges carmakers face in adopting a distributed innovation model. Specifically, as far as new product development activities are concerned, we focus on integration and coordination problems with external sources of innovation and the related organizational solutions OEMs adopt in order to benefit from division of labour while minimizing the risks of decay in technological competences and architectural knowledge. Then we shift our focus to the role of upfront research leading to patenting and review the role of patenting in the industry as a means to appropriate returns from innovation in fragmented vertical networks. Finally, the study reviews the potential impact on the organization of innovative activities that the «electrification» of the car may cause. The chapter concludes by drawing the managerial implications emerged from the analysis and highlighting avenues for future research.

2 Organizational challenges

2.1 Division of labour within the industry value chain

As mentioned in the introduction, the car is a multi-technology product, namely an artefact made up of components that embody a number of technologies. Components are distinct portions of the product that perform specific functions and are linked to each other through a set of interfaces defined by the product architecture (Brusoni, Prencipe, Pavitt 2001). In the past decades, the range of disciplines relevant to the design, development and manufacturing of a car has largely expanded in both breadth – the number of relevant fields – and depth – their specialization and sophistication (Wang, von Tunzelmann 2000). Given the increasing expansion of the set of knowledge and resources, carmakers rely on specialized suppliers in order to complement their research and develop-

ment efforts and to cope with the increasing product and technological complexity. The outsourced activities comprise different phases of the innovative process, from design to engineering and production tasks.

Managerial literature outlines that relying on a network of external suppliers provides OEMs with several benefits that, ultimately, positively impact the firms' innovative performance (Clark 1989). Indeed, suppliers' involvement in the innovation process provides access to specialized and tacit knowledge that for OEMs would be difficult to replicate in-house. Further, supplier's expertise and comparative advantage in the performance of specific tasks decreases the costs and time of design and engineering phases of the development process. Finally, by relying on a network of several suppliers, firms have access to heterogeneous and diversified technological competences.

Despite the outlined benefits, the division of labour along the industry value chain poses important challenges to carmakers. Firstly, firms have to govern multiple and concurrent ties in order to access external knowledge and skills; OEMs have to manage complex portfolios of relations with external suppliers, selecting appropriate governance mechanisms to boost inter-firm collaboration while minimizing partner's opportunistic behaviour. Secondly, they face a key organizational decision: which components/capabilities should be outsourced and which should be retained internally? In the next sections, we will analyse both issues and describe the organizational solutions helping firms to benefit from a distributed innovation model while coping with its complexity.

2.2 Coordination and governance mechanisms

Managing a network of external suppliers requires carmakers to identify the efficient governance mechanism in order to access external knowledge and skills while avoiding issues of opportunism, knowledge leakage and appropriability. The choice of the governance mechanism is key in determining partners' incentive to cooperate. Under specific circumstances, different governance forms might lead to heterogeneous performance outcomes in terms of partners' coordination, knowledge sharing and innovation output. As outlined by the broad literature on alliances (Colombo 2003; Oxley 1989), contingent on the motives and content of the exchange, some organizational forms are more suitable than others in easing and coordinating partners' interaction.

Transaction costs literature pinpoints that the choice of the governance structure is dependent on the contractual and appropriability hazards firms face in the technology exchange (Oxley 1997). The higher the complexity and specificity of the exchanged product, the more likely that

the relationship is governed by a hierarchical mechanism in order for partners to align incentives to cooperate and cope with product complexity (Kogut 1988). Hierarchical forms, such as joint ventures, provide firms with the opportunity to restrain opportunistic behaviour and hold-up issues. Similarly, when appropriability concerns threat the exchange, transaction costs literature predicts that firms will recur to hierarchical governance structures in order to monitor knowledge flows and avoid unintended knowledge spillovers and innovation circumvention issues.

Another stream of research – the competence perspective literature – argues that the choice of the governance mechanism is dependent on the degree of overlap between the technological competences of the partners involved in the transaction (Colombo 2003; Mowery Oxley, Silverman 1996). A high dissimilarity in partners' technological bases hinders the exchange and learning opportunities, leading partners to choose a hierarchical governance form based on tight coordination mechanism in order to optimize the technology absorption process and hence the knowledge transfer.

Traditionally, in the automotive industry, OEMs manage networks of external suppliers through a diversified portfolio of contractual arrangements, ranging from traditional arm's length market transactions to more hierarchical governance mechanisms such as formal alliances and joint ventures. Bensaou (1999), in reviewing the type of carmaker-supplier relationships, proposes four modes of exchange: market exchanges, captive buyer tie, strategic partnership and captive supplier tie. The former – market exchange – is used for highly standardized products based on mature technologies that require little engineering efforts and expertise from the supplier. Given the standardization and maturity of the underlying technology, these ties require neither idiosyncratic investments on both parties to the transaction nor coordination and knowledge sharing mechanisms.

Unlike market-based exchanges, captive buyer relationships are characterized by an asymmetric commitment of the partners: the carmaker is held hostage by the supplier. Suppliers typically control a proprietary technology and benefit from a strong bargaining power over the OEM (Bensaou 1999). These are contingencies where the exchange involves complex components that require customization, but do involve stable technologies (e.g. bearings, glass products). The carmaker heavily depends on the supplier specialized skills and assets.

Strategic partnerships are usually associated to the exchange of highly customized and complex components/subsystems, for instance the breaking system or the air-conditioning system. Due to the technology and capabilities requirements, both the OEM and the supplier put highly

specific assets into the relationship. On its side, the carmaker has to undertake tangible and intangible investments relative to the supplier's component, given the high interdependence between these components and the rest of the vehicle. Suppliers, on their side, develop design and production skills tailored to the buyer's requirements. Hence, due to the undertaking of co-specialized investments on both sides of the transaction and the need of extensive coordination mechanisms to cope with technological complexity, partners recur to strategic partnerships to manage the tie.

Finally, captive supplier ties refer to those asymmetric relations where the supplier is held «hostage» by the carmaker and commits large specific investments to hold the customer and stay in the market. The exchange involves complex subsystems based on a new technology typically developed and owned by the supplier but whose commercialization depends on the carmaker.

In light of these different outsourcing modes, the choice of governance structure to manage the supplier relationship greatly influences the capability of the carmaker to involve external knowledge sources in its innovation activities. A mismatch between the type of relationship and the content of the exchange might produce negative effects from outsourcing, hindering the ability of carmakers to benefit from an open innovation model. Such «matching» is indeed very complex as carmakers often cooperate with the same supplier on a set of multiple and concurrent projects, each featuring different level of involvement of the supplier in the new product development process of the carmaker (Zirpoli, Caputo 2002). In this respect, the matching of the governance structure and the type of relationship must be managed at the level of the single project rather than at the firms' one.

2.3 Outsourcing decisions and the scope of the knowledge base

The second key challenge posed by an open innovation model is related to carmakers' decision on which disciplines and components should be developed and produced in-house and which ones are to be contracted out to suppliers. In performing innovative activities, OEMs face two divergent objectives. On the one hand, they aim at exploiting flexibility and economies of specialization by outsourcing design and engineering of components/subsystems to suppliers. On the other hand, they need to base their competitive advantage on the capability to introduce breakthroughs and new product architectures. Indeed, firms need to reconcile economies of specialization while remaining integrated in the knowledge domain (Brusoni et al. 2001).

In the past, management scholars proposed modularity as the guiding principle in outsourcing decisions (Sanchez, Mahoney 1996). Through the specification of standardized components interfaces, carmakers could outsource the design and development of entire subsystems and reduce the coordination mechanisms with the suppliers for the development activity. Further, through modularity, firms could increase the specialization of their knowledge base and focus on the product-architectural knowledge, since the component-specific knowledge was left to the specialized supplier.

Recent studies, however, pinpoint the limits of modularity and the threats it poses to carmakers in effectively relying on external sources of knowledge (Macduffie 2012). Many carmakers incurred negative effects when implementing design and engineering outsourcing. In this respect, Fiat is a leading example. During the 1990s, the heavy reliance on external suppliers in the engineering and design phases of new product development activities led the firm to a gradual decay in technological and component specific skills, which ultimately hurt its capability of managing component interdependencies and above all product performance. Zirpoli and Becker (2011) pinpoint two main reasons for the negative effect of outsourcing activities based on the modularity principle. The first one is related to the intrinsic features of the car, whose product architecture is characterised by persistent integrality. This restrains the degree of «modularization» of the product. The overall performance of a car, in fact, is not dependent only on the performance of the specific components but also on how these different components/subsystems interact with one another. Hence, it is risky to outsource activities on the basis of the product architecture, since vehicle-level performance cannot be attributed to particular components.

The second reason is related to competence accumulation issues. Due to the distributed learning process characterizing the automotive industry, the carmaker acts as system integrator: it coordinates the work of suppliers and manages the relevant technological and organizational interfaces (Brusoni et al. 2001). However, by heavily outsourcing the design and engineering of specific components and subsystems, OEMs loose knowledge and familiarity with component-specific technologies. This loss hinders their understanding of potential product interdependencies, ultimately weakening their capability to act as system integrator. Hence, the key challenge carmakers face in their innovative activity is the following: how to benefit from outsourcing while concurrently feeding internal knowledge domains both in component and architectural knowledge?

The achievement of a balance between economies of specialization and competence accumulation is non-trivial. However, according to recent studies in innovation management (Brusoni, Prencipe 2006; Zirpoli 2010), this challenge can be accomplished through the adoption of specific solutions in the organization of innovation activities. OEMs need to maintain in-house technological and engineering capabilities in order to effectively coordinate the work of suppliers, and this calls for organizational solutions that favour the accumulation of competences. In this respect, the division of innovative labour between the OEM and its suppliers should be based on this principle rather than on pure product architecture and cost-efficiency principles, traditionally proposed by the modularity literature (Sanchez, Mahoney 1996). The division of labour should be such that guarantees the system integrator opportunities of learning-by-doing in component-specific knowledge as well as capabilities to introduce new product architectures. Organizational solutions that favour in-house learning opportunities on key components and subsystems allow the OEM to experiment on component interdependencies and the vehicle overall performance while concurrently benefiting from the involvement of suppliers in the innovation process.

3 Strategic challenges

3.1 Beyond economies of scale: the strategic implications of raising complexity

Exploiting scale efficiencies, a traditional driver of competitive advantage in the automotive industry, plays a less relevant role in a world that has turned towards a distributed innovation model. In the new business ecosystem, there are many evidences showing that the key challenge for carmakers will be to handle complexity in new forms.

First, as manufacturing, design and engineering of cars are not performed any more in vertical integrated companies but in highly fragmented vertical networks, flexibility of cost structure at carmakers' has increased, but so has organizational and strategic complexity. As a consequence, while the need for standardization within each single model design engineering and production is much less pressing nowadays, OEMs must face new threats. In fact, outsourcing has produced the consequence of (1) increasing competitive tensions within the value chain (with suppliers' bargaining power growing) and (2) complicating integration and coordination among a higher number of actors (car makers, first- and second-tier suppliers, research centres, etc.). In such

a scenario, strategic success is a consequence of the ability of firms to device organizational solutions consistent with their strategy and less dependent on traditional strategic levers, such as economies of scale. At the moment, only few producers – notably Toyota – have been able to take full advantage of a more distributed mode of production in the industry with some, like Fiat, forced to back source design and engineering activities after having experienced the complexity of managing a distributed product development process (Becker, Zirpoli 2003; Zirpoli 2010) or GM and Chrysler forced to bankruptcy.

Secondly, the minimum optimal dimension of plants due to the adoption of flexible manufacturing systems and lower product development costs due to the introduction of virtual simulation tools in product development has, once again, reduced the strategic role of pure «scale» considerations but augmented the level of complexity to be managed. As far as manufacturing is concerned, new production technologies have eased the joint production in the same plant and with the same tools and equipments of different models lowering break-even points. For example, thanks to the flexibility of production technology, Fiat and Ford produce in the same plant the Fiat Panda, the Fiat 500 and the Ford Ka. On the other hand, the complexity in managing operations has grown accordingly. As far as product development is concerned, the growing use and accuracy of virtual development and simulation tools has been a major source of novelty in the overall product development strategy of firms. Traditionally, literature has associated with the use of virtual development tools (1) the reduction of experimentation costs due to the speeding up of the testing phase, (2) the reduction of the number of costly physical prototypes and redesign linked to their fast obsolescence, and (3) the improvement of design quality via the availability of information very early on in the development process (front loading problem solving, Thomke 1998). More recently, however, literature has observed how virtual tools help engineers to *observe* phenomena that are much less readily observable otherwise enabling almost infinite iterations of the same experiment and, importantly, isolating one parameter in each run. As compared with physical experimentation, they therefore approach a «laboratory-type controlled environment». In this way, virtual experimentation allows testing hypotheses that are not constrained by the logical bounds of the premises one starts from. It thereby enables a non-conservative design, which is important in order to achieve distinctive new designs (Becker, Salvatore, Zirpoli 2005). These features provide carmakers with the opportunity for enlarging and differentiating their product portfolios without scarifying efficiency. However, also in this respect, it is important to note that the sustainability of an aggres-

sive marketing strategy based on the proliferation of niche models and model variants is premised on the sharing of components and platforms across these models. Only this measure would contain the industrial costs to a sustainable level. To do so, the challenge is leveraging economies of scope on both competences and components. This is, once again, a hard and complex task from an organizational point of view. In order to develop models that share components and systems of components without sacrificing their differentiation for customers, company must introduce several constraints to design, engineering and manufacturing activities and manage a tight organizational integration between internal functions, product development platforms and external suppliers. So far, few carmakers have fully succeeded on this pattern (e.g. Toyota and Volkswagen), especially due to its ensuing organizational complexity.

Overall, considering the new modes of designing, producing and marketing cars, there is consensus that the key challenge has switched from managing product development activities (and manufacturing efficiency) by leveraging economies of scale, to governing complex value chain relationships and integrating new product development efforts.

3.2 Leveraging patents across firm's boundaries

In the previous paragraphs, we examined the organizational solutions OEMs implement in order to access and integrate external knowledge into internal innovative activities and the strategic challenges brought by the raising organizational complexity of product development. However, along with the organizational challenge of how to reconcile division of labour and competence accumulation, it is to emphasize that firms also face a key strategic issue: how to profit from innovation? Due to the distributed innovation process and the high competitive pressure in the current industry scenario, it is key to identify and analyse the mechanisms carmakers have at their disposal in order to appropriate the returns from innovation.

Past innovation literature pinpoints several modes through which firms may appropriate value from research investments: secrecy, lead time, patents, and complementary assets (Cohen, Nelson, Walsh 2000; Teece 1986). The effectiveness of these modes is clearly dependent on the appropriability regime of the industry – namely a set of environmental factors that influence an innovator's ability to capture the profits generated by its invention (Teece 1986, p. 287). Relative to this issue, past studies highlight that the tighter the appropriability regime, the higher the strength of patents, allowing firms to effectively appropriate returns from their inventions and to earn monopoly profits.

In the automotive industry, major carmakers traditionally implement aggressive patent strategies through up-front research, applying for patents worldwide and investing large amounts of resources in maintaining and renovating their patent portfolios. This is particularly true for the large incumbents of the industry. For instance, Toyota applies 1,000 patents per year on average. Other large competitors implement similar patent strategies – Volkswagen is an example.

At first, such a recurrence to patenting might indicate that firms use them for profiting from innovation: patents protect the profits directly accruing from the commercialization of the patented innovation. Despite the intense patenting activity of carmakers, a survey investigating the mechanisms firms use to profit from innovation shows that, in the industry, patents are rarely employed as appropriation mechanisms (Cohen et al. 2000). Firms strongly prefer secrecy, lead time, and the control over strategic complementary assets such as manufacturing and commercialization infrastructures. Many patents, in fact, can be invented around at modest costs and they are ineffective at protecting process innovations, which represent a large share of OEMs' innovation outputs. Hence, the questions to be posed are the following ones: what is the role of patents in the industry? Why do carmakers adopt aggressive patent strategies, despite reporting that patents are ineffective in appropriating returns from innovation? We believe that the strategic reason has to be found in the organization of the innovation activity itself.

Given the distributed innovation process and the fact that the car is a complex multi-technology product, it often incorporates several innovations not directly controlled by the carmaker, but rather by external suppliers and competitors. In this context of distributed and highly partitioned knowledge, building up large patent portfolios might serve OEMs the achievement of three main objectives. First, they serve as isolating mechanisms in order to protect the firm's competitive advantage. Patents provide firms with an exclusionary right: they can exclude others from the development, use and sale of the patented invention. Given the costs of applying and maintaining patents, a proprietary patent strategy is likely to be pursued for technologies with high «strategic stakes» for the carmakers. In order to build effective barriers to imitation, firms frequently build overlapping and complementary patents to minimize the chances that the technologies are invented around (Somaya 2012). In this respect, an example is provided by the patent strategies implemented by Fiat during the past decade. In order to protect key core technologies, such as the multi-jet and subsequent multi-air technology, Fiat applied for families of patents worldwide and hired legal experts to ensure that the patents were legally robust in order to effectively protect

core technologies for the firm's competitive positioning. These patents were then carefully maintained over the patent life-period.

Another frequent mechanism through which firms pursue a proprietary patent strategy is co-patenting with suppliers – the patented innovation is assigned both to the carmaker and the supplier. Since it is frequent the case that competing OEMs share suppliers for specific components/technologies, it is key to overcome issues of unintended knowledge leakage and threats of invention re-engineering by competitors. By sharing the proprietary rights with the supplier and integrating the joint patenting contract with specific clauses (Hagedoorn 2003), the carmaker can overcome these risks. It can effectively control the use the supplier makes of the technology, for instance monitoring and limiting the diffusion of the technology to competitors through licensing.[1]

The second function of patents from a carmaker's standpoint is that of a defensive strategy tool. Through patenting, OEMs aim to acquire freedom to operate and to avoid expensive litigation costs and delays in product development and launch, by directly controlling several proprietary technologies included in the final product. Firms build large patent portfolios in order to avoid the risk of being held up for instance by competitors and to prevent potential patent disputes with competitors. Patent infringement – the use or sale of a patented invention without the applicant's permission – in fact is a recurrent event in the industry.

Finally, large patent portfolios might serve to reinforce the bargaining power of the carmaker in the distributed innovation process. By guaranteeing patent coverage, for instance on a core technology that other firms are using or developing and on which there are sufficient costs and risks in working around the firm's patents, the patent gives the firm the bargaining power vis-à-vis users of the technology through the threat of patent litigation (Somaya 2012).

In light of the current organization of innovation activities within the industry, it emerges the importance for carmakers to strategically manage their patent portfolios both for defensive as well as leveraging purposes. The IP management issue becomes central in order for firms to protect their competitive position (Reitzig 2004). As management scholars have outlined, in this context, supporting organizational conditions such as patent knowledge in the top-level management and optimal

1. Literature on co-assigned patents reports that, in the past, firms considered co-patenting as a second-best solution, since under specific regimes (like in the US), the co-assigned patent can be used or licensed by both assignees without approval from the other. However, firms over the years have gained experiences with forging additional contracts in order to better monitor the use of the invention by the co-assignee (Hagedoorn 2003).

cross-functional coordination between legal and technical experts (Reitzig, Puranam 2009) become key organizational capabilities to enhance performance and appropriate returns from innovation.

4 The challenges to innovation processes brought by the «electrification» of the industry

Recently the potential technological discontinuities brought by the new hybrid and electric power-train technologies have been indicated as a potential trigger of a relevant change in carmaker strategic approach, industry dynamics and new product development. At the moment, as a high number of supply and demand factors can potentially influence the evolution of the technological trajectory of hybrid and electric vehicles, it is extremely difficult to evaluate the relative importance of each factor in isolation as well as its interaction effects (see also Errichiello, Zirpoli 2013).

Similarly, it is not easy to predict the potential changes that the «electrification» of the industry might bring to the organization of innovation activities in the automotive industry. So far, the picture that emerges on the power train technology of the future, its evolution, firms' strategies and appropriability regimes is characterized by high «structural uncertainty» (Knight 1921). The technology is still in the phase of «variation» and technological ferment – with electric power train competing with many hybrid technologies and they altogether competing with other «green» and perhaps more efficient solutions (EUCAR 2009). In this situation, the mechanisms leading to a «selection» of a dominant design and the consequent «retention» of a specific value network and community organization configuration (Rosenkopf, Tushman 1998) are far from being clearly defined. Under the current scenario where a dominant design has not yet emerged, we would expect firms' innovation activities to be mainly devoted to upfront research activities in order to explore and seize (through patents) the benefits of a new standard. In this phase, firms are likely to experience a period of exploration in order to experiment with the different technological solutions and gain capabilities on a wider set of technological domains in order to effectively react to an eventual technological shift towards the «industry electrification». However, so far we do not have systematic empirical evidence showing that carmakers and suppliers are carrying out such a type of research activity and, hence, no accounts of its effects. Moreover, in case of emergence of the electric car as a dominant technological paradigm, we expect to observe a re-organization of the automotive value chain

and a re-assessment of the value distribution along the supply chain. The electrification of the industry might indeed favour the entry of new players in the industry (e.g. electricity providers, battery suppliers, etc.) with important consequences for what concerns the value creation and value appropriation strategies of leading carmakers in the organization of innovative activities. On the contrary, if the electric car will remain confined to a niche-market, no relevant changes in the organization of new product development are expected and industry incumbents will be in a position to rapidly switch to alternative and less disruptive solutions without loosing the knowledge-base they have accumulated over the years.

5 Final remarks

In the past decades, technology and market factors led to a radical re-organization of innovative activities within the automotive industry, with a shift from a closed-innovation model to a distributed one. The aim of this chapter was to identify and discuss the main organizational and strategic challenges in innovation activities that industry incumbents are currently facing in light of this radical change.

From an organizational point of view, the analysis pinpoints the centrality for carmakers to effectively manage networks of external suppliers both for what concerns the mechanisms through which govern external ties as well as the type of activities to allocate to external partners. On the one side, the choice of the governance mechanisms – from arm's length market transaction to strategic partnerships – appears to be key in order for carmakers to access external specialized knowledge while avoiding issues of partner's opportunism, knowledge leakage, and appropriability. The analysis casts a light on the importance of selecting the governance relationship by taking as primary unit of analysis the project-level rather than the partner's one. Carmakers, in fact, often cooperate with the same supplier in a set of different and concurrent projects. It is therefore key to choose the partnering mode that at a project level guarantees the effective and efficient involvement of the supplier in the internal development activity.

Another major challenge brought by a distributed innovation model is the scope of the knowledge base carmakers should master. In order to effectively act as system integrators, carmakers need to properly balance economies of specialization with competence accumulation. In this business context, division of innovative labour should hinge on where system integrators experience learning opportunities both in compo-

nent-specific knowledge as well as architectural knowledge. The chapter highlights that outsourcing decisions should be based on a competence accumulation principle rather than on pure product architecture and cost-efficiency principles as past modularity literature has proposed.

From a strategic point of view, the chapter reviews the role of economies of scale within a business environment characterised by a distributed and highly partitioned knowledge. The study sheds light on the fact that, due to a set of different factors – increasing flexibility of carmakers' cost structure, decrease in the minimum optimal dimension of plants, etc. – the key strategic challenge has shifted from managing product development activities by leveraging economies of scale to governing complexity in value chain relationships and integrating new product development efforts.

Secondly, the chapter clarifies the role of up-front research leading to patenting and the use of patents in the industry, highlighting the strategic function large patent portfolios may play in favouring carmakers to appropriate value in fragmented vertical networks. By providing firms with exclusionary rights, patents represent defensive and isolating mechanisms to protect core innovations of the technology portfolio as well as to protect firms from the risks of being held-up by competitors and incurring into long and expensive patent disputes.

The analysis put forward highlights clear avenues for future research. First, in light of the likely technological shift the industry may face in the next years, future studies should focus on the technological competences carmakers are currently accumulating through their patenting upfront research activity. The analysis would clarify the type and scope of technologies carmakers are currently experimenting and may provide empirical insights on the technological standard that is likely to emerge and the likely incumbents that, under this standard, may dominate the market. Moreover, future studies should also attempt to model the different industry scenarios and hence patterns of division of innovative labour that may emerge under the different technological standards. This would clarify the future organizational and strategic challenges carmakers will face in the coming years.

References

Antonelli C., Calderini M., 2008, «The Governance of Knowledge Compositeness and Technological Performance: The Case of the Automotive Industry in Europe», *Economics of Innovation and New Technology*, 17, 1-2, pp. 23-41.
Becker M., Salvatore P., Zirpoli F., 2005, «The Impact of Virtual Simulation Tools

on Problem-Solving and New Product Development Organization», *Research Policy*, 34, 9, pp. 1305-1321.
Bensaou M., 1999, «Portfolios of Buyer-Supplier Relationships», *Sloan Management Review*, 40, 4, pp. 35-44.
Brusoni S., Prencipe A., 2006, «Making Design Rules: A Multidomain Perspective», *Organization Science*, 17, 2, pp. 179-189.
Brusoni S., Prencipe A., Pavitt K., 2001, «Knowledge Specialization, Organizational Coupling, and the Boundaries of the Firm: Why Do Firms Know More Than They Make?», *Administrative Science Quarterly*, 46, 4, p. 597.
Chesbrough H., 2003, *Open Innovation: The New Imperative for Creating and Profiting from Technology*, Boston, Harvard Business School Press.
Clark K., 1989, «Project Scope and Project Performance: The Effect on Parts Strategy and Supplier Involvement in Product Development», *Management Science*, 35, pp. 1247-1263.
Clark K., Fujimoto T., 1991, *Product Development Perfomance: Strategy, Organization and Management in the World Auto Industry*, Boston, Harvard Business School Press.
Cohen W.M., Nelson R., Walsh J., 2000, «Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not)», *Working Paper 7552*, pp. 1-50. Cambridge, National Bureau of Economic Research.
Colombo M.G. 2003, «Alliance Form: A Test of the Contractual and Competence Perspectives», *Strategic Management Journal*, 24, 12, pp. 1209-1229.
Cusumano M., Nobeoka K., 1992, «Strategy, Structure and Performance in Product Development: Observations from the Auto Industry», *Research Policy*, 21, 3, pp. 265-293.
Cusumano M., Takeishi A., 1991, «Supplier Relations and Management: A Survey of Japanese, Japanese-Transplant, and U.S. Auto Plants», *Strategic Management Journal*, 12, pp. 563-588.
EUCAR, 2009, The Automotive Industry: Focus on Future R&D Challenges. Brussels.
Hagedoorn J., 2003, «Sharing Intellectual Property Rights: An Exploratory Study of Joint Patenting amongst Companies», *Industrial and Corporate Change*, 12, pp. 1035-1050.
Kogut B., 1988, Joint Ventures: Theoretical and Empirical Perspectives, *Strategic Management Journal*, 9, pp. 319-332.
Langlois R., 2003, The Vanishing Hand: The Changing Dynamics of Industrial Capitalism, *Industrial and Corporate Change*, 12, 2, pp. 351-385.
Macduffie J.P., 2012, «Modularity-as-Property, Modularization-as-Process, and 'Modularity'-as-Frame: Lessons from Product Architecture Initiatives in the Global Auto Industry, *Global Strategy Journal*, 3, 1, pp. 8-40.
Maxton G., Wormald J., 2004, *Time for a Model Change: Re-engineering the Global Automotive Industry*, Cambridge, Cambridge University Press.
Meyer M.H., Utterback J.M., 1993, «The Product Family and the Dynamics of Core Capabilities», *Sloan Management Review*, pp. 29-48.
Mowery D.C., Oxley J.E., Silverman B.S., 1996, Strategic Alliances and Interfirm Knowledge Transfer, *Strategic Management Journal*, 17, pp. 77-91.

Nishiguchi T., 1994, *Strategic Industrial Sourcing*, New York, Oxford University Press.
Oxley J.E., 1989. «Appropriability Hazards and Governance in Strategic Alliances: A Transaction Cost Approach», *Journal of Law Economics & Organization*, 13, 2, pp. 387-409.
Reitzig M., 2004, «Strategic Management of Intellectual Property», *Sloan Management Review*, pp. 35-40.
Reitzig M., Puranam P., 2009, «Value Appropriation as an Organizational Capability: The Case of ip Protection Through Patents», *Strategic Management Journal*, 30, 7, pp. 765-789.
Rosenkopf L., Tushman M., 1998, «The Coevolution of Community Networks and Technology: Lessons from the Flight Simulation Industry», *Industrial and Corporate Change*, 7, 2, pp. 311-346.
Sanchez R., Mahoney J., 1996, «Modularity, Flexibility, and Knowledge Management in Product and Organization Design», *Strategic Management Journal*, 17, pp. 63-76.
Somaya D., 2012, «Patent Strategy and Management: An Integrative Review and Research Agenda», *Journal of Management*, 38, 4, pp. 1084-1114.
Teece D.J., 1986, «Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy», *Research Policy*, 15, pp. 285-305.
von Hippel E., 1988, *The Sources of Innovation*, New York, Oxford University Press.
Wang Q., von Tunzelmann G.N., 2000, «Complexity and the Functions of the Firms: Breadth and Depth», *Research Policy*, 29, pp. 805-819.
Wheelwright S., Clark K., 1992, «Creating Project Plans to Focus», *Harvard Business Review*, pp. 1-14.
Zirpoli F., 2010, *Organizzare l'innovazione - Strategie di esternalizzazione e processi di apprendimento in Fiat Auto*, Bologna, Il Mulino.
Zirpoli F., Becker M., 2011, «The Limits of Design and Engineering Outsourcing: Performance Integration and the Unfulfilled Promises of Modularity», *R&D Management*, 41, 1, pp. 21-43.
Zirpoli F., Caputo M. 2002, «The Nature of Buyer-Supplier Relationships in Codesign Activities: The Italian Auto Industry Case», *International Journal of Operations & Production Management*, 22, 12, pp. 1389-1410.