Introduction

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Introduction

In many industries there is a strong trend towards outsourcing in the context of design activities. This trend has been mirrored in the academic literature, where considerable attention has recently been focused on understanding the phenomenon and what it takes to manage it well. The automotive industry is no exception to this trend (Brusoni et al., 2002; Clark and Fujimoto, 1991; Cusumano and Takeishi, 1991; Fujimoto, 1997; Takeishi, 2001, 2002). In recent years, it has faced many challenges, arising both from technology and markets. One of the main tensions is between the need to reduce excess production capacity and the need to build new design and production competences in order to address

more diverse technologies and market demands. Moreover, auto makers and suppliers need to draw on knowledge domains exogenous to the auto industry. This has led to increased complexity in the knowledge and competences required to design, manufacture and market cars, and the management of inter-firm relationships. As the papers in this Special Issue show, these trends have impacted the division of labour in the industry, and the internal organisation of OEMs and suppliers.

This Special Issue presents a collection of articles from four continents, covering European, US, Latin American and Asian perspectives that address these issues and help us understand better how firms react to these challenges. The paper by Francois Fourcade and Christophe Midler entitled '*The role of 1st tier suppliers in automobile product modularisation: the search for a coherent strategy*' reports on a case study of a first tier supplier headquartered in France. The paper shows how suppliers can choose different supply strategies and how this affects their knowledge and competence dimensions. In so doing, the paper provides a detailed description of the strategic implications of a modular strategy in terms of the positioning of the supplier, clarifying the nexus between the process of modularisation and the competences needed for the supplier in order to succeed. The paper by Sebastian Fixson, Young Ro and Jeffrey Liker entitled '*Modularisation and outsourcing: Who drives whom? A study of generational sequences in the US automotive cockpit industry*' presents the result of a study based on data collected on 18 development projects from six different companies (five of the companies in the data set are suppliers, one is an OEM). The analysis of the link between outsourcing and modularity is based on the longitudinal observation of the processes of modularisation and outsourcing in cockpit design and production. The authors carefully distinguish between the product design, the manufacturing, and the programme management process.The results show that there is not a simple unidirectional effect that modularity has on the organisational structures of the supply chain, or vice versa. Rather, they find that in most cases there is a two-way relationship between both aspects, and that the relative strength of the forces in the two directions can change over time, resulting in a zig-zag path towards higher levels of modularity and more work content being outsourced. Luiz Bautzer's paper with the title '*Bringing together knowledge about the product lifecycle to improve inter-firm collaboration capabilities*' reports on a case study of a first tier supplier whose headquarters is located in France. The paper analyses the managerial toolkit that firms have used in their NPD process over the last ten years. In so doing, it offers a micro-analytic approach to the issue of inter-firm collaborations. Bautzer observes how the development of tools (from CAD tools to company PDMs) have impacted the knowledge integration capabilities of firms. The paper sheds light on the very nature of the problems associated with the co-development of new products and offers an original view of NPD management tools and their potential for knowledge integration. The paper by Arturo Lara Rivero, Gerardo Trujano and Alejandro García entitled *'Modular production and technological up-grading in the automotive industry: a case study*' takes the point of view of the Mexican branch of a US supplier and shows which forces are at work in driving products onto a modular path. The contribution of the paper lies in evidencing the link between exogenous (regional characteristics) and endogenous drivers of modularisation, showing the role played by modularity in plant location choice and management. The paper adds to the link that exists between modular design and the production model it enhances. Kyung-Hee Jung's paper entitled '*Task shift of automakers to steel suppliers in the value chain of automotive sheets*' offers a deep insight into the issue of task partitioning between OEMs

and supplier in NPD in the global steel industry. It shows how in the steel industry, too, forces are at work to increase the level of product development tasks, outsourcing and even modularisation. This is the case even though the steel industry is characterised by a high level of asset specificity. The paper takes into consideration regional differences in a longitudinal perspective, detailing the state of the art of buyer–supplier relationships in the steel industry and sketching their future directions. The paper by Dylan Sutherland entitled '*OEM-supplier relations in the global auto and components industry: is there a business revolution?*' complements the mostly micro-analytical perspective of the other papers with an analysis of trends in the auto industry based on industry statistics. The author shows that there is a tendency towards the use of modularity in the task partitioning process between OEM and suppliers. This is confirmed by the development of product platform strategies (for the OEM) and the strong concentration in the industry (both at the OEM and the supplier level).

The articles, therefore, cast light on the issues surrounding task- and knowledge partitioning in new product development from different methodological angles, analysing statistical macro-data, industry surveys and case studies (with careful consideration also of the supplier point of view). In the light of the breadth of industries, geographies and methodologies covered, the consistency with which they point to some common emerging trends is particularly noteworthy. All papers engage in the in-depth exploration of a particular research question connected to the issue of task- and knowledge-partitioning in the auto industry. In so doing, they allow the reader to grasp the complexity facing the firms engaged in making outsourcing decisions. One immediate conclusion that emerges strongly from the contributions in the Special Issue is, therefore, a note of caution regarding stylised theoretical treatments of questions of outsourcing: some 'middle-range' link between extant theoretical frameworks and empirical reality might still be lacking.

The main contributions of the papers can be grouped in four main streams:

- shifts in task partitioning between OEMs and suppliers currently occurring in the automotive industry
- paths to new arrangements of the division of labour and knowledge between OEMs and suppliers
- the causality of the relationships between product architectures and firm boundaries
- knowledge integration in product development processes.

2 Shifts in task partitioning between OEMs and suppliers

The papers in this special issue present the reader with a snapshot of the shifts in task partitioning between OEMs and suppliers that are currently taking place in the global auto industry. Broadly speaking, the picture is impressively consistent across the different geographical (US, France, Mexico, South Korea) and supplier industry contexts (e.g. steel, lighting systems, interiors, front modules). At the same time, each study adds detail to our knowledge about how precisely tasks are shifted from OEMs to suppliers (and vice versa). The paper by Jung is dedicated to documenting and analysing the task shift between automakers and steel suppliers on a global basis. It lays out for the reader how OEMs transferred processes such as painting to steel suppliers, and steel suppliers

extended their roles in the automotive supply chain, partly due to the introduction of a process innovation in producing steel sheets (tailor-welded blanking). The paper is all the more remarkable because steel is generally considered a stable technology and a commodity good. Fixson et al.'s article confirms and details the anecdotal evidence of how many tasks are handed up the supply chain, putting first-tier suppliers in control of some value chain activities. Fourcade and Midler take a micro-analytical view on the matter, analysing shifts in task partitioning between a French OEM and its supplier of front modules, due to product modularisation. While some firms have become suppliers of modules by adopting a strategy to that end (maybe without being fully aware of the competences required), others have realised they had competences and/or opportunities for becoming module suppliers, without having explicitly pursued such a strategy. Their case also emphasises that in reality, the OEM's and supplier's roles are not always as simple and clear-cut as the systems-integrator-vs.-first-tier-supplier discussion suggests. More fine-grained taxonomies of supplier relationships are needed. In other cases, again, it seems that technological innovations (Jung's case provides a good example) or economic and technological arguments (differences in labour cost, see Lara, et al.) have pushed industry participants to a certain shift in task partitioning. Bautzer's analysis focuses on how suppliers manage the task shifts. He identifies tools that suppliers can use to that end, and presents a longitudinal analysis of how the problems, and the solutions, have shifted over time. Problems of knowledge transfer and knowledge integration are in the foreground. In particular, Bautzer's analysis highlights the need for tools that enable a good description of the product lifecycle, including 'product information maturity'. Sutherland complements the micro-analytical angle of the case studies with a macro-analysis of global trends in the automotive industry, as documented in trade and industry statistics. He identifies a trend towards concentration not only for OEMs, but also in the supplier industry. The implications of industry concentration are well-known. Sutherland then argues that these trends also represent a shift of underlying business logic. Obviously, understanding the logic that determines the industry is indispensable for navigating successfully in the industry.

3 Paths and dynamics of changing supply relationships

The structure of the automotive industry is changing. Tasks are shifting from OEMs to suppliers, and with it, the division of knowledge (who knows best how to do what). OEMs and suppliers (1st, 2nd, and 3rd tier suppliers) are, therefore, facing new issues and demands. Bautzer describes in detail some of the difficulties arising in the implementation of task shifts from OEMs to suppliers. Firms in the automotive industry need a guiding framework in order to take decisions, for instance on entering challenging supply commitments such as supplying larger modules instead of individual components or to make irreversible commitments in the form of dedicated investments (both illustrated in the Fourcade and Midler case). A complete theoretical framework on these questions is not yet available. The papers in this Special Issue contribute some building blocks, though, which we set out below.

Most of the papers contained in this Special Issue take a longitudinal perspective and allow identification of some of the dynamics behind changing supply relationships. Bautzer describes the evolution of management tools and their impact on the paths to task

and knowledge partitioning in the industry, Fourcade and Midler the evolution of suppliers' product definitions and strategies, Fixson et al., the evolution of various forms of modularity, Jung the evolution of process technology and its impact on shifting task partitioning, and Lara et al., the evolution of the geographical distribution and the organisation of plants. Fixson et al. present evidence that such paths, e.g. in the example of modularisation and outsourcing, are much less neat and more zig-zag than some theories suggest. Fourcade and Midler show that different paths are viable in different circumstances and for firms with different characteristics; providing preliminary evidence for the hypothesis that that there might not be 'one best path'. Rather, Fourcade and Midler point out, what matters is whether general strategies and module strategies are linked in a coherent manner. Their case study also illustrates how decisions of strategic dimension present themselves to suppliers (and, to a lesser degree, to OEMs) in the guise of purely operational decisions. Jung's article, tracing the impact of a process innovation in the steel industry on the task partitioning in the auto industry, arrives at the same conclusion. A framework for systematically putting those in a strategic perspective of supply management is, therefore, required.

4 Causality of the relationships between product architectures and firm boundaries

One of the drivers of change of supplier relationships is the change of product architecture (notably, from an integral to a modular product architecture). It is, in fact, the driver that perhaps most attention is focused on in the academic literature. Still, our understanding of the link between product architecture and the division of labour (firm boundaries) and the division of knowledge in the automotive industry remains incomplete. One important open question concerns the direction of causality between product architecture and firm boundaries. Does (should) product architecture determine firm boundaries? Famously, Sanchez and Mahoney (1996) have argued so. If not, what else does (should)? Do (should) firm boundaries determine product architecture? Both transaction cost economics (Williamson, 1985) and the resource-based view of strategic management (Barney, 1991; Peteraf, 1998), in particular in its 'core competence' stamp argue that (Prahalad and Hamel, 1990). Obviously, the question is important for deciding what is the most appropriate managerial action, organisational structure, and product architecture. Sutherland reminds us that the analytical perspective for looking at this has to be the supply chain as a whole, not the individual firm. Fixson et al. tackle the question head on and present empirical evidence focused on the question. In general, in most cases there is a two-way relationship between both aspects, and the relative strength of the forces in the two directions can change over time, resulting in a zig-zag path towards higher levels of modularity and more work content being outsourced.

5 Knowledge integration in product development processes

What does the more fine-grained understanding of the changes currently occurring in the automotive industry mean for how to govern supplier relationships? The papers presented in this Special Issue point out that knowledge integration across the buyer-supplier interface is one of the most pressing problems.

A key problem evidenced by Bautzer is knowledge integration, i.e. integration of expert and detailed knowledge dispersed throughout the extended enterprise. While this problem is well-known (Becker, 2001), the case study makes the point that under (increasing) strengthening constraints, even 'heavyweight project managers' are not capable of bringing together different types of knowledge, for instance knowledge concerning the product definition, tasks dependencies and load and lead time estimates. Neither does the project manager manage to attain the necessary understanding of the underlying relationships between cause and effect concerning the way the mechanical components, the software and the hardware would interact when design changes were introduced. The task is simply too complex and complicated to be solved merely by an organisational measure, i.e. putting a manager in charge of it. The means for integrating knowledge are crucial. The case study evidences in particular the necessity for tools for product life cycle description, which Bautzer sees as especially powerful in providing knowledge integration across the buyer-supplier interface. From Fourcade and Midler's case emerges the necessity of a very clear indications of who is in charge of what (clearly expressed task partitioning), in other words, of someone with the authority to resolve residual ambiguity left, for instance, in framework agreements on top management levels or in contracts. Furthermore, while the project manager on his own cannot bring about knowledge integration, he can foster it, for instance by acting as a 'knowledge broker' facilitating more frequent iterations between project teams and engineering teams. An issue that comes through very clearly is the dominance of efficiency and effectiveness objectives amongst the new product performance objectives, and the absence of knowledge-based criteria, notably knowledge integration. Fixson and Fourcade and Midler also claim that a more balanced view and a strengthening of knowledge-related product performance objectives need to be taken from the beginning of development projects. This is necessary not only because of the importance of avoiding the negative impact of neglecting the knowledge dimension (e.g. hollowing out of the knowledge base, loss of 'parts evaluation capability', (Lincoln et al., 1998)). As Fourcade and Midler observe, it is also necessary because the cost of modularisation might sometimes be underestimated, due to attention being focused more on the benefits of modularisation than on the changes it involves, that are often very deep.

6 Final remarks

If one identifies the drivers that impact new product development strategies, it is noteworthy that almost all drivers mentioned in the papers in this special issue relate to efficiency and effectiveness objectives (lower labour cost, due to location in low-wage countries or less unionised work forces of lower tier suppliers, process innovation, change in product architecture (modularisation), return on assets (RoA) as a management objective, economies of scale, flexibility, constraints such as space shortage, learning curves and capabilities of suppliers to offer certain products and services). In new product development, efficiency and effectiveness objectives usually take the guise of the objectives of cost, lead time, and product integrity (Wheelwright and Clark, 1992). This is mirrored in the literature on 'make or buy' decisions which usually refers to the division of labour within the supply chain (task partitioning).

However, recent research in strategy theory has emphasised that knowledge is the most important resource from a strategic point of view (Grant, 1996; Spender, 1996). As underlined elsewhere (Becker and Zirpoli, 2003a,b), in the new product development literature 'make or buy' decisions also affect the distribution of the knowledge required to carry out design tasks (knowledge partitioning). The reason for this link lies in the concept of learning by doing. Without engaging in carrying out the design task, detailed component-specific knowledge will erode due to lack of opportunity for learning-by-doing. The decision on how to allocate tasks along the supply chain in such a way that the coordination is most efficient (including minimising transaction cost) has to be matched with the decision on which knowledge each part of the supply chain should maintain. The outsourcing rationale and the 'management toolkit' available to manage the problem of coordination induced by outsourcing, however, become more complex to handle when the knowledge dimension is taken into account. The chosen solution of the make-or-buy question, hence, is tightly intertwined with the solution to the choice of task and knowledge partitioning. Moreover, given the existence of a tension between the efficiency and knowledge criteria, it may happen that the most efficient task partitioning scheme does not work due to the lack of incentives for knowledge integration.

As the empirical articles in this Special Issue document, it does not seem that the message on the importance of knowledge- and competence-focused new product development objectives has yet fully come through to managers in the automotive industry. When deciding on how to manage supplier relationships, managers have the classical, efficiency- and effectiveness-based product development objectives in mind. Knowledge-based objectives, such as learning, building up new knowledge bases, developing new skills, etc., often do not seem to occupy the minds of the managers who manage the new product development process (the Fourcade and Midler paper is the exception that documents, that, at least in some cases, managers were taking the knowledge objective seriously). Recent empirical evidence (Becker and Zirpoli, 2003a,b; Lincoln et al., 1998), however, has shown that neglecting knowledge-related objectives in new product development can have important costs and detrimental effects in the medium term. This comes through very clearly in the descriptions of tasks shifts in some of the articles (notably Fourcade and Midler, Fixson et al. and Jung), for instance of how suppliers (including service providers) accumulate an increasing amount of value-added steps in the automotive value chain. Linking this to Sutherland's evidence of increasing concentration amongst suppliers illustrates the severity of this threat for OEMs.

The evidence, therefore, clearly speaks for considering knowledge- and competence-related objectives in new product development at the same time as the classical new product development performance objectives. The question, however, is how one can combine, or otherwise take into account, both efficiency- and knowledge-objectives at the same time. In order to answer this question systematically, a framework for a comprehensive analysis of the *impact of both kinds of objectives on both dimensions*, task partitioning and knowledge partitioning, is required. So far, such a framework is still substantially lacking. Some building blocks, hinges, and key drivers, however, can already be discerned. Setting them in relation in the form of research hypotheses will sketch out the research programme for building up such a framework. Some of the key parts of the puzzle seem to be the following:

- a mapping of the task partitioning (division of labour) – who is assigned which tasks
- a knowledge and competence profile of who is assigned to carry out tasks (knowledge partitioning)
- a mapping of the knowledge and competence to carry out the task, including its further development (knowledge requirements)
- a mapping of the governance instruments (contracts, incentive structures, ways to influence the informal aspects of relationships, etc.) available and actionable to those who are assigned the tasks
- a mapping of the relationships between each of the above; as a short-cut through the many possible combinations, one might start by identifying their relationship in extreme cases (e.g. complete allocation of tasks in-house, complete allocation of knowledge beyond the firm boundaries, etc.).

The following steps would be to identify the key variables that drive the process of integrating and coordinating knowledge in dispersed product development processes. The literature and the papers contained in the special issue give much importance to the role of product architecture (modularity). There are, however, other factors that have an impact on the knowledge related problems that firms face in NPD and the viable solutions. Among the issues we think should be integrated into the framework are the following (the list is indicative, not exhaustive):

- Industry structure and competitive dynamics. Industry concentration both at the OEM and supplier level will have several consequences in the way OEMs deal with big suppliers. OEMs, in many cases, have less access than before to suppliers' specialised knowledge (both because the suppliers tend to protect their knowledge and due to confidentiality issues linked to the fact that suppliers sell their products to different OEMs). In some cases this modifies knowledge–related choices (many OEM are 'insourcing' at least design capabilities) and changes the supplier governance mechanisms.
- The role of finance. In many cases financial reasons produce many choices that indirectly modify task and knowledge partitioning strategies, as underlined by recent attention to financial indicators (such as ROA).
- The pace of technological change. The auto industry is characterised by the coexistence of fast and slow changing technologies. This makes it difficult to apply models such as that of the Fine 'helix' (Fine, 1998). The task and knowledge partitioning scheme is influenced by this circumstance. For example, the predominance of the fuel cell or other different systems will change not only the product architecture but also the industry structure. Something similar is happening with the diffusion of information and communication technologies in modern car systems.

Specifying in detail the causal links between factors such as those we have just sketched will then add considerable insight to the issues of coordination, governance and learning in new product development.

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