

# From Product Architecture to Templates: A New Paradigm for Organizing Innovation

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## ABSTRACT

How firms that develop complex products decompose the overall development task and allocate such tasks (in-house or to suppliers) has important consequences. Amongst others, these two decisions hold the key to benefiting from drawing on suppliers without losing control of product performance or supplier governance. This article focuses on how firms decide on task allocation in order to benefit from the advantages of leveraging external sources of innovation while protecting against the drawbacks involved in doing so. We identify the drivers of the task allocation decision, and its effects on the firm's competences and the organization of the product development process. Drawing on a longitudinal case study of a major European auto manufacturer and eight of its first tier suppliers, the article identifies a profound change in how the auto manufacturer allocated design tasks along its value chain. We observe a shift from allocating design tasks based on the decomposition schemes provided by product architecture, to allocating design tasks based on the distinction of *template* and *derivative* product development projects. Because this distinction is used as a criterion for task allocation, the allocation choices are now taken independently from the product decomposition scheme used. Task decomposition and task allocation decisions can therefore be de-coupled, contrary to what much literature has argued. We identify why separating task decomposition and task allocation decisions, and using the development of templates as the criterion for task allocation, can be useful to draw on external sources of innovation while protecting against the drawbacks involved by doing so. We argue the new system represents a paradigm shift in organizing the development of complex products.

**Keywords:** task allocation, task decomposition, product architecture, automotive industry, innovation management, system integration, organization of new product development, replication

## **From Product Architecture to Templates: A New Paradigm for Organizing Innovation**

### **1. Introduction**

Developing complex products is a difficult task. Firms that develop such products must face two major challenges: complex problem solving (Simon, 1962) and, for many complex products, the need of managing a heterogeneous and broad range of technologies (Pavitt, 1998). Problem solving complexity is usually handled by decomposing products. At sufficiently fine decomposition, the number of elements and interdependences are reduced sufficiently so that agents are able to deal with the remaining complexity (Simon, 1962). Decomposition thus has become a standard approach to dealing with complexity (Baldwin & Clark, 2000). A stream of engineering literature, for example, has focused on the optimal way of decomposing complex products and of analyzing the architecture of systems in order to ease decomposition and integration of complex products (Steward, 1981; Smith & Eppinger, 1997; Browning, 2001). The decomposition of problem solving tasks implies the need of coordinating these tasks. In the case of complex products, however, residual technical interdependences that are not eliminated by the decomposition scheme employed often produce the need of managing residual organizational interdependences (Thompson, 1967) between the design and engineering activities of the different sub-components and systems. This issue has been widely considered in the innovation management literature (von Hippel, 1990). Given an optimal decomposition scheme of the product, the literature has been concerned with identifying ways of designing the organization so that design teams responsible for developing components address all the interactions between components (Sosa *et al.*, 2003). As far as the need of drawing on heterogeneous and complex technologies is concerned, the literature shows how firms that develop complex products tend to have diversified technological competences (Granstrand *et al.*, 1997, Patel and Pavitt, 1997, Gambardella and Torrioni, 1998), and often develop system integration competences in order to

rely on external sources of innovation (Brusoni *et al.*, 2001; Pavitt, 2003). Much of the literature, in fact, assumes that involving specialized suppliers in product innovation processes is particularly important in the case of multi-technology products. The reason is that due to the multi-technology and multi-component nature of products, it is difficult to maintain all the relevant knowledge bases in-house (Christensen, 2006). Most of the attention in this literature is captured by the question what type of knowledge firms that develop complex product should retain in house (Takeishi, 2001, 2002) and by identifying the consequences that drawing on external sources of innovation has on the firms' competences (Fine, 1998).

This article is concerned with how firms organize the development of complex products. Our focus is on how firms decide on task allocation. The dominant literature considers task allocation to be a function of the task decomposition scheme adopted. In the remainder of the article we refer to *task decomposition* as decisions concerning technical problem solving, i.e. how to decompose the complex bundle of design and engineering tasks required for developing a complex product into smaller sets of tasks that are more easily manageable. Following the dominant current of literature, we consider task decomposition to be influenced mainly by product architecture (Baldwin & Clark, 2000). In other words, the architecture (decomposition) of the product to be designed influences (or even determines) the decomposition of the design task. We use the term *task allocation* decision to refer to the decision who (within and outside the firm) should carry out design and engineering tasks. This decision can also be referred to as decision on the distribution of tasks among individuals and firms (von Hippel, 1990), the boundary of the firm, the scope of the firm's (design and engineering) activities, task partitioning (von Hippel, 1990; Takeishi, 2001), vertical architecture (Jacobides & Billinger, 2005) or industry architecture (Jacobides, Knudsen & Augier, 2006). Our interpretation of the term task allocation is consistent with those terms, also because we focus particularly on the allocation of tasks across the firm's boundary, rather

than how tasks are allocated to different units within the firm. We prefer the term task allocation because it is close to the term task decomposition. The importance of this link will emerge as our argument unfolds.

The innovation management literature has considered these two decisions in great detail. We want to highlight two features of this discussion here. The first concerns the origin of task decomposition schemes. The dominant current of the innovation management literature considers task decomposition to be influenced mainly by *product architecture*. Baldwin & Clark (2000) establish this point quite strongly in their influential book. They write, for instance: ‘Understanding the structure and functions of an *artifact* and how they differ is an essential *first step* in building our theory. .. We delve into the ‘microstructure’ of artifacts and designs to lay bare their essential organization. It is in these microscopic elements of structure that we find the critical *mappings that link* changes in designs to changes in organizations, markets, and industries’ (Baldwin & Clark, 2000: 21; emphasis added). In other words, the structure and decomposition of the product to be designed influences (or even determines) the decomposition of the design task. On the basis of this idea, the second feature we want to highlight does not come as a surprise: the strong focus of the innovation management literature on the *link* between task decomposition<sup>1</sup> and task allocation decisions: task decomposition decisions are perceived to guide, and thus constrain, task allocation decisions. The two are tightly coupled. Sanchez and Mahoney (1996), for example, have emphasized the implications of one particular product architecture, modular product architecture, on task allocation and organizational forms. More recent literature that draws on more sophisticated tools has shown how firms can optimize their task allocation decisions and the relative organizational solutions, given an optimal task decomposition scheme (e.g. modular or integral) (Brusoni and Prencipe, 2006, Takeishi, 2001, 2002, Brusoni *et al.*, 2001, Fine,

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<sup>1</sup> Because of the strong association between product architecture as a driver of task decomposition in some parts of the literature, when we use the term ‘task decomposition’ we also refer to what some authors have considered under the term ‘product architecture’.

1998). As recent empirical evidence from many industries indicates, however, the link between task decomposition and task allocation is not just uni-directional, from task decomposition to task allocation (Fine, 1998; Chesbrough and Kusunoki, 2001). In this respect, the empirical literature has also pointed out that knowledge partitioning (Takeishi, 2001, 2002), i.e., how *knowledge* is allocated along the value chain, also constrains the feasible *task* allocation schemes (Fine, 1998; Brusoni *et al.*, 2001). Hence, there are repercussions from task allocation regarding what are feasible task decomposition schemes. This is because the knowledge held by firms is the result of learning by doing, and thus, of learning opportunities allocated together with innovation tasks (Fine, 1998). As a consequence, the task allocation decision can generate drawbacks regarding the firm's ability to understand the components of a product, the ways in which they are integrated into systems, and how to manage systems integration, that is, the OEM's *architectural knowledge* (Henderson and Clark, 1990).

In summary, the innovation management literature has a strong focus on the link between task decomposition and task allocation. Task allocation is predominantly seen as being determined by task decomposition, in turn determined by product architecture. Recent empirical research, however, has complicated the idea of task decomposition as a map for task allocation by introducing knowledge partitioning and feedback loops into the picture.

This article tackles the question how to take the task allocation decision in order to benefit from the advantages of leveraging external sources of innovation while protecting against the drawbacks involved in doing so. Building on and expanding the management literature on developing complex products, the link between task decomposition and task allocation will be an important focus. The paper is structured as follows. The next section reviews previous research on the issue. Section three explains the methodology applied in the empirical

research, section four describes the empirical findings, section five discusses them on the backdrop of the literature and section six concludes.

## **2. Previous research**

Task decomposition and task allocation decisions, and how they are linked, have been dealt with extensively in the innovation literature. We start the review of previous research with the literature that turns around the concept of ‘design rules’ (Baldwin & Clark, 2000). Design rules define how to decompose products in components and how to link these components and integrate them into a final product (Baldwin & Clark, 2000: 77). The starting point is, therefore, the product. Design rules are made up of the architecture, interfaces, and integration protocols and testing standards (Baldwin & Clark, 2000: 77). They capture ‘architectural knowledge’, i.e., knowledge about how to decompose the products in components and how they are linked together and integrated into the final product (Henderson & Clark, 1990).

### *The dominant approach to task allocation*

One of the most prominent features of research on design rules is that it revolves around the concept of modularity (Brusoni & Prencipe, 2006: 179; Ulrich, 1995; Sanchez, 1997; Baldwin & Clark, 2000). Modularity refers to a decomposition scheme that assumes independence between modules, with interdependencies confined within module boundaries (Baldwin & Clark, 2000).<sup>2</sup> Some parts of the literature have suggested that modular product architecture can serve as a good map for task allocation (Sanchez & Mahoney, 1996; Baldwin & Clark, 2000). There are two reasons why modular task decomposition has powerful implications on task allocation. First, standardized interfaces provide *new possibilities for task allocation*. Standardized interfaces generate ‘market modularity’, i.e., a situation in which ‘suppliers can

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<sup>2</sup> A somewhat different but also influential definition of modularity has been given by Ulrich: Key to modular architectures is a one-to-one mapping from functional elements to the physical components of the product, which specifies de-coupled interfaces between components (Ulrich, 1995: 422). We stick to Baldwin & Clark’s (2000) definition here.

opt to provide some portion of the system, without fear of disrupting other parts of that system' (Chesbrough, 2003: 179). Second, modularity makes *certain task allocation schemes seem highly attractive*, for two reasons. Modular decomposition is supposed to have beneficial effects on coordination as it enables independent problem-solving for each chunk, while standardized interfaces assure that all the chunks will fit together without the need to bring about such a fit by coordination. Moreover, modular decomposition enables knowledge specialization by focusing on a number of tasks. This is made easier by modular decomposition as sets of tasks are more clearly separated from each other (and with fewer interdependencies between sets of tasks). As Sanchez states, 'the standardizing of component interfaces based on the firm's current architectural knowledge largely decouples architectural knowledge-based processes from the component-level knowledge used to develop specific component design during product development' (Sanchez, 2003: 382). Modular task decomposition thus provides new possibilities for task allocation, and makes modular task allocation schemes appear highly attractive. Because of these features of one particular decomposition scheme, *task decomposition* more generally has been considered to guide *task allocation decisions*. Because task decomposition requires architectural knowledge (Henderson & Clark, 1990), that the import is that for taking *task allocation decisions*, *architectural knowledge is required*. The literature on systems integrators (Hobday, Davis and Prencipe, 2005) has picked up this idea and extended it. Aiming at increasing specialization effects, it has argued that system integrator firms should focus on systems integration as their core capability. As Hobday, Davies & Prencipe (2005: 1128) write, what is typical of systems integrators is that 'the lead firm moves away from an in-depth control over component design and manufacture to the systems integration knowledge and skills needed to integrate the modules produced by others in the supply chain'. In other words, architectural knowledge holds the key to successful systems integration. In summary, this perspective emphasizes the

product, choosing a decomposition scheme of the design task in function of the *product architecture*, and allocating tasks according to the task decomposition scheme chosen.

*Tensions in the approach to task allocation*

The ideas in the dominant approach to task allocation are clear, and strong. Empirical research has, however, identified some limits to this approach. The first arises from limits to the decomposability of complex products; they often are nearly, rather than fully, decomposable (Simon, 1962). This difference is important because it makes it impossible to decompose the product so that no interdependencies at all will remain between the chunks in which the product is decomposed. In order to address those remaining interdependencies, component-specific knowledge is required (Takeishi, 2001, 2002). Without it, firms can have problems in taking technical decisions regarding interdependencies, resulting in performance problems of the product. A second reason is that product technologies can change (including the interdependences between parts of the product). To counter the risk of being stuck with an inadequate decomposition scheme (resulting in not addressing the remaining interdependencies), task decomposition schemes need to be adapted over time (Chesbrough & Kusunoki, 2001; Brusoni, Prencipe & Pavitt, 2001). Again, in order to be able to adapt decomposition schemes according to interdependencies, component-specific knowledge is required (Brusoni, Prencipe & Pavitt, 2001; Takeishi, 2001, 2002). Third, empirical studies in the Japanese automotive industry have concluded that component-specific knowledge is particularly important in the case of technological newness (Takeishi, 2001, 2002). The reason is that new technology is less well-understood and thus, an understanding of the interdependences with other components of the system can only be developed through strong knowledge of the component-specific technology of the other components. Fourth, Brusoni *et al.* (2001) make a similar argument for the importance of component-specific knowledge by pointing to the uneven rates of development in the technologies on which the firm's products

rely, and unpredictable product-level interdependencies. Brusoni *et al.*'s (2001: 597) argument is that having component-specific knowledge 'in excess of what [firms] need for what they make enables firms to cope with imbalances caused by uneven rates of development in the technologies on which they rely, and with unpredictable product-level interdependencies'. In other words, component-specific knowledge holds the key for avoiding some of the main problems in developing complex products. In summary, all these arguments highlight the role of component-specific knowledge in preventing two problems: problems in integrating systems (which involves building architectural knowledge) and designing systems performances, and problems with governing suppliers due to an inferior level of component-specific knowledge relative to suppliers, leading to dependence on suppliers for such knowledge (Fine, 1998). In order to avoid these two problems, firms need to nurture component-specific knowledge (Fine, 1998; Takeishi, 2001, 2002). One of the most important means for nurturing knowledge is learning by doing, particularly in the case of tacit knowledge (Polanyi, 1958; Nonaka & Takeuchi, 1995). In all the circumstances identified above, firms therefore should retain some of the design tasks that could, in terms of task decomposition, be allocated to suppliers. In other words, the arguments from the empirical research amount to recommending caution in applying a modularity approach to the full extent.

Figure 1, below, shows the approach of the dominant current of literature: taking the task allocation decision in function of the degree of modularity of the product architecture. The noteworthy feature is the tension that firms face. On the one hand, the benefits of modular product architecture push towards the left of the x-axis. On the other hand, the empirical literature has argued that 'firms should know more than they do', i.e., carry out more design tasks in-house than would be necessary in terms of the task decomposition scheme (i.e., also design components that are fully modular). This pushes upwards on the y-axis. Now, the

possibility of allocating tasks to suppliers is strictly linked to how modular the product architecture can be (cf. Veloso and Fixson, 2001). For this reason, the relationship between task decomposition (x-axis) and task allocation (y-axis) is linear, as shown in figure 1. The two pressures therefore translate into two antagonistic forces along the diagonal, towards the lower left-hand and the upper right-hand corner.

FIGURE 1 HERE

The result is that firms developing complex products face a trade-off. On the one hand, due to the multi-technology and multi-component nature of their products, they need to involve suppliers in innovation in order to reap the benefits of knowledge specialization and of leveraging external sources of innovation (Christensen, 2006). Pushing towards a modular product architecture opens up possibilities of allocating design tasks to suppliers and thus, catering to this need. On the other hand, firms are cautioned that a set of circumstances exist where they should not use the full possibilities of allocating tasks to suppliers that are offered by the product architecture (task decomposition scheme). Rather, they should keep in-house some of the design tasks that could be allocated to suppliers because they are modular. As an implication of following this advice, however, firms forego the benefits of knowledge specialization and of leveraging external sources of innovation, i.e., the very rationale for involving suppliers in innovation. This tension will play an important role in what follows.

It is important to note that having acknowledged such a tension, to attain the benefits of involving external sources of innovation seems a non-trivial challenge. In the case of products that are not decomposable in a fully modular way, the possibilities of leveraging external sources of innovation are facing some limits. In the case of products that can be made modular to some degree, in circumstances of technological newness, technological change, uneven rates of change of components, or unpredictable product-level interdependencies, firms are advised to maintain a broader knowledge base than the one required for the actual

products and thus, to keep the pertaining design tasks in-house to avoid the problems identified in the literature.<sup>3</sup> It is noteworthy that the circumstances identified above are common, and indeed, characteristic, for many if not most industries. Moreover, to implement the advice, firms would need to build up huge staff in order to cover the increasing range of technologies that some products are comprised of. Many firms simply do not have a resource base that permits such a move. Firms in the circumstances identified above are thus left with no option other than to attempt some fine-tuning, by way of trial and error, of the degree of allocation of design tasks to suppliers in order to balance the two antagonistic forces.<sup>4</sup> Because task allocation possibilities are linked to product architecture (only modular tasks can be easily allocated to suppliers), all that firms can do is to choose at which point of the diagonal they want to be, trading off the benefits of one end of the spectrum against the benefits of the other. The more they keep design tasks (and thus, component-specific knowledge) in-house, (1) the larger their absorptive capacity to pick up, understand and react on new technological developments (Cohen & Levinthal, 1990), (2) the better their chances in building architectural knowledge, and (3) the lower the risk that differences in the component-specific knowledge between the OEM and suppliers give rise to problems in supplier governance (Lincoln *et al.*, 1989; Fine, 1998; Takeishi, 2001, 2002). At the same time,

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<sup>3</sup> Of course, adapting the allocation of innovation tasks (e.g., vertically integrating) or the product architecture are the only means to respond to the trade-off. One could also manage it by relying on organizational measures. This possibility is implicitly submitted by the literature that deals with early supplier involvement' (ESI). This literature explores different forms of networked innovation and highlights the organizational solutions and relational practices OEMs should implement in order to maximize the operational benefits (cost, quality and lead times) linked to the involvement of suppliers in the OEM's NPD process (covering such means as the use of contracts, ICT tools, joint teams, and co-location of engineers) (Helper, 1991, Lamming 1993, Smitka, 1991, Nishiguchi, 1994, Helper & Sako, 1995, Helper et al. 2000, Sako, 2004). Fine and Whitney (1996), however, show that even in the case of a partnership with suppliers, the OEM should never be 'dependent for knowledge', i.e. it should hold some component specific knowledge. Helper et al. (2000) arrive at similar conclusions, emphasizing the importance of relying on 'learning by monitoring' to enhance 'pragmatic collaborations' as a way for integrating external sources of innovation. Learning by monitoring does not work, however, if the OEM lacks component specific knowledge. This once again supports the argument that the OEM should retain some component specific knowledge in-house in order to manage supplier relationships successfully. In conclusion, there seem to be no ways around the trade-off.

<sup>4</sup> If lacking more precise advice, this is likely to be implemented in a trial and error process. Working by feedback, such a process is likely to involve overshooting in one direction or the other, driven amongst others by whether knowledge specialization or supplier governance problems are considered more urgent.

though, the less their benefits from knowledge specialization and drawing on the competences of external suppliers and other partners in the innovation network. In the opposite case, the opposite effects accrue. This trade-off seems a hard one: it appears to be a zero-sum game where one can have only one benefit or the other. Firms, it seems, cannot leave the diagonal and have the benefits of both. They are condemned to having only the benefits of one, or the muted benefits both.

In what follows, we turn to a case study to cast light on the research question: how to take the task allocation decision in order to benefit from the advantages of leveraging external sources of innovation while protecting against the drawbacks involved in doing so? The case study captures a recovery situation: the firm, a major European auto manufacturer, wrestled with the challenges of how to best allocate tasks along the value chain, relied very much on product architecture in doing so, and was struck by the drawbacks of the task allocation scheme it had chosen. The strongest of those drawbacks were decaying design competences. It is a situation familiar to many firms, and a critical one. Our analysis of the case builds on and extends previous literature. The practical contribution consists in pointing out a successful recovery strategy for lost design competences. The theoretical contribution is to identify an empirically grounded way of organizing the development of complex products, that allows leveraging external sources of innovation while being protected from some important drawbacks of doing so, i.e. overcoming the trade-offs emerging from literature.

### **3. Method, unit of analysis and sampling**

The nature of the research questions and the gaps in the literature identified above led us to choose case study methodology.<sup>5</sup> There are many convincing arguments that explain why this method suits the kind of research questions we raised (Eisenhardt, 1989, Pettigrew, 1990, Yin,

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<sup>5</sup> It would be interesting to analyse to what extent such gaps are a consequence of the methods used in previous research. This is an issue for another paper, however.

1994, Eisenhardt and Graebner, 2007). The main reason for this choice, in this context, is the exploratory nature of our research. More specifically, the nature of the research question made the choice of a *longitudinal* case study analysis the most appropriate (Eisenhardt, 1989, Pettigrew, 1990, Yin, 1994). As our unit of analysis, we chose the New Product Development (NPD) process of a technology-intensive firm developing complex products. In particular, we focused on: (1) the decisions (and the rationale applied in making those decisions) concerning the allocation of innovation tasks along the value chain (with specific interest on the outsourcing of design and engineering tasks to suppliers); (2) the effects that task allocation produced on the firm's and its suppliers' knowledge and competence base; and (3) the firm's organization for product innovation.

As far as sampling is concerned, we deliberately decided to choose a case that was '...very special in the sense of allowing one to gain certain insights that other organizations would not be able to provide' (Siggelkow, 2007: 20). Of course, we were aware of the fact that investigating a single company in great depth could not lead to normative results. We chose this sampling approach following the argument that 'cases are selected because they are particularly suitable for illuminating and extending relationships and logic among constructs' (Eisenhardt and Graebner, 2007: 27). Furthermore, our research does not intend to perform any theory testing (Eisenhardt and Graebner, 2007). The sampling process was influenced by the unit of analysis we chose to adopt. It was based on three steps. *First*, we decided to focus on a specific industry. We chose to gather our empirical observations in the context of the automotive industry. The automotive industry is one of the most complex industries in terms of technologies and players involved in innovation processes (Maxton and Wormald, 2004). *Second*, we selected the OEM. The main reasons for the choice are the following. In the past, the OEM adopted a task decomposition strategy that intended to leverage modularity. Moreover, the OEM is an example of clear and extreme task allocation decisions: a

previously fully vertically integrated company (as far as design tasks are concerned) that became an extreme outsourcer and subsequently decided to once more reverse its task allocation scheme. These changes were observable within in a time-span of only 10-15 years.<sup>6</sup> The description of these changes and the in-depth analysis of their triggers were well-suited to address our research questions. Third, the two research centres of the OEM, as well as eight first tier suppliers belonging to the OEM's value chain were included in the field work. Suppliers were chosen on the basis of the following criteria: relevance in terms of contribution to the OEM's development activities; heterogeneity of their industry, technologies, dimension, ownership, and nationality; and not to be OEM captive (for an overview of the suppliers analyzed see appendix). The objective of this third step was to observe the same units of analysis from the angle of the car maker, its research centers and its suppliers. This perspective fit well to the nature of the research questions (and the nature of the phenomenon of open innovation that, by definition, relates to the interactions between different actors). Moreover, it allowed us to confirm the reliability of the data in those instances in which they were consistent, and induce a new round of field work when they were not. As we analyzed the same unit of analysis from different perspectives, we considered inconsistencies indicative of the perspectives of different participants and used them to generate a deeper understanding of the interactions between the OEM and suppliers.

Two main data collection methods were used. The first was the study of archival sources to define the characteristics of the sector and the history of the selected companies. The second involved extensive semi-structured interviews with managers in the selected companies. Such data gathering enabled triangulation between the quantitative and qualitative data, and

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<sup>6</sup> The case, therefore, offers at least as much insight into industry evolution as the electronics industry – the paradigmatic example of an industry where changes are observable in a relatively short time span (Fine, 1999). This point is a matter of interest in itself and makes the case intriguing for analysing industrial and organizational change. For this reason we believe our sampling choice seizes, as good single-case research does, the 'opportunities to explore a significant phenomenon under rare or extreme circumstances' (Eisenhardt and Graebner, 2007, p. 27).

between what managers belonging to different organizations had to say on the same units of analyses. Moreover, the sample also contributed to address the research question looking at both the OEM and supplier sides. This is a distinctive characteristic of the present study.

While the bulk of interviews we build on in this paper was carried out between January and July 2006, we also draw on sets of interviews carried out from 1997 onwards (see appendix). Overall, between 1997 and 2006, we interviewed personnel belonging to 20 different companies for about 135 hours. All interviews were taped and transcribed. During this 10-year period, the research focus (and some suppliers in the sample) has adapted somewhat according to the evolution of the scholarly debate. Overall, however, it has remained highly consistent over time. The main unit of analysis, in fact, has remained stable. The data gathered in this period, hence, can be usefully drawn upon this paper. Moreover, the interviews and data gathering activities carried out before 2006 were a solid starting point for a more fine grained and in depth analysis in the last set of interviews and, at the same time, the baseline for a longitudinal comparison. The main tenets of the paper, however, build on the last round of interviews, carried out in 2006. The interviewees were chosen according to the relevance of their role in the innovation process of the OEM and its first tier suppliers. At the OEM, two company advisors supported the definition of the interview agenda and helped us gain access to the OEM's top management, and to archival sources.

We deliberately involved both people in charge of strategic decisions and personnel with more operative roles. In this way, we combined the perspectives of top management with the micro analytical details provided by people involved in the execution of the NPD process. We interviewed the Chief Technology Officer, the Senior Vice President Human Resources, the Vice President Product Portfolio Management (all three members of the OEM's top-level steering committee), and the Director of Vehicle Concept & Integration (i.e., the manager responsible for systems integration for chassis and vehicle), four of the five vehicle line

executives (i.e. the engineers responsible for the development of cars in the small (A-B), medium (C), and upper (D-E) as well as the commercial vehicle segments), and the staff functions of the Design and Engineering division (the Human Resources Manager and the Division Controller). We thus covered most of the top managers leading the product development process. This set of interviews provided us with a comprehensive picture of the OEM perspective. Regarding the eight suppliers involved in the 2006 interviews, we interviewed ‘account managers’ (responsible for the commercial relationship with the OEM from the pre-offer phase till the end of the project) and ‘project managers’ (responsible for component or system development). In some cases we also interviewed the supplier’s CEO (for a list of the interviewees see appendix). The people we interviewed at the OEM and at the suppliers frequently dealt with each other on a daily or weekly basis. In these cases, there was a solid possibility for data triangulation, strengthening our interpretation. Overall, given the nature of the research questions, our investigation greatly benefited from this double perspective: much of the information concerning the real competences of OEM and suppliers in performing design and engineering tasks, the complexity of system integration tasks, the inter-organizational routines of product development, and the overall complexity of organizing open innovation could not have been gathered if we had relied on taken solely the OEM’s or suppliers’ point of view.<sup>7</sup>

#### **4. Case study**

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<sup>7</sup> On a final note, we also addressed the issue whether new conceptual development arising from interview data reflects, primarily, a sort of retrospective sense-making by *image-conscious informants*. Eisenhardt and Graebner (2007: 28) suggest that a key approach to mitigate this problem is to use ‘numerous and highly knowledgeable informants who view the focal phenomena from diverse perspectives’ and to ‘combine retrospective and real time cases’. As emerges from the data gathering description, we employed both counter-measures. Our choice of the data to be presented in this article, finally, deserves a comment. Our main concern in gathering and presenting the data was to try to connect the constructs used with the conceptual argument we wanted to address (Siggelkow, 2007). Of course, we do not report all the data we gathered, being well aware of the trade-off in presenting qualitative data: given the amount of data and details, we preferred to *narrow* our attention in order to avoid a typical drawback of case study research, i.e. the lack of selectivity.

#### **4.1 The OEM's task allocation strategy**

Over the last 15 years, three different phases in terms of task allocation at the OEM can be distinguished. In phase one, the OEM carried out the design of the whole vehicle in-house. Once detailed designs were completed, manufacturing of components and systems was then outsourced to suppliers, and assembly was provided by the OEM. In this phase, the OEM was fully vertically integrated in terms of design. The task of developing a vehicle was partitioned exclusively amongst internal organization units. In order to reap the benefits of leveraging external sources of innovation and to cut development costs, the OEM then radically changed the allocation of innovation tasks in phase two. In terms of product architecture, the OEM pursued a modularity approach, emphasizing systems and modules. In terms of task allocation, the design of many systems, modules, and components were outsourced to suppliers. In deciding on task allocation, product architecture (task decomposition) played an important role. By the end of the 1990s, the OEM had reached an exceptionally high level of design outsourcing (up to 85% of components and systems, in terms of the total value of a car, was designed and engineered by suppliers). In practice, suppliers were in charge of both the conceptual development of components and systems and of their detailed engineering. As we will report in the next section, this strategy created some problems. In phase three, these problems pushed the OEM to adopt a more moderate approach to design and engineering outsourcing. The task allocation scheme it adopted presents many elements of novelty. It will be the object of a detailed description below, as will be the changes induced in the passage to phase 3.

FIGURE 2 HERE

#### **4.2 Problems of extreme outsourcing**

In phase two, the OEM first decomposed the car in systems and modules, then allocated the design tasks to suppliers according to that decomposition scheme. This allocation of design

activities along the value chain was quite standard and mirrored the distribution of competences in the industry. *For each development project, the OEM applied the same task partitioning scheme*, just fine-tuning the level of involvement of each component and system supplier according to the type of product under development (car segment, car novelty, etc.). This logic allowed the OEM to have full control of 100% of all car development projects, i.e. managing the project with an OEM-led development team, while controlling only around 30% of the technology involved (this was the average percentage of engineering design the OEM carried out, including the definition of the product architecture). The Director of Vehicle Concept & Integration explained the key rationale for allocating tasks in this way:

‘We thought we could be substantially detached from certain component and systems technologies and focus primarily on ‘architectural’ know-how. The idea of systems integrator that we applied was coupled with the idea of modularity, and sometimes interpreted in the sense that the system integrator should have the competence of integrating systems as its core competence’ (Director of Vehicle Concept & Integration , 2006).

Accordingly, the OEM tried to build and maintain architectural competence, privileging it over other competences such as knowledge about component technologies (as exemplified by the high level of outsourcing). In summary, the OEM focused on system integration as its core competence, and at the same time, used product architecture as a map for task allocation<sup>8</sup>.

This strategy, however, turned out to be problematic in practice. We do not describe the roots of the OEM’s problems in detail here because this is out of the scope of this paper (for such a description see Becker and Zirpoli, 2007). The main problems the OEM experienced are summed up effectively in the following quote:

‘It is naïve to believe you can integrate a system without holding an in depth and detailed knowledge of the components that are going to affect the performance of the whole car.

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<sup>8</sup> In some interviews we found traces of the idea that modular architectures offers the possibility that much of the coordination work will be done by the standardized interfaces, rather than having to be accomplished by ‘active’ intervention of the OEM.

Managing each system performance does not, in fact, automatically result in effective system integration. The performance is the ultimate objective, not systems' (Director of Vehicle Concept and Integration, 2006).

The OEM managers realized that *acting as a system integrator without underlying component-specific knowledge* was just not possible: without such underlying component-specific knowledge, systems integration competence was difficult to achieve. Precisely such knowledge, however, had been lost by focusing exclusively on the competence of systems integration. As mentioned, the level of outsourcing of component specific technologies had reached 85% of the value of products under development.

#### **4.3 The OEM's reactions to the problem**

The OEM's manager in charge of Systems and Vehicle Integration introduced the OEM's reaction to the problems the OEM encountered as follows:

'We realized you cannot integrate components performances you know very little about ... if you have never designed a component or a system it will be very difficult to understand the subtle interactions with the rest of the vehicle. We should have reversed our strategy by integrating back competences that we had lost. We had two problems, however, no money and no time' (Manager in charge of Systems and Vehicle Integration, 2006).

In fact, once the OEM recognized and acknowledged the problem, its first reaction was to reduce the level of outsourcing and change its attitude towards supplier involvement in the NPD process. In this respect, the OEM's first goal was *to recover lost competences*. The OEM started hiring staff knowledgeable in the areas where it had lost competences, and started to enable internal development and learning. The OEM now outsources only 50% of the design and engineering of new systems (down from 85%). Because it is standard industry practice to outsource the design and engineering of components whose technology is mature (i.e. the calliper for a brake), or outside the traditional scope of automakers' activities (i.e.

electronics hardware), the OEM's managers consider 50% 'natural' for the auto industry. However, as highlighted in the quote, the OEM's managers could not just in-source the competence lost in the past. The OEM did not have sufficient financial and human resources to in-source component specific technologies for all projects under development. Given the impossibility of vertical integration, this put the OEM's management in a situation with no options to choose from. The OEM's management realized they could overcome this constraint if they reconsidered the current way of allocating resources to development projects, and the task partitioning scheme. Acknowledging the role of learning by doing, OEM top management decided to focus its efforts on acquiring the knowledge of all key systems technology 'at the expense' of *not* controlling the project management of all vehicle projects. It decided to dominate *all* required *competences* (with some lower threshold defined by what are considered standard components), but to select certain *car models* where it would exercise them. The OEM did not carry out design in the other projects, and relinquished control it previously exercised by dominating project management. This passage is important and requires attention to the details in order to be grasped fully. We thus dedicate the remainder of this section to reconstructing it carefully.

At the heart of the OEM's new strategy lies the concept of 'template model'. A 'template' is a set of design archetypes. A design archetype is a set of engineering solutions that will be employed in all models belonging to the same segment. In a metaphorical sense, this set of all the design archetypes defines a model that becomes the 'ancestor' which then gives rise to a family of variant models. This translates into a product development team that develops a new car managing all the key systems and components design and engineering in house. In the Chief Technology Officer's words:

'Engineers we staff on template projects hold an above average component-specific know how. This know how derives from the fact that they themselves develop the key systems. Our engineering teams continue to work with suppliers but delegation is not according to black

box sourcing as before. Learning by doing plays a key role to understand the systems we are integrating' (Chief Technology Officer, 2007).

The template model does not just consist of a set of components, systems and modules carried over to derived models. It is also used as a means for setting the standards on how to solve engineering problems. Such standards then characterize products in a given market segment. In other words, during the development of a template model engineers develop engineering solutions that are supposed to be re-applied to other models for some time, as long as technology does not call for a new design archetype. Examples of design archetypes are, for instance, the architecture of a suspension for small cars, the layout of the panel instruments for sports cars, or the design of the sealing system for luxury cars. Following a template means that every time a derivative project is started within a segment, engineers will have to apply the template solution from the same segment (the segment's ancestor). This is done either by carrying over the same components or, in the case of physical misfit, by designing the new components by scaling the archetypical solution up or down. A template model thus consists of many archetypical solutions regarding the most important components and systems and the way they interact. In particular, the OEM chose to develop a bundle of archetypes for each market segment because each market segment has its own characteristics in terms of the key performances that customers value. Archetypical engineering solutions vary accordingly. This helps the OEM to economize on the cognitive, engineering and financial resources devoted to derivative projects<sup>9</sup>.

Moreover, the template also provides a means for developing system integration competences. This observation links back to the quote of the CTO reported above that emphasizes the central role of the integration of overall product performance in system

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<sup>9</sup> This move also addressed further problems: As the CTO observed (confirmed by the suppliers we interviewed), if one had reverse-engineered two of the OEM's models, it would have been difficult to say that the cars had been engineered by the same company. This observation pointed to two problems: first, the OEM obviously had to leverage component and systems standardization much more. Second, it had to increasingly develop common engineering solutions (design archetypes).

integration. The CTO's description of what characterizes template projects adds further evidence on this point:

'Template projects are a means to learn about key technological interdependences and on how to manage key performance trade-offs' (Chief Technology Officer, 2007).

The interesting feature we observed, however, regards the consequences of applying the template model concept: it *introduces a completely new task allocation scheme*. In the old system, the overall design *tasks* were decomposed (along the lines drawn by the task decomposition, e.g., in components and systems). Some were then outsourced (along the same lines, allocating the tasks of designing the safety system, for instance, to a system supplier). This decomposition scheme was then applied to *all vehicles*. For instance, dashboards were *always* outsourced and for *no* car models did the OEM design dashboards in-house. The OEM subsequently saw its own design competences in some of the outsourced designing tasks erode. With the template model, the task of designing a whole car model is not split up and allocated to different firms any more (even though this might seem incredible in the age of outsourcing, or even a typographic error). The OEM assumes the responsibility and control for designing *all* key systems of a template model (i.e., it develops the whole car model). At the same time, for models that are considered to derive from the template model it allocates the task of designing the whole car model to suppliers. Control over the supplier that is responsible for developing the derivative model is assured by using the model it has designed in-house as a template for the models that will be outsourced. (The knowledge acquired in developing the template model has an important role in being able to control suppliers.)

When it develops a template model, the OEM continues to involve system suppliers but is now fully responsible for the engineering and the application of all the most relevant systems in the vehicle. In both cases, system and component suppliers provide complete systems. However, the integration of these components is managed completely either by the OEM or

by the engineering suppliers. Figure 3 compares and synthesizes the old and the new task allocation scheme.

FIGURE 3 HERE

The new task allocation scheme has an immediate practical consequence. For derivative projects, the OEM has the option of relying on external suppliers that can provide system integration (turnkey engineering suppliers can provide such a service).<sup>10</sup>

The OEM's decisions concerning the allocation of innovation tasks have an impact on the following variables: (1) project management, i.e. who leads the development projects (in the previous section we have seen that the new solution gives a new role to engineering suppliers in this respect); (2) task allocation, i.e. who does what in the value chain; and (3) the competences of the actors involved, i.e. who knows what (and will nurture such knowledge through learning by doing). As described above, the knowledge aspect was key in triggering the changes the OEM has implemented. Figure 4 provides a synthesis of the new approach the OEM uses to allocate innovation tasks in its value chain, and the corresponding supplier roles.

FIGURE 4 HERE

## **5. Discussion**

The case study represents a remarkable instance of a successful recovery of lost competences, one of the key problems identified in the innovation management literature (Lincoln *et al.*, 1998, Fine, 1998). It can therefore contain lessons for other firms that have to recover lost competences while being constrained for resources.<sup>11</sup>

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<sup>10</sup> Our interviews indicate that the formalization of the role of engineering suppliers and their growing responsibilities are amongst the most relevant new findings that can help understand why the template model approach works. Engineering suppliers therefore seem an important element in the strategy the OEM has implemented. Engineering suppliers, as opposed to component and system suppliers, are responsible for integrating functions within the vehicle. When compared to the role engineering suppliers have played in the past, the great change lies in the typology of vehicles they develop: not any more just niche products with small volumes and low manufacturing complexity (due to small numbers) but rather, key mass models with high expected production volumes. This makes a big difference in terms of the importance of the project for the OEM's fate and its intrinsic engineering complexity.

<sup>11</sup> On the boundary conditions see the conclusions section.

How did the OEM recover lost competences? So far, the only organizational solution available to retain or re-acquire component-specific and architectural knowledge was to carry out more design tasks in-house and thus, increasing vertical integration of design tasks (with the drawbacks of diminishing the benefits of leveraging external sources of innovation). The key to the recovery was to profoundly change the way to allocate tasks. The template model system of allocating tasks represents a substantial novelty in organizing the development of complex products. In this section, we explain why it is so novel, and what its consequences are.

As described in the section on previous research, recent empirical literature has put a question mark behind the idea of a uni-directional link from task decomposition to task allocation. The key reason for the question mark is the importance of component-specific knowledge. Our empirical evidence contributes to expanding this perspective. The OEM we studied not only had realized the importance of component-specific knowledge. It also made the need of *nurturing component-specific knowledge* required for deciding on performance trade-offs and integrating overall systems performance the *most important criterion for task allocation*. In practical terms this translated in substituting the criterion for task allocation. Rather than allocate tasks in function of task decomposition (product architecture), tasks are now allocated in function of the component-specific knowledge required for deciding on performance trade-offs and for integrating overall systems performance. The link between task decomposition and task allocation – in the sense of task decomposition *guiding* task allocation – is broken. Task decomposition (product architecture) and task allocation are now completely de-coupled. Task decomposition decisions are taken with a focus on addressing the complexity of *technical* problem solving, i.e., addresses technical interdependences. Task allocation, however, is decided based on a very different criterion, on which technical interdependences have a much lesser influence than previously. That is a completely novel

way of considering the link between task decomposition and task allocation, and of allocating tasks. The OEM has implemented it. It is the first time it has been observed and documented.<sup>12</sup> It also has very powerful effects.

In order to appreciate the effects, consider three key problems that firms developing complex products face. (1) Organizing the development process so that overall product performances are optimized. (The main problem is to organize successful systems integration, making sure that technical interdependencies are matched by appropriate coordination mechanisms, Sosa *et al.*, 2003). (2) Strategic competence issues (avoiding competence erosion and adapting competences over time, Lincoln *et al.*, 1998, Fine, 1998, Kotabe *et al.*, 2007). (3) Avoiding dependence on suppliers (Williamson, 1985; Roy *et al.*, 2007), in particular, for knowledge (Fine, 1998; Kotabe *et al.*, 2007). The template model simultaneously generates advantageous effects on all three: (1) Organizing so that overall product performances are optimized becomes easier and more likely (if not completely automatic). Because there is always one ‘residual responsible’ (the OEM for template models or the turnkey engineering supplier for derivative projects), with the template model system, it is more likely that all interdependencies are attended to, even if they are not specifically assigned to anyone. Using product architecture as a map for task decomposition – as the OEM did previously – risks that some interdependencies between chunks are not assigned to anyone and thus, not considered

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<sup>12</sup> Three factors can explain why we could observe this new system of organizing the development of complex systems emerge. In terms of the phenomenon emerging, the fact is significant that the OEM was in a grave crisis that exerted extreme pressure, had been given ‘free hands’ to top management and accepted radical measures, and was severely constrained for financial resources. An OEM in a less extreme situation would, without doubt, have presented a much lower probability of shifting to a new system of organizing the development of complex products. In terms of picking up the phenomenon – which is quite abstract in nature – two factors were crucial. The setting of the case was extreme, for instance, the OEM came from a situation of outsourcing 85% of design tasks (in terms of value). This made changes stand out quite clearly and allowed to gain ‘insights that other organizations would not be able to provide’ (Siggelkow, 2007: 20). Moreover, we worked on the background of 10 years of following the case, and had access to the almost complete set of managers responsible for innovation management (most importantly, the Chief Technology Officer, the managers in charge of systems integration, innovation methodologies, and 4 out of 5 managers of the product segments). Only this depth and breadth allowed us to capture the phenomenon, and to double-check (and confirm) our interpretation with these interviewees. In July 2007, we had the chance to present our findings – described in this article – to the Chief Technology Officer and the manager responsible for Innovation methodology. Both confirmed that our interpretation of the empirical material concurred with the strategy they had decided on, and implemented over the last two years.

adequately in designing overall project performance. (2) The template model system provides a means to protect against erosion ('hollowing out') of the knowledge and competence base by assuring learning by doing across the full range of technologies – not for every model, but once in a handful of car models (for example, once for a product segment). The notable feature is that such protection is achieved without vertical integration (in-sourcing design tasks and competences). The same is true, by the way, for the possibility to gain control of architectural competences. (3) According to previous research, being on a par with suppliers as far as component-specific knowledge is concerned seems to be the strongest lever for controlling suppliers, and perhaps, a necessary prerequisite. Without it, other measures for supplier governance seem to be limited in their effectiveness. A truly noteworthy feature of the template model system is that the template model has advantageous effects on all these three dimensions *at the same time*.

The full power of this point can be appreciated when the effects of the template model system are considered against the backdrop of the trade-offs identified in the literature review. The important change the template model approach introduces is to break the trade-off. It allows going beyond the trade-off, and to have the positive effects regarding absorptive capacity, architectural knowledge, and supplier governance, *without* losing the benefits of knowledge specialization and leveraging external suppliers. Figure 5 represents the radical change in the way of deciding task allocation.

FIGURE 5 HERE

On the x-axis, task decomposition as criterion for task allocation has been substituted by the need to maintain component-specific knowledge for deciding on performance trade-offs and integrating overall systems performance. As a consequence, the strict link between task decomposition and task allocation disappears. (It does not just disappear on the diagram. As figure 3 has shown, the OEM does indeed choose task allocation schemes independently of

the product architecture and its degree of modularity.) The trade-off between the benefits of leveraging external sources of innovation, and the benefits of keeping design tasks in-house thus also disappears, opening the possibility of reaping both benefits. The way to realize this potential is by choosing a task allocation scheme that introduces a logic of template and derivative, and thus, a time dimension (first template, then derivatives). This enables reaping the benefits of keeping design tasks in-house fully in a first time step, and in a second time step, reaping the benefits of leveraging external sources of innovation fully. Figure 4 expresses that by showing how firms can ‘occupy’ *both* the lower left-hand corner *and* the upper right-hand corner, rather than be stuck somewhere along the diagonal. A key move to opening such a possibility is to consider making certain projects template projects and others their derivatives. This introduces one more variable that innovation managers can manipulate. As it turns out, doing so helps to de-fuse one thorny problem and trade-off for firms developing complex problems.

## **6. Conclusion**

One of the key challenges for firms that develop complex products is to draw on suppliers without losing control of product performance or supplier governance. The main finding of the case is to identify a way how firms can respond in a novel and advantageous way to this challenge. Previous empirical research had established a list of circumstances under which firms were advised to maintain a broader knowledge base than the one required for the actual products, and thus, to keep the pertaining design tasks in-house. Accordingly, rare were the circumstances where a full ‘open innovation’ strategy could be implemented (these limitations also concerned fully decomposable products). Even when that was the case, the effect of following such advice was to dampen the benefits of leveraging external sources of innovation. Grounded in empirical observation, this article has identified a way of organizing

the development of complex products that offers an alternative to adjusting the degree of design outsourcing, in function of the product architecture. The effects of this novel alternative are very powerful, and able to surpass the trade-off that characterized earlier alternative responses to the challenge.

The new way of deciding on task allocation, the replication of template models, contributes to a number of discussions in the literature. To the *innovation management literature*, it has added further support to a number of insights that have accumulated there over the last years: most importantly, the dangers of design outsourcing (Lincoln et al., 1998; Fine, 1998), and the centrality of integrating performances as a criterion for which component specific knowledge should be maintained in house (Takeishi, 2001, 2002). It has also added detail on other notions in the innovation management and the design rules literature, most importantly, the role of task decomposition as a guideline in organizing the development of complex products (Sanchez and Mahoney, 1996; Baldwin and Clark, 2000). As opposed to this idea, the case strongly makes the point this holds only for the (limit) case of modular product architecture. In all other cases, innovation managers should focus on task allocation. This obviously is slightly difficult if task decomposition and task allocation are considered the same, or where task decomposition and task allocation schemes are, in fact, identical (because task allocation was carried out according to the task decomposition scheme). In fact, for all cases where products are not fully modular, specific efforts of *organizing* development hold the key for developing complex products so that high product performances are achieved without major drawbacks. Without the insight that the two are different things, and that they can be de-coupled, innovation managers have a problem. The case also contributes to the literature on *complex product systems and systems integration* (Hobday, Davis & Prencipe, 2005). The findings of the case remind us that developing a performing system is the final goal of product development. While this sounds – and in fact, is – obvious, the case represents

a vivid example of what happens if this objective gets slightly sidelined by other objectives such as time or cost. It also identifies what it takes to maintain a strong focus on systems performances in the *organization* of the development process (we are not discussing the engineers carrying out the actual design and engineering). What it takes is to make integrating performances, overall system performance and the competence of deciding on performance trade-offs a priority – also in deciding on task allocation. The article, moreover, also contributes to a more general *literature in management that considers decomposition* (Simon, 1962, Levinthal, 1997). In terms of this literature, firms that develop complex products search for optimal product designs. In the language of NK-models (Kaufman, 1993), they look for the optimal combination of N elements that have K interdependencies. This would correspond, for instance, to the search for an optimal product decomposition scheme. A substantial literature has considered search processes for such optimal combinations in different circumstances, and has identified many interesting features of such search processes. In NK model terms, what has happened in the case is that a two-step search process was created. In the first search process, the OEM searches for the engineering archetypes that best fit the objectives. In the second search process, these are provided to the engineering supplier and thus represent a constraint for it that delimits the search space to be searched for detailed solutions within the constraint. While this might look obvious, two-step search processes have not yet been considered widely in the NK literature. Recent treatments of two-step search processes, however, show they have powerful features that differ considerably from one-step search (Knudsen & Stieglitz, 2007). As for the *engineering literature* that treats decomposition (Sosa et al., 2003), the present article suggests it is important not to lose from sight the fact that decomposition, developing product architectures, and component and system design take place within organizations. Such organizations also deal with other issues at the same time, such as task allocation. Sometimes, non-technical considerations such as

task allocation have powerful implications also for technical issues (such as product architecture). Systematically identifying the links between technical and organizational issues, such as technical and organizational problem-solving, can lead to solutions that are superior also regarding the technical criteria. The article also, finally, contributes to the *literature on open innovation* (Chesbrough, 2003). It considers how to implement open innovation, and contributes a new way to take a key decision on how to leverage external sources of innovation. We have explained this above. A second contribution to the open innovation literature is to the recent discussion regarding the situatedness of organizational approaches to leverage external sources of innovation (Christensen *et al.*, 2005; Staudenmayer *et al.*, 2005). The article puts in evidence decisions on task allocation, for instance, are limited by what range of products and services suppliers on the market offer. This will be heavily influenced by the product architecture. For products with a standard product architecture (such as automobiles), suppliers will in principle offer the same ‘bundles’ of products and services (e.g., brake systems). When redefining these bundles, finding suppliers might turn out difficult. This is an important limit to the malleability of the link between task decomposition (product architecture) and task allocation.

While the article contributes to these literatures in different ways, its main contribution has a similar impact on them all. As mentioned in the title, we consider the new way of allocating tasks a new paradigm of organizing the development of complex products. Considering the case of object-oriented design in computer programming can illustrate the point. Object-oriented design shifted from designing (programming) objects, to designing classes. The term ‘class’ refers to a set of objects that have the same features (e.g., the same attributes, operations, methods, relationship, and behaviors); a specific instance of a class is called an object. As a textbook on object-oriented design says, ‘think of a class as being a template for objects – a class determines the structure (set of features) of all objects of that class. All

objects of the same class must have the same set of operations, the same set of attributes, and the same set of relationships, but may have different attribute values' (Arlow and Neustadt, 2002: 110). In other words, objects are expressions of a set of possibilities the class defines. It now becomes clear that what the case company has done is shift the object of design efforts: the OEM now designs classes (such as archetypes for a particular segment or product line) rather than individual objects (car models). Another parallel is that designing classes means to design patterns that can be reused (because it is outlines of general solutions that are being programmed, rather than particular, situation-specific processes). This is similar to what the OEM does with designing, and then applying, templates. Just like object-oriented design was a real paradigm shift in programming, we think the template model system is a paradigm shift in complex product innovation management.

A paradigm shift does not mean a panacea, however. There are difficulties and limits in implementing the new approach. As the Chief Technology Officer pointed out, the *availability of engineering* suppliers with sufficient competences to fully develop derivative projects represents a limit to the feasibility of this approach. The strengths of these limits will depend on issues such as the reaction of suppliers to opportunities of offering larger bundles of design and engineering services, the speed with which they can build up additional competences that are required in order to do so successfully, the incentives and pressure OEMs can build for suppliers to offer such services, the industry structure, etc.. A second practical difficulty pertains to problems with *protecting intellectual property* when the template, i.e., the set of engineering archetypes, is handed over to a supplier. One of the key motivations for creating templates is to convey the archetypical engineering solutions to those who develop derivative models in a concise and precise way. This also fuels the risk of imitation. The power of the template model approach will be limited to an important extent by which solutions will be found to allow replication (by parties that are intended to develop

derivative models) while avoiding imitation (by parties that are not intended to do so). Previous research has looked into these issues (Winter & Szulanski, 2001; Rivkin, 2001) and can inform this question and thus, how strong a limit this issue is likely to set to the power of the template model approach. A third practical problem is that having mastered the generation of templates, *replicating* them reliably is not trivial either (Winter & Szulanski, 2001). Amongst others, it poses the challenge of developing new competences for replicating the template and of adapting the organization for this purpose (remember that in the previous organization, task decomposition and task allocation were considered tightly linked; thus, because of the predominantly technical nature of task decomposition decisions, the people and organization units that took task allocation decisions were very much focused on technical matters). Such competences will go beyond merely competences relating to creating and replicating templates. It should have become clear that the new system is quite radically different. This also applies to the supplier relations. We have highlighted how the turnkey engineering supplier has much larger responsibility, is required to adapt its competences, and there are new problems that both OEM and suppliers have to deal with (such as protecting the intellectual property of the OEM). These are only some examples that hint at how OEM-supplier relations will have to be adapted. In turn, it is likely that such changes will have knock-on effects on the structure of the industry architecture. Finally, a potential practical problem might arise from the fact by shifting to a template model system, one ‘freezes’ technical solutions – if only archetypical ones, i.e., on a more abstract level – for a particular period. This means that the time steps in which technical solutions are adapted are longer. In principle, this could lead to making the template platform model approach unfeasible for technologies that change very fast (faster than the time step for which an archetypical solution will be held in place).

Our study is also subject to limitations. Our sample could be biased by the fact that we only interviewed companies located in one country, and belonging to one industry. However, the vast majority of companies in the sample are local branches of multinational corporations. Moreover, technological heterogeneity counterbalances industry specificity. As shown in the appendix, the companies analyzed belong to completely different sectors (from pure mechanical engineering to electronics, engineering consultancy, and rubber). Exposure to multiple technological domains, product development priorities, communities of practice, technical complexity, and system, component and module integration characteristics during the research process provided a source of learning and contributed to reaching conclusions that are well informed and empirically grounded (although they can, of course, be considered neither normative nor generally applicable). There are, of course, also the intrinsic limitations of case study research (see Miles and Huberman, 1994, for a comprehensive discussion.) Our insights do not apply generally. The domains they seem to apply to are limited in various ways. First, they are limited to the domain of complex products. In the case of non-complex products the problem of interdependencies is much less pressing, and thus, decomposition much simpler and the problem that is our starting point is much less deep. Moreover, it is much more likely the product is multi-technology. Accordingly, the tension between having to draw on outside sources of innovation and the drawbacks of doing so is much less pronounced. Second, the template model way of allocating tasks only applies to cases where a meaningful relationship between templates and derivatives can be established. A product series that caters to a particular market segment, that belongs to a particular product generation, or that covers different markets offers a straightforward occasion to identify template and derivative models. That might not always be the case, however. Third, our analysis was focused on design and engineering services. These processes might have some specificities. For instance, design and engineering very often have a key impact on *both* task

decomposition and task allocation decisions. Not all sub-processes of the innovation process seem to share this characteristic. The purchasing process, for instance, has an impact only on the task allocation decision, not on the task decomposition decision (at least not a direct impact). Understanding the limitations of the applicability of our findings, however, also makes emerge the potential of the insights: within the limitations identified, there seem to be many domains where the system we have described has not yet been applied but supposedly could, with powerful positive consequences. That points to new and exciting possibilities, both for firms that develop complex products and for scholars of innovation management, organization and strategy.

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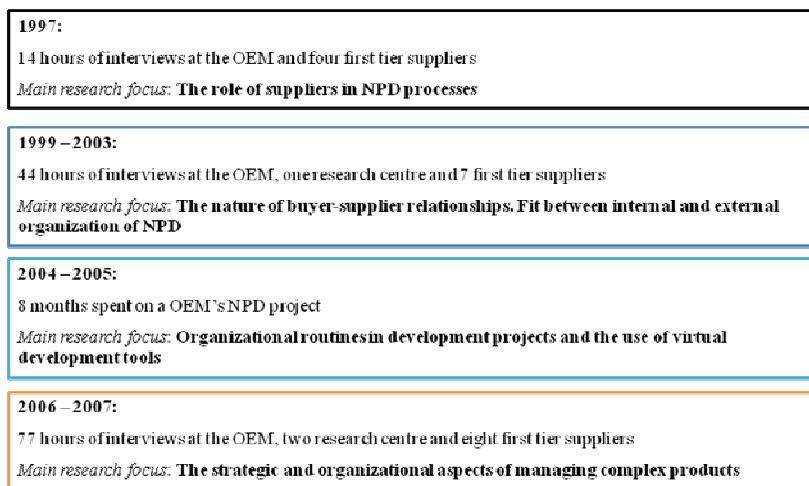
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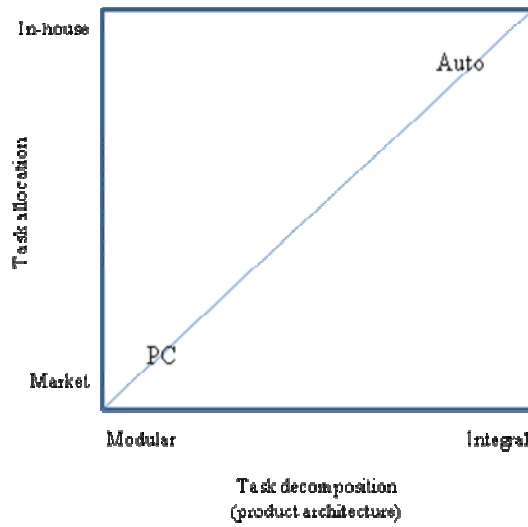
**APPENDIX**  
**Appendix 1 – Interviews (period January-July 2006)**

Company name	Product/role	People interviewed	Date of interview	Total length of interviews (hours)
OEM	Cars (European)	VP Investor relations, VP Product Portfolio Management, VP Human Resources, Business Development Manager, Director of Vehicle Concept and Integration Manufacturing Director (Mirafiori Plant), VP Design & Engineering (CTO), Vehicle line executive segment A-B, Vehicle line executive segment C, Vehicle line executive segment D-E, Vehicle line executive segment, Commercial Vehicles, HR Director for Design & Engineering	8_02_2006 9_05_2006 23_06_2006 14_07_2006	24
OEM Research Centre	Research Centre	CEO, Business Development Director Technologies Division	8_02_2006 22_03_2006	5
Company A	Sealing systems/supplier	Plant General Manager, Engineering&Design Technical Director Assistant, Quality Manager	21_02_2006 07_06_2006	9
Company B	Brakes/supplier	Business Development Director, Product Engineering R&D Manager Brake Systems	28_03_2006	3
Company C	Car design development, turnkey development projects/supplier	Business Strategy Development Manager, Project Manager, Technical Division Manager, Customer Manager, Project Leader	23_03_2006 15_05_2006	10
Company D	Chassis control (ABS – ESP, etc), power train, car multimedia/supplier	Manager Automotive Technology Product Planning and Marketing, Cross Functional Project Manager	29_03_2006	4
Company E	Car interiors, seats/supplier	CEO, Senior Program Manager Fiat Account Manager	9_02_2006 23_03_2006	5
Company F	Safety systems (airbags, seat belts, brakes, chassis control (ABS – traction control systems, etc.) /supplier	Account Director, Manager Programs & Application Engineering Inflatable Restraint Systems	9_02_2006 23_03_2006	5
Company G	Stamped parts in metal/supplier	Plant manager	3_02_2006	5
Company H	Thermal systems/supplier	Sales & Marketing General Manager, OEM sales manager, R&D Thermal Systems Division Manager	3_04_2006	6

**Appendix 2 - Research timeline and focus over time**



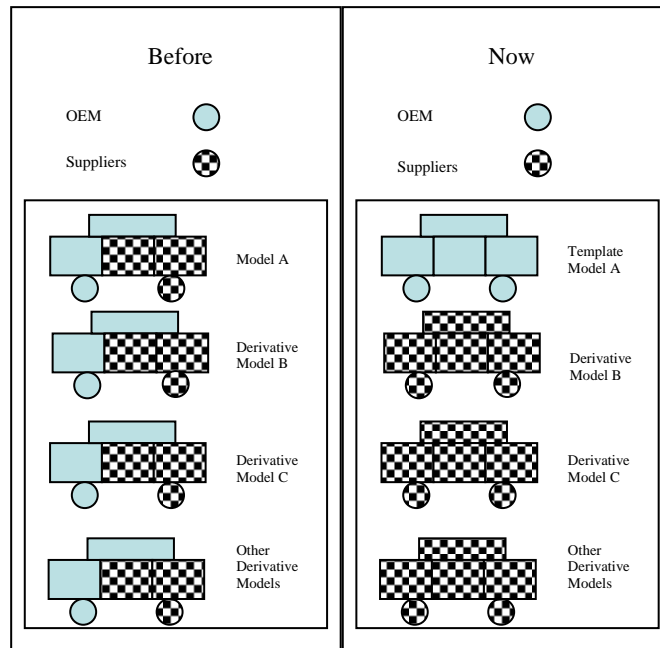
**FIGURES**



**Figure 1 - Task decomposition and task allocation according to the literature**

<b>Phase (years)</b>	<b>OEM's priorities</b>	<b>Task allocation (design and engineering)</b>
Phase 1: 1987 – 1993	Supply base rationalization	Vertical integration
Phase 2: 1993 – 2001	Cost cutting and strategic flexibility	Radical design and engineering outsourcing
Phase 3: 2002 – 2006	Recovery of lost design competences	In-sourcing and substantial change in the way design and engineering tasks are allocated

**Figure 2 – The evolution of the OEM's task allocation strategy**



The figure shows the allocation of design and engineering tasks for each development project (the number of projects is illustrative). On the left side, the figure describes how the OEM used to control a limited number of technologies before. This resulted in a situation in which the OEM led the development project of all products under development but designed and engineered only a selected typology of components and systems, the same for each product under development. On the right side, the figure shows that the OEM fully develops, i.e. designs and engineers a template model. Derivative product development projects can be either led by the OEM or by engineering suppliers. The detailed engineering of components and systems of the derivative models can be allocated both to suppliers and to the OEM itself.

**Figure 3 – Old and new task allocation schemes**

		Before	Now	
<b>Key variables</b>	<b>Project scope</b>	For all products	For 'template products'	For 'derivative' products
	<b>Task allocation</b>	OEM for 25%-30% of components/systems Suppliers for the rest	Mainly OEM	Mainly suppliers
	<b>Technological competences</b>	OEM holds competences on selected technologies and <i>outsources</i> the remaining	OEM controls the competences to manage performance trade offs Suppliers hold component specific technologies	
	<b>Project management / control through hierarchy</b>	OEM	OEM	OEM, Off-shore development and engineering centres, Engineering Suppliers

**Figure 4 – A synthesis of the new approach**

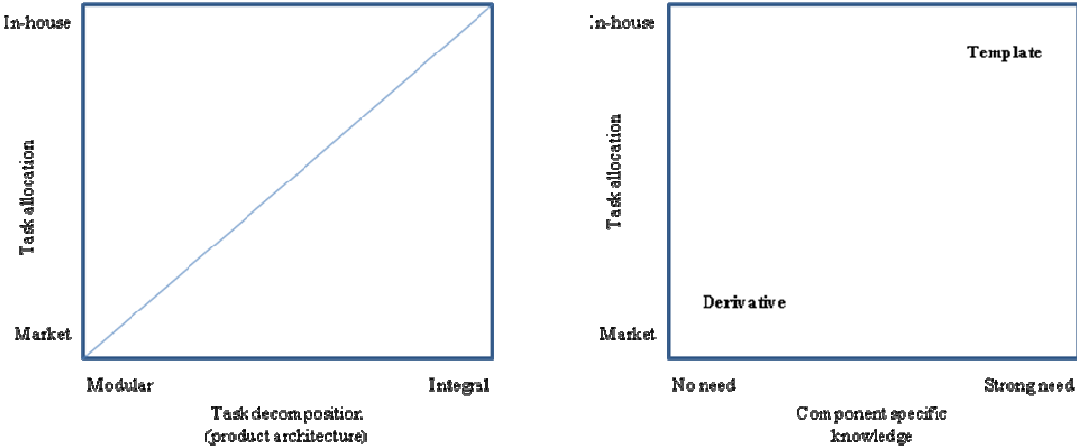


Figure 5 - Old and new systems of deciding on task allocation