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Organising new product development: Knowledge hollowing-out and knowledge integration

The Fiat Auto case

by

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Abstract
The paper analyses the organization of the new product development process at FIAT from a resource-based perspective. The focus is on organizational resources for integrating dispersed specialist knowledge required in the development of complex products. The analysis shows how the application of a resource-based perspective is able to uncover negative long-term effects of outsourcing on the knowledge base (hollowing out), despite beneficial short-term effects on cost.

Key words: New product development, FIAT Auto, knowledge integration systems integration, modularity, knowledge hollowing-out, resource-based view
JEL Codes: O32, M30, M10, L22

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1. Introduction

Firm resources have increasingly been recognized as important for developing corporate strategy. The resource-based perspective of strategy complements the Industrial Organization-perspective of strategy (Porter, 1980) and has become the dominant school in the marketing content literature. Building on the fundament provided by Penrose (1959) on the role of firm resources in the growth of the firm, the resource-based perspective has specified different kinds of resources, centring increasingly on intangible resources such as knowledge (Grant, 1996) and dynamic capabilities (Teece, Pisano and Shuen, 1997). In particular, core competences have come in the focus of strategy makers (Prahalad and Hamel, 1990). Resource-based thinking is used for identifying the drivers of sustained competitive advantage ('SCA') (Barney, 1991; Peteraf, 1993) and for analysing corporate diversification, i.e. outsourcing decisions.

The world automotive industry is amongst the industries that have experienced a wave of strong engineering outsourcing in recent years (Fujimoto, 1997; Liker et al., 1995; Helper and Sako, 1995; Womack et al., 1990). Besides lead time shortening, product integrity and flexibility, the main motivation for outsourcing is cost efficiency (Clark, 1989; Clark and Fujimoto, 1991; Nishiguchi, 1994). Outsourcing decisions, however, also decide on the possession of and access to resources. In what follows we highlight knowledge and competencies, those being the resources that contribute most to sustained competitive advantage because they are the most difficult to imitate. The present paper focuses on knowledge integration in the new product development process. The notion of knowledge applied here is the following: knowledge is a belief, the formation of which is *influenced* but not necessarily *wholly determined* by the processed information. Knowledge is distinct from information, which is data relating to states of the world and the state-contingent consequences that follow from events in the world (Fransmann, 1998, p. 189). In the context of new product development, knowledge is not important as such (for instance, as the belief that cross-functional teams are the best way to organize new product development), but when applied (being capable to organize such teams and make them work). To be able to apply some knowledge means to have a competence, or capability. While the latter two terms are used in different ways by different authors, we take them as synonyms here. The important point is that competence or capability is organizational. The building blocks of organizational competences or capabilities are individual skills (Dosi, Nelson and Winter, 2000). Both organizational competences or capabilities and individual skills refer to the ability to apply some knowledge. Throughout the article, we stick to the term 'knowledge integration' because it is used widely in the literature (e.g. Grant, 1996). It is important to keep in mind, however, that what ultimately matters is competence or capability. We ask the reader to remind him- or herself of that whenever encountering the term 'knowledge' in the text.

Outsourcing decisions have effects not only on cost, but also on the knowledge-base. They decide on the location of knowledge and competencies along the supply chain (in-house or outsourced) and on the allocation of learning opportunities. The contribution of the resource-based perspective is to bring the knowledge dimension into the picture. In the medium and long run, outsourcing can lead to a 'hollowing out' of the knowledge base, which can offset short-term cost advantages. Moreover, outsourcing also leads to a dispersion of specialist knowledge and competencies among the carmakers and its suppliers. Subsequently, outsourcing requires carmakers to integrate and co-ordinate *more fragmented* knowledge.

The present paper focuses in particular on how FIAT Auto has achieved such integration of knowledge and competencies. The paper reports on a longitudinal case study of FIAT Auto's (henceforth FIAT) new product development process (henceforth 'NPD') organisation. FIAT is an interesting case for studying the integration of specialist knowledge and competencies for NPD because it has undergone a still uninterrupted stream of reorganisations in the last 10 years. The FIAT case therefore allows comparison of different resource configurations for integrating and coordinating knowledge. FIAT Auto also represents an extreme case with regard to design outsourcing. In fact, as shown in more detail elsewhere (Zirpoli and Caputo, 2002), the strong level (in terms of value of the overall product design costs) of design outsourcing to few first tier suppliers achieved by Fiat Auto during the nineties, was associated with the absence of some contextual features characterising the North American and Japanese context necessary to maintain a control over the “knowledge” outsourced (Fine and Withney, 1996, Dyer and Chu, 2000). In particular, Fiat did not hold significant equity stakes in its more competent first tier suppliers and, at the same time, its relationship with them was not rooted in long term consolidated business practices that are usually considered necessary to develop not equity co-operative long-term business practices.

Because in extreme cases the process of interest is more transparently observable than in other cases (Eisenhardt, 1989) we can expect the FIAT case to be helpful in casting light also on the relation between a systems-integrator strategy and its implementation.

The major contribution of this paper is the provision of an in-depth analysis of the relationship that exists between (1) design outsourcing strategy, in particular the currently dominant strategy based on systems- and module-integration, and (2) the question of which organizational structures to choose for implementing such a strategy and for managing the new product development process.

Hence, in order to maintain focus we deliberately confine ourselves to knowledge integration in the NPD process, convinced that the NPD process is a good telling instance of the general problem of knowledge integration in companies, because the problem arises in such a pronounced form. Section two develops a framework for analysing knowledge integration . Section three describes FIAT's organisation of the NPD process. Section four then highlights some of the features of FIAT's NPD organisation from the perspective of how well it is suited for providing knowledge integration, the main challenge to the organisation and the management of NPD. Section five concludes and draws implications for the case of FIAT, as well as implications of the application of the theoretical framework to the case.

2. A framework for analysing knowledge integration

In new product development, particularly of complex products such as cars, a high number of very different knowledge inputs are required. For instance, in developing a new model of a car, chassis, engine, interior, and many components are involved, as is market intelligence about customers, knowledge about new materials, and knowledge about new production technology, to give only a few examples. A high degree of specialisation is required in all cases. From a management perspective, the central challenge in the organisation of the NPD process is therefore how to integrate and co-ordinate the specialist knowledge and competences of the participants in the NPD process. It is not easy for product development managers to meet this challenge. In particular, despite the fact that a modularity strategy seems to be an attractive solution, the theory does not offer much guidance to managers on the profound effect of an outsourcing strategy based on modularity and systems integration produces on knowledge integration in NPD. While much scholarly literature concerned with knowledge integration issues overlaps with that on product innovation, despite such overlap, there is a gap between the two bodies of literature. Theories anchored in economics (such as Hayek, 1945 and Arrow, 1962) or in knowledge management (such as Grant, 1996) are somewhat too abstract. The literature on product development is too specific and theoretically eclectic to generate more comprehensive models (Hedlund, 1994: 74). This paper attempts to close this gap. It presents a framework that identifies the mechanisms which create problems with knowledge integration, and that allows to assess how efficient strategies adopted by firms are in achieving such integration.

Our main concern in the present paper is to analyse the "macro" organisational mechanisms designed to address the problem of knowledge integration in new product development. From this perspective, (1) we first define what knowledge integration is and how it relates to knowledge creation, (2) show the variables that influence the integration of knowledge in new product development, (3) describe the dominant strategies to cope with integration issues and, finally, (4) present how these strategies find a place in the literature on new product development.

Knowledge integration

Our starting point is the observation that the automotive industry recently has experienced a high degree of engineering outsourcing (Fujimoto, 1997; Liker *et al.*, 1995; Helper and Sako, 1995; Womack *et al.*, 1990). Such outsourcing necessarily has the implication that specialist knowledge, such as about designing dashboards, car seats, or wiring systems, is more dispersed across the supply chain than before. The degree of dispersion of knowledge involved has increased. This poses challenges for the new product development task (Moorman and Miner, 1997; Galunic and Rodan, 1998) The present section identifies the drivers behind problems arising from dispersed knowledge. The subsequent section identifies generic strategies available for encountering these problems. Three effects that can be discerned in the literature concerned with dispersed knowledge seem to have particularly grave implications on actors: large numbers, knowledge asymmetries, and uncertainty (Becker, 2001).

Large numbers. By sheer logic, the first implication of a higher degree of fragmentation, or dispersion, is that there are more 'elements' than there were before. Where before, one unit of the engineering division held all the knowledge for designing a component, a supplier and the engineering division are now involved, both holding some part of the required knowledge (overlapping to some extent, but not completely). Dispersion thus leads to a problem of 'large numbers'. Large numbers have two effects on actors. The first is an increase in resource requirements. The more fragments there are which have to be drawn together, the more often the process of drawing together those fragments will have to be repeated. Thus, time and other resource requirements (e.g. attention) will increase. To actors with bounded cognitive resources (Simon, 1955) this in turn means a lower limit regarding the number of 'issues' that can be dealt with at the same time. The second effect of large numbers is opaqueness. If there are 'too many' elements, actors simply lose overview (Egidi, 1996). This presents a problem in decision-making (“How many alternatives are there?”), and at the same time a problem of attaining understanding (e.g. of the working principle of a complex component).

Asymmetries. The second implication of dispersion of knowledge is the asymmetries of the knowledge held by different organizational actors (cf. Fransmann, 1998). If there would be no asymmetries, the knowledge held by each 'part' (each actor, organization unit, etc., depending on the level of analysis), would be identical. But then there would be little sense in outsourcing, as there are no gains from specialisation. If there are such gains, the knowledge base of the different 'parts' is asymmetric. While for a long time it was assumed that specialisation, which can be seen as dispersed organizational memory, was an efficient way to capture and use knowledge, popular wisdom has today reversed that assumption. Often, shared knowledge and redundancy are credited with new product success (Moorman and Miner, 1997). One argument for such a reversal is that knowledge asymmetries cause problems because the division of labour influences the possibilities for the creation of new capabilities by way of learning by doing (Loasby, 1999). What is learned and what capabilities are acquired, however, depends on and is limited by what one can do in the first place (specialist knowledge being required for that). Due to learning by doing, and asymmetric development opportunities, the original knowledge asymmetries will deepen further. Such asymmetries are not just limited to knowledge and capabilities. They also 'spill over' to interpretive frames, as actors learn how to apply certain knowledge within their community of practice (Brown and Duguid, 1998). The effect is that knowledge integration becomes increasingly more difficult over time.

Uncertainty. Minkler (1993) and Tsoukas (1996) identified uncertainty as a third effect of the dispersion of knowledge that causes problems. Dispersed knowledge causes structural uncertainty, a strong form of uncertainty that exists if a decision-maker cannot *ex ante* specify all relevant alternatives or outcomes (Minkler, 1993):

> A firm's knowledge is distributed, not only in a computational sense ... or in Hayek's (1945: 521) sense that the factual knowledge of the particular circumstances of time and place cannot be surveyed as a whole. But, more radically, a firm's knowledge is distributed in the sense that it is inherently indeterminate: nobody knows in advance what that knowledge is or need be. Firms are faced with *radical uncertainty*: they do not, they cannot, know what they need to know (Tsoukas, 1996: 22).

Structural uncertainty (Minkler, 1993) leads to a particularly severe form of decision problem. The literature on decision-making helps understand the problem. Structural uncertainty is a form of 'second-order uncertainty' (Kahn and Sarin, 1988, p. 266), leading to ambiguous situations, not stochastic ones (cf. Mosakowski, 1997; Hu, 1994). The difference is that where in a stochastic situation the *probabilities* of uncertain events are known, only a *probability distribution* for the perceived frequencies is known under ambiguity (Kahn and Sarin, 1988). Ambiguity thus results from the uncertainty associated with specifying which of a set of distributions is appropriate in a given situation (Einhorn and Hogarth, 1986). Decisions under ambiguity are decisions where there is uncertainty about the probabilities under which outcomes can occur (Curley, Yates and Abrams, 1986).

Under structural uncertainty, neither the probabilities of the different alternative choices nor all the different alternatives are therefore known. And they cannot be known *a priori*. They are indeterminate and emerging. The basis for taking decisions is not clear. The dispersion of knowledge thus aggravates decision problems.

The starting point of the paper was the observation that outsourcing, although beneficial in terms of cost and lead times, can also create problems, such as for instance a 'hollowing out' of a firm’s knowledge base. In order to address this trade-off systematically, however, managers need to understand what are the mechanisms by which outsourcing creates problems. Once such mechanisms are identified, their effects can be assessed, and counter-measures can be taken. The above section has identified mechanisms by which the dispersion of knowledge (due to outsourcing) leads to management problems. The next section identifies strategies for responding to these management problems.

Solutions for integrating and co-ordinating knowledge

Organisation structures as integration mechanisms. In the literature known as the 'knowledge-based approach' to the theory of the firm[1], *firms* are seen as providing the integration of specialist knowledge (Grant 1996). Firms hire specialists, put them under the authority of a manager, and thereby integrate the knowledge the specialists hold. This literature sees firms doing so by creating the *conditions* for knowledge integration, for instance providing incentives designed to foster co-ordination between individual specialists. Providing knowledge integration is taken to be the reason why firms exist. To provide the *conditions* for knowledge integration does not mean to provide knowledge integration, however. We have to ask: What are the mechanisms underlying the integration of knowledge in firms? Grant (1996) specifies rules and directives, sequencing, routines, and group problem solving and decision making as mechanisms for integrating specialised knowledge.

Now, there is one problem with the notion that firms integrate specialist knowledge. A firm is a hierarchy, a co-ordination mechanism based on authority. The question whether an employee will perform a certain task is decided not by demand and supply (with prices conveying all necessary information), but by superiors who have authority over their subordinates to tell them what task to perform. The problem is that a hierarchy and its underlying mechanism, authority, is not a good way to integrate specialist *knowledge* inputs – even though it might be a good way to co-ordinate and integrate *labour* inputs. In the case of knowledge, it is not possible to know *about* the knowledge that has to be integrated and co-ordinated for its utilisation with *having* that very knowledge. But in that case there will be no specialisation advantages realized through the coordination of specialists, due to the duplication of the specialist knowledge in question. Under the assumption of limited cognitive capacity (Simon, 1955), the possibility of integrating knowledge in this way will therefore be subject to limits – it is not possible at the same time to have the expert knowledge of an engineer, accountant, strategist, marketer, salesman etc. The knowledge of an organisational unit is therefore neither integrated in the unit manager's head nor through the unit manager's directives. Famously, this point has been established by Friedrich A. von Hayek who stated that "dispersed knowledge is *essentially* dispersed, and cannot possibly be gathered together and conveyed to an authority charged with the task of deliberately creating order" (Hayek,

[1] See for instance Grant, 1996; Kogut and Zander, 1992; Kogut and Zander, 1993; Spender, 1996; Foss and Foss , 2000 provide a good overview.

1988, p. 77).

Substitute knowledge by access to knowledge. A second way to provide the integration of dispersed specialist knowledge is to create communication structures through which knowledge can be acquired (Cohen and Levinthal, 1990; Nahapiet and Ghoshal, 1998). Know-what or know-how is substituted by 'know-whom'. Maybe the most common manifestation of this strategy is 'company yellow pages' or databases that allow searching for who has what specialist knowledge in the organisation. One key to achieving co-ordinated action in the face of dispersed knowledge is to develop ways of interrelating and connecting the knowledge each individual has (Tsoukas, 1996). A communication channel itself, however, only provides the necessary, not the sufficient, requirement for integrating knowledge. In addition to the availability of a channel, willingness and motivation, as well as the competencies to use it, are also required. The notion of 'absorptive capacity' (Cohen and Levinthal, 1990) is particularly important here, i.e. being able to receive, interpret and apply knowledge.

The competency to fill in knowledge gaps. Knowledge gaps created by the dispersion of knowledge can also be dealt with by having the competence to fill them in, rather than by transferring the 'missing' knowledge. Egidi suggests that "in reality, individuals (...) have 'incomplete' knowledge, and they are able to complete it by *recreating its missing components"* (Egidi, 1996, p. 307). Collins and Kusch (1998) argue that this strategy – at least to a certain extent – is applied by almost everyone in everyday life. Think about your own capacity to 'repair' misspellings by still recognizing the meaning. In a similar way, one can assume that software users typically have certain competences (for instance, understanding the meaning of a word even despite a missing letter) – an example of the competence to fill in knowledge gaps. The higher this competence, the less is possessing the knowledge required in order to fulfil the task.

Decomposition. The problem of integrating dispersed knowledge can also be handled by containing the size of the problem, thus side-stepping its implications. This can be done by decomposing the organisational units that are to provide knowledge integration into smaller units. In this way, the problems caused by large numbers, and the lack of overview, are alleviated. Decomposition is implemented by delegating tasks. One form of delegation is delegation to an external unit – outsourcing. The need to integrate and co-ordinate the decomposed elements is often fulfilled by what Mintzberg (1979) has called ‘co-ordination by standardisation of work outputs’: Outputs are standardised when the results of the work, for example the dimensions of the product or the performance, are specified. The notion of modularity is a contemporary expression of co-ordination by output standardisation. Modularity has been defined as an approach for organising complex products and processes efficiently by decomposing complex tasks into simpler portions so they can be managed independently (Baldwin and Clark, 1997). It consists in a scheme by which interfaces shared among components in a given product architecture are standardised and specified, thereby allowing for greater reusability and commonality sharing of components among product families (Sanchez and Mahoney, 1996).

Is this also a viable response to deal with the integration of knowledge? In a decomposition or modularization approach the outcome of processes is integrated in which the knowledge in question has been applied. For example, a certain component of a brake system is integrated with other components to form the whole brake system. Knowledge is integrated by integrating the 'products' or 'outcomes' of the processes it was used in – but the underlying knowledge itself (for instance, the expertise and competencies of the engineers) is not integrated. This can easily been seen when considering who holds the knowledge underlying the competence to construct the components: in the case of outsourcing, the supplier holds it, while the car-maker integrates the products produced with this knowledge, but not the knowledge itself. This leads to a self-reinforcing effect: the fact that specialist knowledge is dispersed triggers a further specialisation and division of labour (possibly including outsourcing again) and thereby fuels the necessity of integrating (now even more specialised) knowledge. Once a far-sighted view on the problem is taken, the secondary (i.e., indirect and long-term) effects appear to outweigh the primary (i.e., direct and short-term) effects. In other words: decomposition can only be a short-term remedy and comes at the cost of increasing the very problem it is supposed to solve in the long term.

Integration embodied in physical & virtual artefacts. Artefacts also help knowledge integration. They do so in three ways. First, artefacts represent the knowledge they are composed of. This is why reverse engineering can work. For instance, a particular table represents a solution to the problem of sustaining objects at a certain height against gravitation. As we know, this can be done by four vertical legs, by two legs with a broader base, by one leg ending in a very broad base and so forth. An observer with the appropriate background knowledge (such as of gravitational forces) can infer that knowledgel from looking at the table. The example becomes less evident when one thinks of the proportions of the different parts of a table that are required in order to render it stable. Second, artefacts are a reference for a group, each individual of which may hold different knowledge. The artefact provides an ‘example’ of an architecture along which the individuals can ‘place’ their knowledge and structure their inputs into a problem-solving process (cf. Baba & Nobeoka 1998). Third, due to the fact that they are a reference, they improve communication and coordination amongst the holders of dispersed knowledge, thus making knowledge integration easier (D'Adderio, 2001; Baba & Nobeoka, 1998). Interestingly, not only real objects do have this feature – virtual objects (objects created in computer simulations) have a very similar capacity (D'Adderio, 2001; Baba & Nobeoka, 1998).

Organisational tools for knowledge integration in NPD

After the presentation of strategies for responding to management problems created by dispersed knowledge (due to outsourcing), this section identifies how these strategies are implemented in new product development. As shown in Corso *et al*. (2001), there are at least two dimensions under which the literature on knowledge management in product innovation can be framed: literature concerned with the scope of the knowledge creation system (single product innovation process, product innovation portfolio, relationship with external actors) and literature that deals with the knowledge management process (knowledge creation and management, knowledge transfer for re-use, knowledge sharing). In practice, these two dimensions are strictly intertwined and inform the choice of the organisational tools to manage new product development.

The first attempt in the direction of integrating knowledge in a new product development can be framed at the beginning of the 80’s with the introduction of the concept of concurrent engineering (CE). CE was trying to address the problem of integrating different product development phases at the single project level (Nonaka, 1990; Dowlatshahi, 1994). Overlapping ongoing activities by means of multifunctional teams has rapidly become a common practice in product development and an implicit means of addressing knowledge integration issues across different phases of the process.

At the beginning of the nineties, the literature started to focus on how to improve the performance of teams suggesting solutions such as the *heavyweight* project manager (Wheelwright and Clark, 1992) emphasising the role of the project leader in integrating knowledge and development efforts within teams. Moreover, it began to emerge that the creation of teams did not by itself solve the knowledge integration problems along two dimensions: space and time. Literature on the multi-project management (Cusumano and Nobeoka, 1992), the role of product families (Meyer and Utterback, 1993), the role of product architecture (Henderson and Clarks, 1990), and the importance of developing long term product plans (Wheelwright and Sasser, 1989) has tried to address both the spatial and temporal problem moving the focus of knowledge integration from the individual project level to the company level. As a consequence, from an organisational point of view, new managerial roles diffused such as the product manager, platform and program managers.

In the nineties, moreover, there was also a strong emphasis on the role of external sources of innovation such as suppliers and customers in product development (von Hippel, 1988; Clark, 1989; Cusumano and Takeishi, 1991; Nishiguchi, 1994). Hence, the integration problem began to move from the intra to the inter-company dimension. The most common solution to address the integration problems here, was the use of *guest engineering* (Nishiguchi, 1994) and teams that involved also suppliers. Some literature, in this respect, suggests the importance of *gatekeepers* (Ancona and Caldwell, 1990) to interact with the external sources of knowledge.

A further step of the literature is linked to the re-interpretation of concepts such as component modularity (Whitney, 1988; Ulrich and Eppinger, 1995; Sanchez, 1994). The design strategies that hinge on modularity have been demonstrated to have an impact beyond the engineering aspects. The co-ordination of different actors (R&D centres, OEMs, suppliers, engineering firms) does not hinge only on the hierarchical power but is based on the design interfaces themselves that should act as a co-ordination mechanism.

Finally, recent literature has underlined the crisis of both traditional project-oriented and function-oriented organisations in facing the new innovation and multi-project managerial challenges and has proposed new organisational tools (Hatchuel and Weil, 1999). The new model shows that three different typologies of organisational units are needed in order to develop products in highly innovative contexts: *concept-oriented units*, *knowledge-oriented units*, *management-oriented units*.

This distinction can give useful indications on the organisational modes to achieve an advantageous separation of research, development and product strategy. Once the component's or system's *concept* is defined by the first type of unit (*concept oriented unit*), the *knowledge oriented units* can develop the so-called *half way solutions*. The latter, in contrast to what happens with the traditional research centres, are tested and validated so that the *project leaders* can introduce them with few risks. These knowledge oriented units are not project-based. People and functions are grouped on a technological basis or according to the type of system/component under development. Similarly, the units that manage the applications (*management oriented unit*) are not responsible for the overall product innovation contents but have the task to define the spectrum of action of the units in charge of developing new concepts. To sum up, organisational units endowed with a strong technological know-how on the basis of market indications and science developments elaborate, develop, test and industrialise new *concepts* that will be exploited in specific applications by product managers.

This solution seems to able to address the integration problem by distinguishing the type of knowledge required to carry out the development tasks. However, this solution pushes toward the centralization of R&D opposed to the outsourcing of design. Recent evidence seems to confirm this trend (Argyris and Silverman, 2002).

Whether these co-ordination mechanisms are able to integrate knowledge has not been fully investigated yet and will be object of specific attention when results from the case study will be compared with the framework described above.

In what follows, the streams of NPD literature presented above and the organisational solutions present in the literature are used as a backbone for the organisational analysis of the FIAT Auto case study.

In Table 1, we provide a synthesis of the relationship between the strategies to cope with knowledge dispersion and the organisational tools suggested by the dominant literature on NPD organisation. The use of teams and heavyweight project managers can be associated with the strategies based on the usage of organisation structure. The first integration mechanism is hierarchical power. The new organisational roles such as that of the platform manager, in charge of coordinating several projects and leveraging knowledge across them, can be framed within the strategies of fostering knowledge sharing through organisational information channels. The same role is played by companies *gatekeepers* in inter and intra firm integration of knowledge.

We did not find any formal NPD solution relating to the strategy of *competency to fill in knowledge gaps*, probably because it is not possible to formalise a competence that is strictly embodied in people in form of organisational tools.

The use of standard interfaces as design and organisational coordination mechanism is clearly related to the *decomposition* strategy. Defining standard interfaces allows the decomposition of complex design and NPD process tasks in simpler ones.

Finally, the development of *half way solutions* in the transaction between different units of the company allows the integration of knowledge that is embodied both in physical and virtual artefacts.

Table 1. *Strategies to cope with knowledge dispersion, and organisational tools to implement these strategies*

Strategy	NPD Solution
Organisation structures (hierarchy)	– Concurrent engineering (C.E.), Teams, Heavyweight project managers
Substitute knowledge by access to knowledge	– New organisational roles (i.e. platform managers) – Gate keepers
Competency to fill in knowledge gaps	– None
Decomposition	– Modularity (i.e. integration by standard interfaces)
Physical and virtual artefacts	– Half way solutions

3. FIAT's internal organisation for NPD: the macro-structure

The FIAT case

FIAT Auto was chosen because it has carried out an impressive number of organisational changes, both with reference to its internal structure and its supply chain. Together with an unprecedented outsourcing strategy it has also recently revolutionised its NPD process. In line with recent trends in the industry, FIAT, at the beginning of the nineties, set as its goals (1) platforms number reduction, (2) leadership in the distinctive style of its models, in the presence of a multi-brand strategy and (3) involvement of suppliers in the vehicle design up to 85% of the overall dedicated design effort.

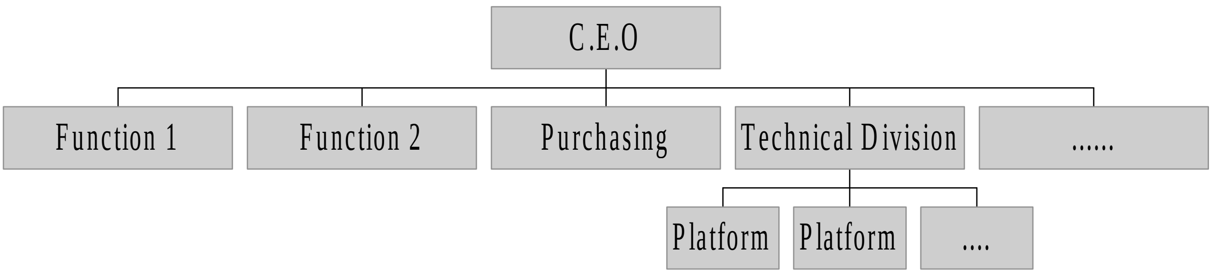
The nature of our research made the choice of the *exploratory* case study method the most appropriate (Yin, 1994). Two data collection methods were used. The first was the study of archival sources to define the characteristics of the sector and the history of the selected company. The second involved extensive semi-structured interviews with managers from

FIAT Auto and one of its research centers. Data gathered refer to the last decade and were collected between 1998 and 2001.

Period 1991-1996

In 1991, the effort to rationalise the new product development process and to maximise common parts across models had led FIAT to create a typical matrix structure to organise product development. Platforms were defined on a market segmentation criterion in correspondence with five segments (A, B, C, D, E and Commercial Vehicles)[2]. Each platform managed the three brands, Alfa Romeo, FIAT and Lancia, and had its own general manager coming from the *technical division*, its *core team*, which encompassed people from all the functions (from purchasing to production), and relied on project leaders for each single NPD project. The platform was responsible for the product until its launch on the market. At this stage the fate of the new car was handed over to the commercial division. All platforms reported to the chief of the *technical division* who had to manage all the feedback and eventually co-ordinate the platforms' efforts (Figure 1).

Figure 1. *FIAT's structure until 1996*



This setting, based on the project management organisation principles, did not seem to be able to cope with the growing product complexity, the new role of suppliers in component design, and the need of product differentiation among the three FIAT Auto brands. The major pitfalls of this first version of FIAT platform were:

(1) centralisation not associated with the benefit of more co-ordination, and

(2) the scope of the activities carried out by the platform.

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[2] In 1975 FIAT Auto had 10 *product* platforms for 13 models, with a ratio of 1.3 products per platform. In 1990 this ratio was 3.2 with 16 models built on 5 *product* platforms and managed by 5 *development* platforms (Volpato, 1996, p. 163). The concept of *platform* in FIAT Auto has a double dimension: it corresponds both to the core of the vehicle and to the organisation unit in charge of managing it. Below, we refer to a platform exclusively from an organisational point of view and will specify when referring to a *product platform*.

The *technical division* had represented the core of FIAT Auto and of its NPD process until the reorganisation in 1991. In fact, the technical division was, together with the technology division, in charge of new components and technologies developments. This legacy resulted in a strong empowerment of the chief of the *technical division*. After the creation of the development platforms in 1991, he was still fully responsible for the NPD and received feedback from platforms on all the models under development. The increasing number of models, the growing complexity of co-ordination of the development tasks (also due to the increasing involvement of suppliers), and the pressure on costs and lead time, contributed to 'congest' the information and knowledge flows in the NPD organisation.

The second most relevant limit of the platform was the scope of its action. The hand-over of responsibility for the product after its launch to another unit limited the ability of the development platform to incorporate customers' feedback in future product generations together with manufacturing insights for future design. Beyond the information processing limits, the motivation of the platform team also suffered from this split responsibility.

Period 1995-2001

Hence, in the mid 1990s FIAT Auto still had to gain (1) strong product integrity[3], (2) cost savings through parts commonality among different products and (3) a renewed brand identity. It was forced to change its structure again.

The success of the new organisation was strongly dependent on its ability to fit the needs of an efficient and effective multi-project strategy and at the same time, given the new FIAT's mission of becoming a *system integrator*, to involve suppliers in the vehicle design more effectively and efficiently.

The new organisational structure, defined in 1995 and operatively starting in 1996, was based on the existing platform concept but it radically changed the power equilibrium within the structure and the responsibility of the platforms.

The *new platform organisation* was based on a market segmentation criterion as far as the seven platforms (A, B, C, D, E, commercial vehicle, internationl platform) were concerned,

[3] Fujimoto et al. (1996) define product integrity on the basis of two elements: the product's *coherence* and the product's *fit*. "The product's coherence defines the extent to which the product's details, subsystems, and component proactively combine to achieve consistency in concept, character, and technical functionality. […] The product's fit is a measure of how well a product's function, structure, and semantics fit the customers' expectations - their objectives, values, production system, life style, or use pattern, for example." (Fujimoto et al., 1996, p.126).

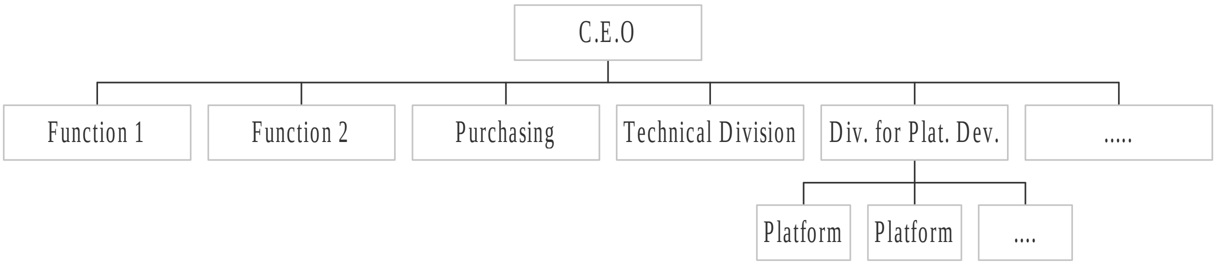
while relying on a technological basis as far as the Component Development Platform was concerned. Completely new were the *international platform* in charge of the FIAT global car (Palio) and the *components development platform* in charge of 70 different sub areas each of which corresponded to a specific typology of component (from ABS to wheel). The seven *platforms* in charge of car development were based on a *core team* formed by seven professional profiles (platform director, product manager, controller, plant manager, purchasing manager, technology engineer, technical engineer). A *platform* followed the life of the product from its generation to its end. This is the reason why, together with the scope of its activities, the new platform was also called *extended platform*.

The development phase was managed by a project manager who was under the platform core team and supervised a systems manager that co-ordinated 4 system developers (chassis, body, engine, electric systems). Under the 4 system developers there were 19 teams, each correspondent to a part of the vehicle. Among these teams there were also the suppliers involved in the NPD. The managers who previously were in charge of the platforms under the *technical division* now reported to the newly created *division for platforms development* that deals directly with the CEO (Figure 2).

The *division for platforms development* (henceforth DPD) has the role of co-ordinating the existing platforms in a coherent fashion[4]. It manages the NPD process from the definition of the process itself to its implementation. It is the point of reference for people belonging to different functional divisions that are employed in development teams and for the platforms. Finally, it is formally in charge of staffing and monitoring the work of platforms and development teams, taking care that a maximum level of coherence is achieved.

[4] It counts between 120 and 160 permanent employees, opposed to almost 3000 belonging to the technical and technology divisions.

Figure 2. *FIAT's structure after 1996*



Parallel to the platforms that manage specific car segments, FIAT started developing long range plans (usually ten years) that encompassed model substitutions and technology developments. These technology developments referred both to pure R&D on new materials (managed by the *technology division* and the research centres), new engine development (managed by the *technical division* and the research centres) and component development (managed by the *components development platform*).

Much of FIAT's multi-project strategy was developed at this stage. Most of the operative work, however, was carried out by the car development platforms that customised the available technology to the model under development. As far as standardisation and supplier involvement were concerned, the *components development platform* (henceforth CDP) played a crucial role which implied three major tasks[5]:

1. Concept development of major systems prior to vehicle application.
2. Component plan to satisfy multiple scenarios.
3. Explicit up-front application planning.

If the CDP had not developed, or was not willing to develop a specific system in-house, which was the case in the majority of situations (85%), it contacted a panel of suppliers to define a long term plan to develop the system. The tendency was to involve suppliers before the concept phase began so that the moment the NPD process started, the platform core team could choose the appropriate component from a range of solutions. This enabled the NPD platform to have an early and precise idea of the technological and economic contents of the car that was going to be created. Usually, this early involvement was finalised to a specific application in a future model, and CDP and the supplier worked on the existing subsystem,

[5] Notably, the CDP has first reported to the DPD, and then it has been incorporated into the Technical division.

taking it as a basis for improvement. This kind of collaboration was not very common at the moment of its introduction but grew considerably. As a FIAT manager put it:

> "We are creating a sort of relay race in which the *components development platform* is the first to start and the NPD Platform is the second. This latter platform has only to integrate the system which has already been developed in the new car." (Interview, Global Sourcing Manager, May 1998).

Once the model was introduced on the market, the product manager handed over the project to another member of the platform in charge of the continuous improvement of the existing model. This structure was characterised by the fact that the platform monitored the model during its whole life, integrating the development phase with the production phase. In this way the feedback for the following NPD was also enriched by customer suggestions and new production process solutions.

Hence, in 1996 FIAT revolutionised its NPD process and organisation[6]. As can be seen, the traditional development team was still at the core of the development process. However, its tasks were narrowed in some respects. The *components development platform*, the *technical division* and the *technology division* did much of the job of components development. The NPD dedicated team had to focus on the *vehicle concept* generation and implementation. Components were developed in the above-mentioned long term plans. FIAT divided a car into 105 parts (systems). Each of the 105 component/system developments was monitored by either the *components development platform,* the *technical division,* or the *technology division* and in most cases outsourced to third parties, such as suppliers or engineering consultancy firms. In this way FIAT was implementing its strategic goal of *becoming a systems integrator*. The new organisation hinged on the concept of *modular product architecture*. This enabled the leveraging of similar technologies on *extended platforms* for application in many different models[7].

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[6] As to the re-engineering of FIAT see also Lipparini and Melloni (1996) and Calabrese (1997).

[7] Areas in which a modular architecture can contribute are wheelbase, track, overhangs, suspension, engines (Sheriff, 1998). The new flexible chassis structure named 'space frame', core of the new FIAT Multipla, is the typical example of this strategy. FIAT, however, is now taking into great consideration the trade-off between *importance to the customer of variety* and *cost of variety*. Thus, Engine and Chassis usually form a *product platform* and are leveraged in different models also across market segments. Components such as door latches are completely standardised, ventilation and axles are often in common, while sheet metal, steering wheels and front fascias are greatly differentiated among models (Sheriff, 1998).

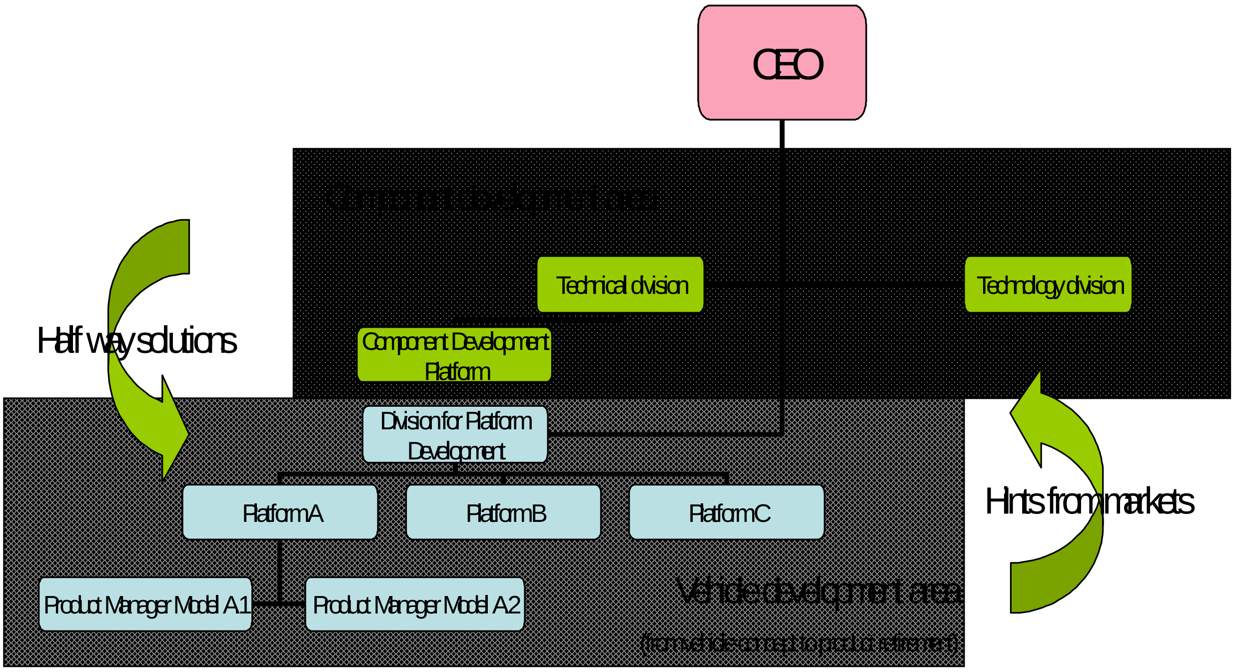
The so-called *multi-project* management (Cusumano and Nobeoka, 1998) was carried out by the *division for platform development*, which monitored and co-ordinated the development teams headed by the product managers and, so doing, co-ordinated the development efforts of different projects. The management of long-term development plans, however, was delegated to the technical division and the technology division (the CDP is now part of the technical division but is considered separately, given its peculiar role in involving external sources of knowledge within the firm). Figure 3 shows how organisational units endowed with a strong technological know-how, on the basis of market indications and science developments, elaborated, developed, tested and industrialised new *concepts* that would have been exploited in specific applications by product managers.

The component development units were not project oriented but mainly organised on a technological basis[8]. They developed solutions that, despite being tested and industrialised, were generic enough to be leveraged on different models. The *extended platforms* focused on the application of these solutions acting, at the same time, as market gate keepers and contributing to the generation of new concepts. With reference to suppliers involved in long term plans of component/system developments, they could, as an extension of the *components development platform*, be considered as *knowledge units* as well.

In reality, there were several frictions that inhibited FIAT's new structure benefiting from the potential of modular design and the *components development platform* as far as supplier involvement was concerned. Problems were mainly related to the fact that those who played the role of interface between the knowledge generator (supplier) and the application manager needed to have a strong technological and marketing command. FIAT's *components development platform* seemed to have these skills. On the other hand, it did not have sufficient independence in choosing the suppliers and managing the relationship with them. The power equilibrium was still in favour of the purchasing department (now FIAT-GM world wide purchasing) whose task it was to lower the price of supply while improving the quality standards of the component purchased.

[8] We refer here to concept, knowledge and management oriented units as described by Hatchuel and Weil (1999). We expand their perspective in the next section.

Figure 3. *A synthesis of new product development organisation at Fiat Auto*



Period 2001 up to date

During the year 2001 the situation has changed again. In March 2000, FIAT Auto set up an agreement with GM based on an equity swap and, from an operative point of view, on the formation of two companies in which all FIAT Auto and GM (Europe and Latin America) activities related to purchasing, engines and transmissions' design and production were merged. The setting-up of GM-FIAT World Wide Purchasing has great relevance here. This company has unified the purchasing activities of FIAT and GM, which have agreed not to use other purchasing channels than this one (FIAT does not have a purchasing division anymore). The new company is willing to achieve results both in the short term, thanks to improved efficiency in the purchasing process due to bigger volumes (in the geographical area where the agreement is in force, FIAT and GM sell 2.700.000 vehicles each), in the medium term with major components sharing between the two companies, and in the long term with the common development of components and platforms.

Another complete reshaping of the internal organization structure has taken place in 2002. It would not be appropriate to report on these changes given the stage of their implementation. What is relevant, however, is that apparently neither the DPD nor the CDP will considerably change its scope of activity. On the other hand, major changes will occur in common platform and brand management.

Table 2. Strategies to cope with knowledge dispersion and organisational tools applied in FIAT Auto

Strategy	**NPD Solution**
Organisation structures (hierarchy)	– C.E., Teams, Heavyweight project managers
Substitute knowledge by access to knowledge	– DPD
Competence to fill in knowledge gaps	– None
Decomposition	– DPD, CDP
Physical and virtual artefacts	– CPD (Half way solutions)

4. The knowledge integration characteristics of FIAT's NPD organisation

4.1 Effects of the reorganization[9]

Effect #1: The integration problem can be expected to increase in the future

In 1995 FIAT had recognised that it had a problem coping with the complexity of the new product development process and decided to change the organizational structure of the NPD process. In the reorganisation of 1996, FIAT introduced the Division for Platform Development (DPD) and the Component Development Platform (CDP). In contrast to the previous organisational structure, the DPD now reported directly to the CEO. Furthermore, the DPD had the task of *organisational co-ordination*, such as staffing of the platforms. It also implemented multi-project management. These measures solved the problem of the 'bottleneck' in the organisation structure that led to difficulties in dealing with complexity. While the DPD was made responsible for organizing the NPD process, the CDP was put in charge of the development of the components themselves, i.e., of the technical level. It is important to note that whereas the DPD reported directly to the CEO, the CDP was part of the technical division.

What implications did the introduction of DPD and CDP have on FIAT's competence of integrating knowledge? In order to identify the implications, we will focus on the range of

[9] The analysis of the FIAT Auto case is based on the passage from the first to the second reorganisation (i. e. that of 1996) and refers to the latter.

'tools' from the literature on the organization of the new product development process and then identify which effect of increased dispersion of knowledge has been addressed, and how. In this section, we concentrate on the three kinds of organisational units in new product development as distinguished by Hatchuel and Weil (1999).

In Hatchuel and Weil's terms, the CDP (as well as the *technical division of which it is a part, and the technology division*), were a knowledge-oriented unit. The DPD, on the other hand, was a management-oriented unit. The CDP and the two divisions just mentioned were not project oriented but were mainly organised on a technological basis. They developed solutions that, although being tested and industrialised, were generic enough to be leveraged on different models. With the *components development platform (CDP),* FIAT was probably trying to put into practice the concept of modular design and the new role of suppliers in the product development process. Such a strategy hinged on the concept of modularity as enabler of generic (*halfway*) solutions that can be used in a relatively safe and quick way by several product managers. Only by creating the *components development platform (CDP),* supplier involvement could be carried out at the concept stage of development and, at the same time, FIAT could count on components and systems that could be introduced in more than one model in an inexpensive way. The reason why this was not possible in the traditional platform-based structure is that the involvement of suppliers at the concept stage becomes too idiosyncratic to the specific model under development, leading to what has been called “fat” design (Fujimoto, 1997). The framework introduced in section 2 allows us to trace which driving forces of the knowledge integration problem have been addressed by the introduction of DPD and CDP. The three driving forces of integration problems identified were large numbers, knowledge asymmetries and uncertainty. The DPD appears to be addressing the large number problem. This becomes clear when informants describe the problem as a communicative bottleneck. Of the two effects of large numbers – higher resource requirements for integrating the dispersed elements and loss of overview – introducing the DPD clearly addresses the first effect. How was the second effect tackeld, the loss of overview? In our interpretation, the CDP was to tackle this problem. The way in which the CDP addressed it was by the strategy of decomposition: rather than *having* the specialist knowledge required for the design of the various components in-house and *co-ordinating* it internally, the choice was to *decompose* the problem, and to *delegate* the integration of the specialist knowledge required for designing (and subsequently, producing) parts either to the technical or the technology division, or to suppliers. The task of the CDP then was to *integrate* that specialist knowledge held by others, within and outside FIAT. Now, the crucial point is that the CDP, responsible for integrating the specialist knowledge and competences of the suppliers, chose exactly the same strategy as the DPD : decomposition. The CDP thus attempted to integrate knowledge and components by integrating the *products* produced with the knowledge, not the *knowledge itself*. This difference matters because it means that efforts of knowledge integration were limited only to architectural knowledge, not component-specific knowledge. Both the management-oriented units *and* the knowledge-oriented units relied on decomposition. The implication was that the knowledge-oriented unit (CDP) was actually not fulfilling its role of integrating knowledge and competencies with regard to component-specific knowledge, but was delegating the problem further, to the suppliers. Remember that CDP stands for 'Component Development Platform'. In fact, the CDP was doing exactly the opposite of *integrating* component-specific knowledge. It was fuelling a further dispersion of component-specific knowledge. The idea that the CDP would integrate the specialist component-specific knowledge turned out to be largely an illusion.

As explained in section 2, the decomposition strategy is only a short-term remedy, as it actually has the implication of aggravating and accelerating the problem of dispersed specialist knowledge. The strategy chosen by FIAT can thus be expected to aggravate the problem that it was designed to solve.

Effect #2: Specialist knowledge is pushed further out of reach

The CDP not only chose the decomposition strategy and the delegation of component development. It also chose to delegate around 80% of the components to be developed *outside* FIAT. This added another difficulty to the task of integrating specialist knowledge: namely, that knowledge was now more difficult to reach, too, as it was held outside the firm. This meant that taking direct influence through authority was not possible anymore. Any kind of influence, for instance through appropriately designed incentives, would be much more complicated. Furthermore, asymmetries in bodies of knowledge held by suppliers and by FIAT would further increase due to the fact that because of outsourcing of design to the supplier, the supplier would experience learning-by-doing effects, while FIAT would not experience those. These asymmetries in bodies of specialist knowledge would then feed asymmetries in cognitive framework such as conceptualizing the architecture of a car.

The conclusion is therefore that specialist knowledge will slip out of reach even more than before, and it will become increasingly difficult for FIAT to integrate it. It has become more difficult because, due to the pursuit of massive outsourcing, the problem now is not only how to integrate specialist knowledge, but also how to integrate specialist knowledge held to a large extent by other firms. On top of that, asymmetries between the specialist knowledge and the cognitive frameworks of the automaker and the suppliers will increase if no action is taken to alleviate this effect.

Effect #3: Internal absorptive capacity is weakened

As will be argued in this section, there is another reason why the organization structure chosen in the 1996 reorganization did not lead to the desired result. While we have described above how the new *organization structure* and the strategy chosen made the integration task more difficult, we will now show why the *organizational capability* of knowledge integration was weakened.

In order to understand how organization structures like the CDP provide knowledge integration, we now focus on the role of teams, one of the key organizational structures in new product development (Clark and Fujimoto, 1991). Teams have also been credited with a role in knowledge integration. More specifically, interaction within teams seems to be where knowledge integration is taking place.

In order to assess the capability of CDP and DPD to integrate knowledge, we therefore need to look at how the introduction of CDP and DPD affects the functioning of teams, in particular interaction flows. In section 2 we have described how the tasks of the traditional development team were narrowed when the DPD was introduced in 1996. The development teams still remained at the core of the development process, however. Importantly, the *delegation* of component development outside the team was stepped up, be it to the technical division, the technology division (in-house), a research centre or to suppliers (outsourcing). In the latter case, the CDP had an integration task. The NPD dedicated team therefore had a narrower focus on the *vehicle concept* generation and implementation, as opposed to *component* generation and implementation. Focussing on the analysis of interaction as the key driver of knowledge integration, the conclusion is clear: the increasing split of *vehicle concept* development and *component* development tasks – by allocating them to different organisational units – will lead to two different circuits of interaction, one regarding vehicle concept development and the other regarding component development. Over time, these circuits of interaction will form two distinct (if possibly overlapping) communities of practice, with distinct mental frameworks, a distinct language, and distinct ways of interacting, planning, reporting and the like. Rather than alleviating asymmetries – and thereby working towards knowledge integration – these are aggravated. This interaction-driven effect will furthermore be reinforced and amplified by the fact that the DPD reports directly to the CEO, i.e. is a relatively independent unit, while the CDP is part of the technical division. It is easy to imagine how the perspective of the CEO will differ from that of the head of the technology division, and thus, that DPD and CDP are exposed to very different influences. It therefore appears highly likely that there will be an effect of *de*creasing knowledge integration capability, as the development of a gap between these two areas is programmed. Such a gap will clearly make knowledge integration more difficult.

Another driver that decreases FIAT's knowledge integration capability is that internal absorptive capacity (Cohen and Levinthal, 1990) is also negatively affected by the reorganization. Absorptive capacity can be generated in several ways: as a by-product of a firm's R&D investment, as a by-product of manufacturing (learning by doing), and as a product of direct investment (for instance in training). Now, to the extent that manufacturing and design are (at least partly) outsourced, there are less sources of absorptive capacity. This has wide-ranging consequences, not in the immediate short term, but in the medium- and long-term. Once absorptive capacity in a certain field has not been generated and/or renewed so that a certain minimum level is kept up, the firm may never assimilate and exploit new information in that field. It will be 'locked out' from further development (cf. Cohen and Levinthal, 1990).

Absorptive capacity is thus also required internally, between different organisational units. It can be provided by boundary spanners or 'linking pins', institutionalised personal contacts across organisational units. The more dissimilar the knowledge to be transferred or integrated, the more important boundary spanners are. As *vehicle concept* and *component* design are becoming increasingly detached, the importance of boundary spanners that can 'translate' the cognitive models, transfer knowledge between the units, and integrate knowledge into the unit under consideration, will be ever more important.

The organization structure put in place by FIAT in the 1996 reorganization therefore seems to make the task of integration of specialist knowledge more difficult and to weaken the organisational capability to integrate specialist knowledge[10].

5. Conclusion

The objective of the paper has been to fill the gap between (1) design outsourcing strategy, in particular the currently dominant strategy based on systems- and module-integration, and (2) the question of which organizational structures to choose for implementing such a strategy and for managing the new product development process. We have cast light on the relation between a systems-integrator strategy and its implementation from the case of FIAT Auto, which seems particularly adequate as FIAT has pursued a design outsourcing strategy to a higher degree than any other firm in the auto industry.

The framework for managing dispersed knowledge introduced in the paper allows us to analyse the way in which such a strategy has been implemented. It is clear that FIAT has relied on a 'pure' strategy of decomposition. Such a strategy was implemented by introducing two new organizational units, the DPD and the CDP. Our analysis has shown that the fact that not only the DPD, but also the CDP have chosen to respond to the dispersion of knowledge by further decomposition, actually led to disperse specialist knowledge even further, rather than to integrate it, at least with regard to component-specific knowledge. The conclusion therefore is that such a strategy will further aggravate, rather than alleviate, the problem. In addition, the measures adopted in the reorganization also led to a weakening of the organizational capability for knowledge integration. FIAT, as the most prominent Italian automaker, therefore appears to be in danger of hollowing out its knowledge-base.

There is more to be learned from the FIAT Auto case. Revisiting the three effects of the measures taken by FIAT Auto as identified above, the following conclusions can be drawn. Effect #1 has shown that there is a difference in kind between the decomposition strategy and the other strategies. The difference consists in the fact that the decomposition strategy, while alleviating the problems created by the dispersion of specialist knowledge in the short term, aggravates them in the long term. For this reason, it is crucial that counter-balancing measures are taken in order to provide a counter-weight to such detrimental effects when pursuing the

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[10] Counter actions such as job rotation fostered by career incentives do not seem to be used extensively at FIAT,

decomposition strategy. Effect #2 has pointed out that when applying outsourcing, managers lose one strategic option out of the range of possible responses: knowledge integration by direction, based on authority within the hierarchy of the firm. While it is not excluded that there are other forms of authority that allow a similar kind of knowledge integration (for instance authority within a network), such forms are not as strong as authority conferred by hierarchy (Williamson, 1985). As it turns out, this option is a very powerful one. Losing it thus significantly diminishes the range of possible managerial responses. Finally, effect #3 means that implementing an outsourcing strategy also has the implication that the efficiency of the 'access to knowledge' response will be dampened. The 'further' away from the firm, the more difficult to access. Taken together, the implications of an outsourcing strategy are that the options available to new product development managers for addressing the central problem in managing the new product development process are drastically reduced, both in number and efficiency.

Implications for practice

The main implication for practice resulting from our analysis of the case of FIAT Auto is that a design outsourcing strategy is difficult to implement. Two difficulties in particular can be pinpointed. First, the danger of hollowing out the knowledge-base. This can lead to problems with evaluating components (Lincoln, Ahmadjian and Mason, 1998) and general loss of design and new product development capabilities, due for instance to loss of the capability to handle the product architecture well (take vibration control as an example). Addressing that danger is the main challenge in implementing a design outsourcing strategy. This is where the second difficulty comes to bear, however. The main task in managing new product development being to integrate knowledge dispersed within the firm and across the supply chain, the possible options for implementing knowledge integration are much diminished when this task is tackled by decomposition (internally in the firm by introducing new, more specialized, orgnizational units, or externally by outsourcing to suppliers). In such a case, it is crucial to be aware that counter-balancing measures have to be taken in order to provide counter-measures for such effects that aggravate the knowledge integration problem. Boundary spanners that can put in place well-functioning communication between the new (internal or external) specialised units are one possibility. Keeping internal organizational units involved in the same activity as the external suppliers, by way of dry runs, shadow

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not as reported by Takeishi (2002).

engineering, or patenting in the supplier's domain, is another one. A clear result of the analysis of the FIAT Auto case is that whenever outsourcing is applied, such counter-balancing measures are urgently required. Without them, the risk of a hollowing out the knowledge-base, and the consequence of loss of parts evaluation capability (Lincoln, Ahmadjian and Mason 1998) will become a reality. With such countermeasures, firms may have a chance of combining the best of both worlds: the speed and cost efficiency of outsourcing, and the maintenance of their knowledge base (while updating it through learning).

Implications for research

From a theoretical point of view, the paper has addressed the question how to implement a systems integrator strategy. Such a strategy can be applied particularly well for modular products, for which reason auto manufacturers are eager to work towards the modularization of cars. Modularity is currently the dominant strategy in the automotive industry.

Now, applying a resource-based perspective on new product development organization has shown that there is an important gap between a systems-integrator strategy and how to implement it. One cannot address the implementation of such a strategy by merely focussing on the physical dimension (production, logistics etc.). Accordingly, transaction cost logic will most likely come to its limits here. Rather, it is important to recognise what is in the gap between that strategy and its implementation, what determines the effects of different ways of implementing a systems-integrator strategy. The resource-based view highlights that the central challenge in new product development is knowledge integration (Grant, 1996). Recently, literature indicates that systems integration is not the same as knowledge integration (Brusoni, Prencipe and Pavitt, 2002; Nesta and Dibiaggio, 2002). The boundaries of the division of labour and the division of knowledge do not always, and not necessarily, overlap. If that is true, however, and if the resource-based analysis is right in that knowledge integration is the central challenge of the new product development process (and not the integration of modules and components into the product as a whole), then a shift of emphasis is needed: from a systems-integrator strategy to a knowledge-integrator strategy. After all, it is at this level that the success of the systems-integrator strategy will be decided.

It should be clear by now that taking a resource-based perspective with a focus on knowledge has something to add in order to understand the organization of new product development. In a transaction cost economics perspective, attention is focused on the question of how to govern exchange relationships in the most efficient way while safeguarding against the risks of exploitable dependencies. A production-cost perspective (such as taken by many managers) is dominated by a short time horizon, just as justifying long-term benefits is difficult due to problems in measuring long-term benefits. In both perspectives, the medium- and long-term perils associated with the hollowing out of the knowledge base are underestimated or neglected. Even more to the point, only the resource-based perspective uncovers strategies to counter-weigh the reliance on a systems-integrator strategy. The FIAT case presented here can thus be seen as a strong case in point for a (complementary) application of the resource-based perspective to strategic questions in the area of operations strategy.

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