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HOW HAS THE CO-ORDINATION OF KNOWLEDGE AND COMPETENCIES CHANGED AFTER THE WAVE OF STRONG ENGINEERING OUTSOURCING IN THE AUTOMOTIVE INDUSTRY? THE CASE OF ITALY

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INTRODUCTION

In recent years, the Italian automotive industry has experienced a wave of strong engineering outsourcing (Fujimoto, 1997; Liker *et al.*, 1995; Helper and Sako, 1995; Womack *et al.*, 1990). The main motivations for outsourcing are cost efficiency, lead time shortening, product integrity and flexibility (Clark, 1989; Clark and Fujimoto, 1991; Nishiguchi, 1994). Outsourcing decisions, however, also decide on the location of knowledge and competencies[1], and on the allocation of learning opportunities. Outsourcing decisions thus not only impact the cost dimension, but also the knowledge and competence dimension. It is important to take the impact of outsourcing decisions on these dimensions into consideration. Even if yielding advantageous effects on costs and flexibility in the short run, in the medium and long run outsourcing can lead to a 'hollowing out' of the knowledge and competence base, which can easily offset all short-term cost advantages gained. Moreover, outsourcing also leads to a dispersion of specialist knowledge and competencies among the carmakers and its suppliers. Subsequently, outsourcing requires the carmakers to solve, through newly designed organisational mechanisms and processes, the task of integrating and co-ordinating increasingly specialised knowledge and competencies.

The present paper focuses on how the integration and co-ordination of knowledge and competencies in the Italian automotive industry is effected. The paper reports on a longitudinal case study of FIAT's new product development process (henceforth 'NPD') organisation. FIAT is an interesting case for studying the integration and co-ordination of specialist knowledge and competencies for NPD because it has undergone a stream of several

[1] The present paper focuses on the integration and coordination of knowledge and competencies. It is not its scope to contribute to the questions 'What is knowledge?' and 'What are competencies?'. For working definition purposes, our notion of knowledge takes account of the differences between data, information, and knowledge, as well as of the distinction between tacit and explicit knowledge (cf. Fransmann, 1998). For our notion of competence, see Dosi, Nelson and Winter (2000).

reorganisations in the last 10 years, which is still ongoing. The FIAT case therefore allows the comparison of different configurations of knowledge and competence locations along the supply chain, as well as different organisational mechanisms and processes for integrating and co-ordination knowledge and competencies.

In order to maintain focus, we restrict ourselves to knowledge and competencies drawn on in the NPD process. The questions along which the paper unfolds are: 'Which organisational structures and practices are used for integrating the NPD knowledge and competencies?', and 'Which effect did the recent reorganisations have on the carmakers' competence to integrate specialist knowledge and competencies?' The answer to the latter question will lead us to consider the location of knowledge and competencies along the supply chain and to address the question 'Which (kinds of) NPD competencies are held by FIAT, and which ones by suppliers?' Section two develops a framework for analysing knowledge and competence integration and co-ordination. Section three describes FIAT's organisation of the NPD process. The subsequent section four then highlights some of the features of FIAT's NPD organisation under the perspective of how well it is suited for providing knowledge and competence integration and co-ordination, the main challenges in the organisation and management of NPD. Section five concludes and draws implications for the case of FIAT, but also for further research on the co-ordination of competencies in the automotive industry.

A FRAMEWORK FOR ANALYSING KNOWLEDGE AND COMPETENCE INTEGRATION AND CO-ORDINATION

One of the central problems of NPD, in particular of complex products such as cars, is that a substantial number of 'elements' of very different types of knowledge has to be integrated and co-ordinated in the NPD process. For instance, in developing a new model of a car, chassis, engine, interior, and many components are involved, but also market intelligence about customers, knowledge about new materials, and knowledge about new production technology, to give only a few examples. Because of strong competitive pressure, each of these bodies of knowledge need to be up to date and able to contribute to at least industry-average efficiency and profitability. In order to fulfil these competitive requirements a high degree of specialisation is required: better brakes are likely to be constructed by engineers focussing only on brakes, rather than by all-purpose mechanical engineers. From an organisational perspective, the central problem to be solved in the organisation of the NPD process is therefore how to integrate and co-ordinate the specialist knowledge of the participants in the NPD process. The issue is twofold: in the first place, the problems underlying the integration and co-ordination of knowledge have to be addressed; in the second place, it is relevant to understand what organisational structures and practices are used for integrating and co-ordinating the knowledge and competencies required in the NPD process.

In fact, which solutions to problems of integrating and co-ordinating knowledge and competencies will be possible and adequate depends on the precise nature of the problem in question. In this section, we therefore dissect the problems that the dispersion of specialist knowledge leads to. We can identify three characteristics of dispersed knowledge that lead to problems with integrating it: large numbers, asymmetries and uncertainty.

Large numbers

Large numbers increase the resource requirements for integration. The more fragments there are to be drawn together, the more resources are needed [to do that]. Limits on (cognitive and other) resources, for instance, translate into limits to the amount of dispersed knowledge that can be co-ordinated and thus 'absorbed'. A second, and maybe much more important, effect is that large numbers give rise to intransparency – a loss of overview. It is this characteristic that has given rise to the now classic notion of a limited 'span of control'.

Asymmetries

If there are problems with integrating knowledge, for instance in gathering all the necessary knowledge in one NPD unit that carries out the whole development of a new car model, it logically follows that different participants in the NPD process will have asymmetric knowledge – they will know different things to different degrees. Such asymmetries in knowledge give rise to further asymmetries in learning and competence development over time. The reason is learning by doing. A team that has the specialist knowledge to develop brake components will have the occasion of learning by doing in the process of developing them, and of developing the knowledge and the competencies connected to it. Knowledge asymmetries are thus in tendency increasing over time. Note that such an effect is not just constrained to the level of knowledge and competencies. It also extends to the level of mental frameworks. Accountants develop an accountant mentality, engineers an engineering mentality etc. This widening gap in mentalities is an additional reason why the integration problem gets more difficult over time.

Uncertainty

Because it is impossible to draw together all the 'parts' of knowledge that would be required in order to have the full overview of all the necessary parameters for taking a decision with certainty (i.e., specifying all choices alternatives, all their outcomes, and the probabilities with which each of them will be realised), the dispersion of knowledge also gives rise to structural uncertainty (Minkler, 1993; Tsoukas, 1996). Structural uncertainty is a strong form of uncertainty that extends beyond risk. While risk can be dealt with by increasing the information available, thereby enabling to choose the alternative with the highest expected utility, this is not possible in the case of structural uncertainty (for more detail on this, see Becker and Knudsen, 2001).

Large numbers, knowledge asymmetries and uncertainty are therefore the driving force behind the problems that the dispersion of knowledge – as triggered by outsourcing – leads to. How can these problems be dealt with?

Which organisational structures and practices can be used for integrating and co-ordinating knowledge and competencies?[2]

Organisation structures as integration mechanisms.

In the literature, known as the 'knowledge-based approach' to the theory of the firm[3], *firms* are seen as providing the integration of specialist knowledge (Grant 1996). Firms hire

[2] See Becker (2001) for more details on the problems of and responses to knowledge integration.

[3] See for instance Barney, 1991; Dosi and Marengo, 1994; Grant, 1996; Kogut and Zander, 1992; Kogut and Zander, 1993; Madhok, 1996; Penrose, 195;, Petera,f 1993; Spender, 1996; Foss and Foss (1999) provide a good overview.

specialists, they put them under the authority of a manager, and thereby integrate the knowledge these 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 (Grant, 1996). Providing knowledge integration is indeed 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 the following mechanisms for integrating specialised knowledge: rules and directives, sequencing, routines, and group problem solving and decision making.

Now, there is one problem with the notion that firms integrate specialist knowledge. A firm is a hierarchy, a co-ordination mode that is based on authority. The question whether the employee will perform a certain task is decided, not by a system of demand and supply (in which prices convey all the necessary information) to make the decisions, 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* – even though it might be a good way to co-ordinate and integrate labour inputs[4]. 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. As Arrow has pointed out, the reason is that knowing *about* knowledge means having the knowledge – knowing about it without possessing it is impossible. Under the assumption of limited cognitive capacity (Simon, 1955, 1956), 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. In order to effectuate knowledge integration by authority, however, possession of knowledge would be necessary, as knowing about something without possessing that knowledge is impossible. Therefore, the knowledge of an organisational unit is 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 writes 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, 1988, p. 77).

Substitute knowledge by access to knowledge

A second way to provide the integration of dispersed, specialist knowledge is to create and foster 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'. Knowledge is substituted by 'knowledge surrogates' (Scheuble, 1998). 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. It has been pointed out that the 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 there also need to be willingness and motivation, as well as the competencies, to use it. In

[4] The difference between labour and knowledge is that in the case of labour it is possible to specify (at least within certain margins of error) the outcome of most processes, with the effect that one can then co-ordinate these outcomes ('co-ordination by standardisation of work outputs', Mintzberg, 1979). The more often the process in question has been repeated, the easier it is to specify the outcome.

particular, 'absorptive capacity' (Cohen and Levinthal, 1990), i.e. being able to receive, interpret and apply knowledge is pertinent here, but also other complementary skills and capacities, like the background knowledge to interpret the information and knowledge exchanged, to judge the (degree of) truthfulness of the information given, and so on.

The competency to fill in knowledge gaps

Knowledge gaps created by the dispersion of knowledge can also be dealt with by filling them in, rather than attempting to transfer 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; see also Nonaka and Takeuchi, 1995; Argyris, 1996; Collins and Kusch, 1998). Collins and Kusch 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, users of software can be counted on to systematically have certain capacities, so that the features a software has not necessarily have to be provided completely by the software alone. The problem of integrating specialist knowledge can thus also be solved by substituting, rather than integrating, the knowledge in question. In order to be able to do that, a competence in completing incomplete knowledge is required. The higher this competence, the less knowledge is 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 and co-ordination 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, the blueprints) is not integrated. This can easily been seen if we consider who holds the knowledge underlying the competence to construct the components in question: 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.*

FIAT's internal organisation for NPD: the macro-structure and the role of teams

The case of Italy

FIAT Auto (and the Italian case) 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, sets 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. The data gathered refers to the last decade and were collected between 1998 and 2001 **(Table 1**)

Table 1. - Distribution of the interviews

Company	Place (in Italy)	Date	Length (hours)	Position of the person interviewed
FIAT Auto	Arese (MI)	April, 27 1998	3	Manager of the development of NPD methodologies
Fiat Auto	Torino	May, 25 1998	2	Purchasing director (segment C)
ELASIS	Pomigliano d'Arco (NA)	June, 25 1999	5	Manager of the development of new methodologies for the NPD
Fiat Auto	Torino	July, 28 1999	1	Global Sourcing Director
Fiat Auto	Torino	July, 28 1999	2	Manager of the components development platform
Fiat Auto	Torino	July, 28 1999	1	Global Sourcing and purchasing politics manager
Fiat Auto	Torino	September, 15 2000	2	Global Sourcing and purchasing politics manager
Fiat Auto	Torino	March, 1 2001	2	Director of the Division for Platform Development
Fiat Auto	Torino	March, 1 2001	2	Global Sourcing and purchasing politics manager (with a new role in GM-Fiat World Wide Purchasing
Fiat Auto	Torino	March, 2 2001	2	Manager of the Product Division
Fiat Auto	Torino	March, 2 2001	2	Manager of the Fiat-GM integration process
Fiat Auto	Torino	March, 2 2001	2	Manager of the development of NPD methodologies

Period 1991-1996

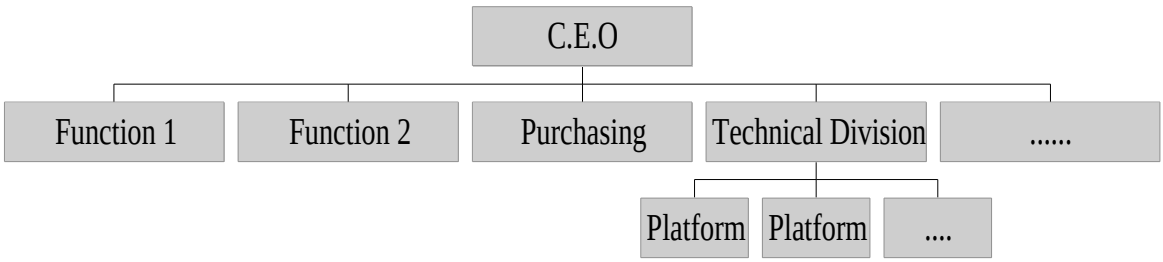
In 1991, the effort to rationalise the new product development process and to maximise common parts across models had led FIAT to create a typical matrix structure to organise product development. Platforms were defined on a market segmentation criterion in correspondence with five segments (A, B, C, D, E and Commercial Vehicles)[5]. 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*, that 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 new car fate 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**).

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.

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 for 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 NPD organisation.

Figure 1. Fiat's structure until 1996



[5] 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. In what follows we refer to platform exclusively from an organisational point of view and will specify when referring to a *product platform*.

The second most relevant limit of the platform was the scope of its action. The hand-over of the 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, also the motivation of the platform team suffered from this split responsibility.

Period 1995-2001

Hence, in the mid 1990sFIAT Auto still had to gain (1) strong product integrity[6], (2) costs savings through parts commonality among different products and (3) a renewed brand identity. It was again forced to change its structure.

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*, effectively and efficiently to involve suppliers in the vehicle design.

A new organisational structure, defined in 1995 and operative from 1996, was based on the existing concept of platform but radically changed the power equilibrium within the structure and the responsibility of the platforms (**Table 2**).

Table 2. - The nine platforms

Platforms	Object of development	Examples	Reports to
Platform A	Segment A	FIAT 600	DPD*
Platform B	Segment B	FIAT Punto/ Lancia Y	DPD*
Platform C	Segment C	Alfa 145/ FIAT Bravo	DPD*
Platform D	Segment D	Alfa 156/ FIAT Marea	DPD*
Platform E	Segment E	Lancia K/ Alfa GTV	DPD*
Commercial Vehicle	Commercial vehicles	FIAT Scudino	DPD*
International	World Car (five versions)	FIAT Palio	DID**
Component Development	Components and systems	From ABS to Steering	DPD*
Engine Development	Engine	New injection systems	Engineering Division
Gear system	Gear systems	Automatic transmission	Technology division

* Division for Platforms Development
** Division for International Development

The *new platform organisation* was based on a market segmentation criterion and on a technological basis. 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 correspondent to a specific typology of component (from ABS to wheel). The seven *platforms* in charge of cars' 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

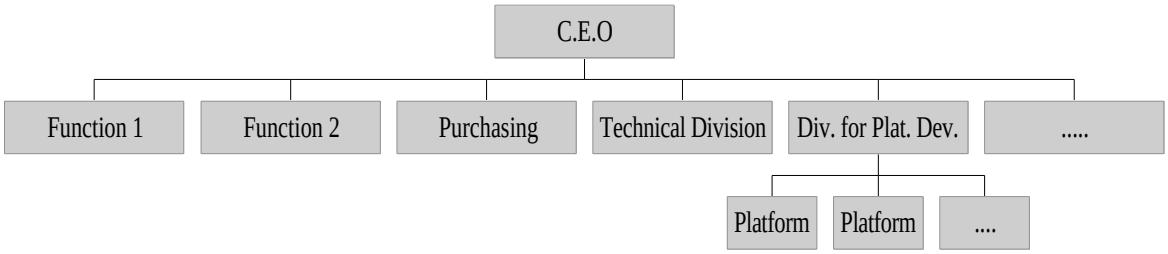
[6] Fujimoto et al. (1996) define product integrity on the basis of two elements: the product's *coherence* and the product's *fit*. "The product's coherence defines the extent to which the product's details, subsystems, and component proactively combine to achieve consistency in concept, character, 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).

the product from its generation to its end. This is the reason why, together with the scope of its activities, in FIAT 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 who 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[7]. 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.

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.

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

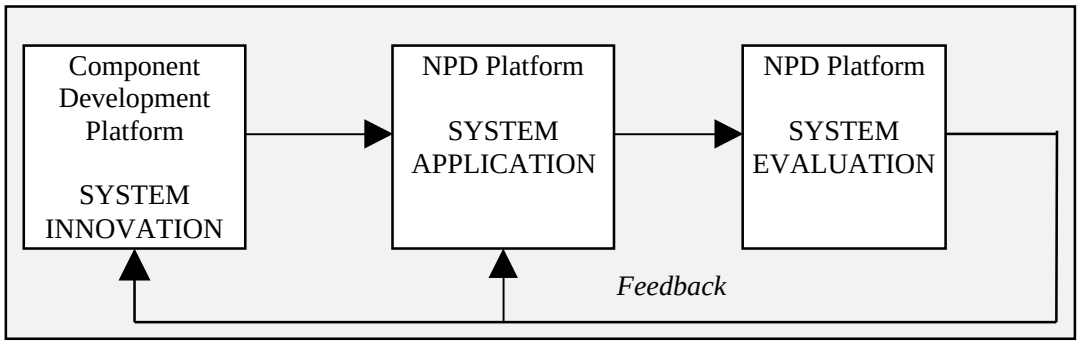
As far as standardisation and supplier involvement were concerned, the *components development platform* (henceforth CDP) played a crucial role which implied three major tasks[8]:

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, nor was willing to develop in house a specific system, 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 at the moment a NPD 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 the CDP and the supplier worked on the existing subsystem as a basis to improve it. This kind of collaboration was not very common at the moment of its introduction but grew considerably. As a FIAT manager puts it (**Figure 3**):

> "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).

Figure 3. -The relay race of the CDP and the NPD Platform teams



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 1996FIAT revolutionised its NPD process and organisation[9]. As it can be seen, the traditional development team was still at the core of the development process.

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

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 development 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[10].

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 longterm 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 4** 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[11]. 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 in order to fully benefit from the potentiality of modular design and of the *components development platform* as far as supplier involvement was concerned. Problems were mainly related to the fact that those who play a 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.

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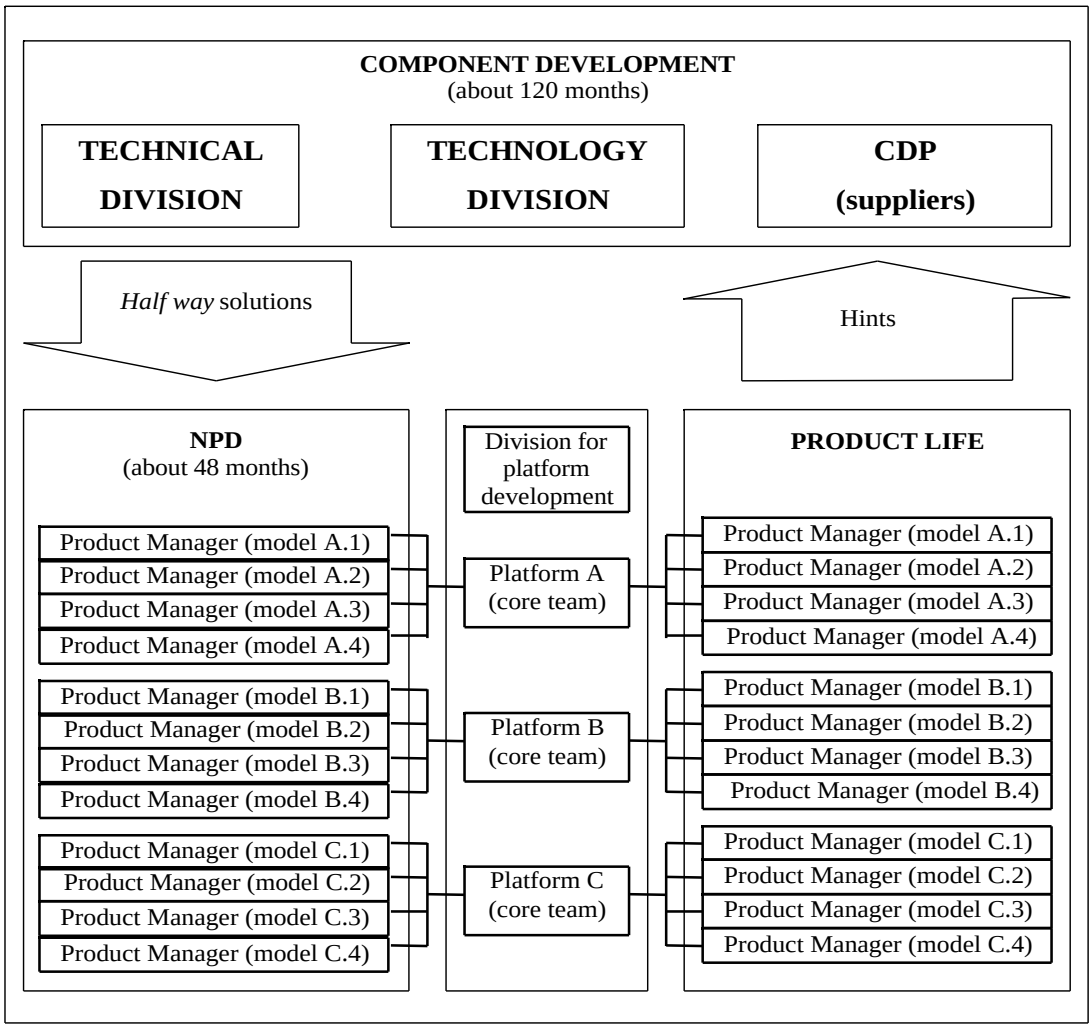
[9] On the re-engineering of Fiat see also Lipparini and Melloni (1996) and Calabrese (1997).

[10] 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).

[11] 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 4. A synthesis of the new organisation for product development at Fiat



*The number of platforms and of models under development is not realistic in the example. The number of platforms is bigger while the number of models for each platform is variable.

Period 2001 up to date

During the year 2001 things have changed again. In March 2000, FIAT Auto set up an agreement with GM based on an equity swap and, from the operative point of view, on the formation of two companies in which all the 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 that 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 working, 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 macro structure has taken place in the last few days. 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 the common platform and brand management.

THE KNOWLEDGE INTEGRATION AND CO-ORDINATION CHARACTERISTICS OF FIAT'S NPD ORGANISATION

The CDP and the illusion of specialist knowledge integration[12]

In 1995 FIAT had recognised that it had a problem of coping with the complexity of the new product development process. It decided to change the organizational structure of the NPD process. In the reorganisation of 1996, the Division for Platform Development (DPD) and the Component Development Platform were introduced. 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 Component Development Platform (CDP) was put in charge of the development of the components themselves, i.e., on 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.

Hatchuel and Weil (1999) have proposed the following typology of organisational units in the new product development:

- Concept-oriented units: these are devoted to define (or redefine) and realise an action system shaped by concepts. A concept defines a task, a mission, a system, a product, a plant, etc.. These units rely on knowledge-oriented units to reach their goals.
- Knowledge-oriented units, devoted to investigate, develop, acquire, produce knowledge that can fit to the concepts used by projects, or that prepare the conceptual base of new projects. This units rely on the concept-oriented units to orient their work.
- Management-oriented units: these units have to define the scope and the life cycle of the two preceding units. In an innovation intensive context the consistent dynamics and interaction of the latter units is the central role of management (Hatchuel and Weil, 1999, p. 17).

[12] 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.

In Hatchuel and Weil's terms, the CDP (as well as the *technical division that it is a part of, and the technology division*), is a knowledge-oriented unit. The DPD is a management-oriented unit. The CDP and the two divisions just mentioned are not project oriented but are mainly organised on a technological basis. They develop solutions that, although being tested and industrialised, are generic enough to be leveraged on different models. With the *components development platform (CDP)*, FIAT was probably trying to put into practice the concepts of modular design and the new role of supplier in the product development process. This strategy hinged on the concept of modularity as enabler of generic (*halfway*) solutions to 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 would 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 and co-ordination 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. In our framework, the strategy followed was that of decomposition: rather than having the specialist knowledge required for the design of the various components in-house and co-ordinating it, the choice was to decompose the problem, to delegate the integration and co-ordination 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.

Now, the crunch of the matter is that the CDP, responsible for integrating the specialist knowledge and competencies of the suppliers, chose exactly the same strategy as the DPD did: decomposition. The CDP thus attempted to integrate knowledge and components by integrating the *products* produced with the knowledge, without integrating the knowledge itself. The level of the underlying knowledge was not touched. This means that both the management-oriented units *and* the knowledge-oriented units rely on decomposition. The effect is that the knowledge-oriented unit (CDP) is actually not fulfilling its role of integrating knowledge and competencies, but is delegating the problem further, to the suppliers. In fact, the CDP was doing exactly the opposite of *integrating* knowledge. It was fuelling a further dispersion of specialist knowledge. The idea that the CDP would integrate the specialist knowledge turned out to be largely an illusion.

Increasing the integration problem in the future

As we have explained in section 2, the strategy of decomposition 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 – amongst other problems – it was designed to solve.

Pushing the specialist knowledge to be integrated 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 the house, to outsource them. This added another difficulty to the task of integrating specialist

knowledge: the knowledge was now more difficult to reach, too, as it was outside the firm. This meant that direct influence through authority was not possible anymore. Any kind of influence would be much more complicated, for instance influence on suppliers had to be exerted through appropriately designed incentives.

The conclusion to be drawn from this assessment is therefore that the specialist knowledge will slip away out of reach more than before, and it will become increasingly difficult for FIAT to integrate it. It will also become increasingly difficult over time to raise the question: when will the 'point of no return' be reached? 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.

Internal disintegration and absorptive capacity

As it will be argued, there is another reason why the organization structure chosen in the 1996 reorganization did not show 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 and co-ordination, we need to identify the mechanisms underlying the knowledge integration capabilities of organisational structures. As mentioned above, some authors credit firms (i.e., hierarchical organisation structures) with a role in knowledge integration (for instance Grant, 1996). What firms do to achieve knowledge integration is to create the *conditions* for knowledge integration. The same literature also points to *teams* as playing a role in knowledge integration. Both firms and teams are thus credited with a role in knowledge integration. We also know from experience that teams are often part of firms (if not necessarily of only *one* firm). It therefore seems plausible that it is actually within teams (nested in firms) that the 'work' of knowledge integration gets performed. Teams are the finer-grained level of analysis, so we must look there if we are interested in identifying the underlying mechanisms responsible for integrating knowledge. If we follow this trail and scrutinise what the literature on teams and their roles with regard to knowledge has to say, we find that *interaction* in teams is credited with playing an important role in knowledge integration. For instance, the accumulation of interactions in teams is said to facilitate the creation of shared coding schemes within functions (Kogut and Zander, 1992). Teams provide a shared context and shared codes. The literature concerned with the role of firms in knowledge integration therefore gives the following picture: firms have the role to integrate the specialist knowledge of its employees; one mechanism for integrating specialised knowledge are teams; what makes knowledge integrated within teams is *interaction.* Our hypothesis is therefore that the 'work' of knowledge integration appears to be done *inside* the firms – but not *by* firms, rather by *teams.* Within teams, *interaction* appears to play a key role in knowledge integration (for a more detailed argumentation, see Becker 2002).

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 influences the functioning of teams. The most important characteristic of teams being interaction, we need to assess how the introduction of CDP and DPD affects 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 center or to suppliers (outsourcing). In the latter case, the components' development platform (CDP) had the integration and co-ordination task. The NPD dedicated team therefore had a narrower focus on the *vehicle concept* generation and implementation, as opposed to *component* generation and implementation. From a perspective highlighting the analysis of interaction as the key driver of knowledge integration, there is one clear conclusion: 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 one regarding component development. Over time, these circuits of interaction will form two distinct (even if possibly overlapping) communities of practice, with distinct mental frameworks, distinct language, and distinct ways of interacting, planning, reporting and the like. This interaction-driven effect will furthermore be reinforced and amplified by the fact that the DPD reports directly to the CEO, i.e.it is a relatively independent unit, while the CDP is part of the technology 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 the influences the DPD and the CDP are under will be very different. It therefore appears highly likely that there would be an effect of *de*creasing knowledge integration capability, as the development of a gap between these two areas was programmed, which then would make integration more difficult.

Another driving force of a decreasing 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, when manufacturing is already outsourced, and design is also outsourced (or partly outsourced in co-development), then the sources of absorptive capacity are slowly but surely drying up. 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 the boundary spanners. 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 more and 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[13].

[13] Counter actions such as job rotation fostered by career incentives does not seem to apply to Fiat, not as reported by Takeishi (2001).

CONCLUSIONS

GERPISA's Research Programme 2000-2003 is concerned with identifying and explaining the diverse nature of the strategies of actors in today's automotive systems, in particular how these handle the co-ordination of competencies and knowledge (Lung, 2000). While it is widely known that modularity is currently the dominant strategy of the automotive industry, there are also suspicions that a strategy of outsourcing – to a large part enabled by modular product architecture – might lead to a hollowing-out of the carmakers' knowledge and competence-base. The paper has considered the case of FIAT and has analysed the question how FIAT has responded to the challenges of the increasing complexity of the new product development process.

As it has been described, FIAT has relied on a 'pure' strategy of decomposition. According to the framework of managing dispersed knowledge introduced in the paper, the way in which this strategy has been implemented – the CDP actually leading to disperse specialist knowledge even further, rather than integrating it – suggests the conclusion that it will further aggravate the problem. In addition, the measures adopted in the reorganization also lead 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- and competence-base.

Although there have been (more) recent reorganisations, it is not clear whether the trend towards hollowing-out has been stopped. In this connection it is important to underline how this organisation has allowed FIAT Auto to push its outsourcing strategy to the maximum level in its long history. At the moment, in fact, about 80% (in terms of the production costs) of the recently realised new FIAT Punto (one of FIAT's best sellers) is designed and industrialised by FIAT's suppliers (Caputo and Zirpoli, 2001 and Zirpoli and Caputo, 2002). In few recent cases, suppliers have been involved even before the concept stage begins. As shown above, they participate in long term development plans that begin up to five years before the vehicle development starts. As can be noted, FIAT intends to act as a mere system integrator and is presumably day by day reducing its competence in component and system design.

This brings us from the FIAT case to larger issues of modularity- and systems integrator-based strategies – currently dominant strategies in the automotive industry. The crucial point of these strategies is to maintain the in-house concept design and the systems integration capabilities to co-ordinate the work of suppliers. These include the technological and organisational capabilities to integrate changes and improvements in internally and externally designed and produced inputs within an existing product architecture.

We believe to have given some (if illustrative) support for what it takes to keep such systems integration capabilities. The crucial threshold is crossed when a systems integrator lets itself become too much detached from the underlying knowledge itself (not the components or modules that the knowledge is embodied in). But precisely that is the principle of modularity! It seems that there is a limit to modularity, a fine balance that when pushed too far means that the systems integration capabilities will erode quickly, leaving the firm incapacitated. The capability to integrate *knowledge itself*, not just components produced with the underlying knowledge, is, to an important extent, a determining factor on the balance. The

organisational mechanisms for doing so successfully, however, seem to be different from those that are successful in co-ordinating a modular product architecture and the development of new products. One of the questions arising is whether a *systems integrator* necessarily needs a parallel organisation charged with the function as a *knowledge integrator*. Further research into this question seems fruitful and of high strategic interest. Taking knowledge and competencies even more seriously than so far might well turn out to change the verdict on modularity as a strategy in new product development.

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