How to avoid innovation competence loss in R&D outsourcing

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Technological complexity, market demands, and uncertainty have led firms to involve external sources of innovation – customers, suppliers, public and private research labs – in complex product development for the last three decades.[1] While the idea is attractive, there are many cases where such outsourcing of Research and Development (henceforth R&D) has led to failures and problems, ranging from the aircraft industry with the Boeing Dreamliner and the Airbus A380 (Kotha & Srikanth, 2013) to the automotive industry (Zirpoli & Becker, 2011a)[2].

Received wisdom and much of the research literature see the principal reasons for such failures in the growing complexity and the coordination challenges that come with involving external parties (Kotha & Srikanth, 2013; Larsen et al., 2013), as well as in increased

[1] This article is a joint endeavor. The listing of author names is alphabetical.
[2] In this paper we focus on the outsourcing of R&D activities that concern later stages of the whole R&D process, i.e. the new product development process (Clark, 1989). We will not make reference to basic or pure R&D activities that are not directly related to the development of new products, nor to manufacturing tasks (thus, we are not concerned with outsourcing manufacturing).

cooperation problems (e.g., Dyer, 1996). Consequently, according to prior research, failure could be avoided by employing sophisticated coordination and governance mechanisms, such as co-located teams, benchmarking and value engineering techniques, ICT tools, and other "best" relational practice in a Toyota-like fashion (Clark and Fujimoto, 1991, Womack et al., 1990, Nishiguchi, 1994, Ragatz et al., 1997, Helper et al, 2000, MacDuffie, 2013).

This diagnosis misses a crucial point in understanding the persistent failures and problems with R&D outsourcing, however: the role of learning by doing for developing R&D competences (Weigelt, 2009, Zirpoli and Becker, 2011a, 2011b). Literature has shown that outsourcing can lead to the hollowing out of corporations and the depreciation of internal capabilities (Hamel, 1991; Bettis et al., 1992, Grimpe and Kaiser, 2010). If the capabilities in question are integrative capabilities, i.e., for integrating systems and components developed by suppliers and other external sources of innovation (Brusoni et al., 2001; Takeishi, 2001, 2002), their lack can explain problems with R&D outsourcing. Pisano and Teece (2007: 294) highlight this point when they write 'vertical disintegration sharpens the need and enhances the difficulties of systems integration, as it requires integrating the activities of parties when there is no common ownership link. Interface standards and modularity, of course, facilitate outsourcing and thereby sharpen requirements for integration. Failure at integration in turn destroys any benefits associated with outsourcing in the first place ... Possession of the systems integration capabilities gives high-tech firms outsourcing choices …With respect to complex systems, system integration capabilities could indeed become the bottleneck asset'. In this respect, extant literature has highlighted that the main problem with extreme design and engineering outsourcing is that it can weaken firms' ability to understand the components of a product. This, in turn, can weaken the understanding of the ways in which components are integrated into systems and how to manage systems integration, that is, the firm's architectural knowledge (Henderson and Clark, 1990, Lincoln et al., 1998, Brusoni et al., 2001; Takeishi, 2001, 2002; Zirpoli & Becker, 2011a, b). As the literature has demonstrated, a key prerequisite for maintaining such integrative capabilities, especially in their tacit form, is learning by doing (Leonard-Barton, 1988; Attewell, 1992; Weigelt, 2009; Weigelt & Sarkar, 2012). Learning by doing is, therefore, a necessary requirement for developing and maintaining integrative capabilities.

Prominent examples of a successful involvement of suppliers in NPD processes (e.g. the Toyota Motor Company case) provide support to the centrality of competence and learning issues in R&D outsourcing. Literature has clarified, for example, that Toyota succeeded in R&D outsourcing not only, and not primarily, because of an exemplary implementation of coordination and governance tools but also because it never fell into the trap of becoming dependent on suppliers for key component knowledge (Fine and Whitney, 1996, Fine, 1998). Contrary to what is often believed, the Toyota case shows that coordination and governance mechanisms become a necessary but not sufficient condition for successful implementation of R&D outsourcing. Failures and problems of R&D outsourcing, in fact, can arise even though optimal governance tools are in place, when the system integrator lacks component specific know how (Takeishi, 2001).

Companies developing complex products, hence, face a crucial dilemma: the much-cited benefits of R&D outsourcing such as cost benefits, access to deep specialist knowledge or shorter development lead times, are often traded-off with the risk of negative consequences for competence development due to the loss of opportunities for learning by doing (Weigelt, 2009). This paper contributes to understanding how firms can tackle such a trade-off and provides insights on how firms can organize R&D to protect against competence loss in R&D outsourcing. Most importantly, we identify a novel solution not yet identified in prior research. While this trade-off has been identified in recent research (e.g., Grimpe and Kaiser, 2010), what solutions can be used to address it is still unclear, even though such solutions are urgently needed.

The case of Fiat Auto is particularly well suited for this purpose. Fiat offers a striking example of the problems that R&D outsourcing can generate[3]. Most importantly, it also offers a novel answer to the question, and a novel solution for how to organize R&D outsourcing to protect against competence loss (i.e., assure learning despite outsourcing). Fiat managed to significantly mitigate the learning trade-off and improve its new product development performance when it started distinguishing between two types of product development projects and alternating them over time: a first type of project ("template") in which Fiat focused on learning about key component technologies and their interdependences with the rest of the product; a second type ("derivative") in which Fiat could economize on the use of internal engineering resources and devolve to suppliers most of the design and engineering tasks. The novelty of Fiat's approach consists in explicitly applying different task allocation

[3] For a full account of Fiat's fall, rise and transformation at the turn of the century see Whitford and Zirpoli, 2016.

schemes over time, and thereby, explicitly employing the time dimension in the division of labor, thus making it dynamic rather than static.

In the remainder of the paper, after a brief recap of the state of the art knowledge on the problems of R&D outsourcing and the solutions for coping with them, we synthesize the strategic re-orientation and re-organization of the product innovation process at Fiat that contributed to recovering from its problems without back-sourcing. We then show Fiat's solution to the persistent problem with R&D outsourcing, a novel solution not yet documented in extant research. Finally, we discuss the lesson learnt and identify an alternative to existing forms of organizing R&D outsourcing without incurring some of its negative consequences.

The antecedents and implications of R&D outsourcing from a competence perspective

Firms' competences, NPD costs and strategic flexibility are the usual motivations of R&D outsourcing decisions (Clark, 1989): allocating R&D tasks to outside parties enables tapping into the deep competences as well as economies of scale and scope of specialized supplier firms, and can be a response to the challenge of having to master an increasing number of technologies in multi-technology products (Granstrand, Patel & Pavitt, 1997).

Outsourcing decisions, however, also have a dynamic effect and longer-term consequences on learning (Teece and Pisano, 1994, Jacobides and Winter, 2005), problem solving processes (Clark and Fujimoto, 1991), and firms' abilities to evaluate, assimilate and apply new knowledge ('absorptive capacity', Cohen and Levithal, 1990). Absorptive capacity is required to leverage knowledge that is not held by the firm. It is one of the most important building blocks of a firm's ability to successfully implement an R&D outsourcing strategy. Allocating tasks to outside parties can deteriorate absorptive capacity because it diminishes the firm's knowledge, one of the antecedents of absorptive capacity (Cohen and Levinthal, 1990). This point is clearly made, for example, by Brusoni, Prencipe and Pavitt (2001). They show that there exists a complex link between what firms make and what firms know and their ability to act as system integrators. Leveraging external sources of innovation, in fact, has a profound impact on the firm's *learning processes* and *competences*. The reason is that the allocation of tasks along the supply chain implicitly allocates learning opportunities (Takeishi, 2001). Where the knowledge to be learned is tacit – for instance, in the case of integrative capabilities (Weigelt, 2009) such as how to integrate components into a high-performing system like a car that does not vibrate at high speeds –, it can only be acquired through *learning by doing* (Argote and Epple, 1990, Weigelt, 2009, Grimpe and Kaiser, 2010). Learning by doing is, therefore, a key aspect for developing a firm's absorptive capacity. The deterioration and lack of integrative capabilities, in turn, generates negative consequences such as problems in evaluating systems or monitoring suppliers (Lincoln et al., 1998).

The short- and long-term consequences of outsourcing innovation tasks to external parties are, therefore, in a trade-off relationship: R&D outsourcing enables tapping into the competences of external specialists and immediate cost cutting benefits but increases the risk of losing the learning opportunities required for maintaining integrative and monitoring capabilities that are needed in integrating the inputs of external parties. In the long term, hence, R&D outsourcing might produce negative consequences on problem-solving processes, absorptive capacity and learning, and in turn, on overall R&D costs (see the case of Fiat below and Reitzig & Wagner (2010) and Larsen et al. (2013) for contexts other than outsourcing R&D).

Put in this light relational practices appear as complements rather than substitutes for learning and for sharing knowledge with suppliers. The "system integrator" firm can, in fact, suffer from difficulties in integrating suppliers' product development activities even though it has implemented organizational measures due to a lack of component specific knowledge (Lincoln et al., 1998, Takeishi, 2001). As our own research shows, a number of prerequisites need to be in place for learning and knowledge sharing to happen (Zirpoli & Becker, 2011a, b). For instance, if engineers are occupied with project management and do not actually engage in profound technical discussions with suppliers' engineers (perhaps because of time pressures), there is no learning and competence development even despite co-location[4]. Rather, the negative consequences of deteriorating absorptive capacity and integrative capabilities materialize. As it turns out, while there are other forms of learning, learning by doing is a form of learning that companies developing complex products cannot do without (Weigelt, 2009, Grimpe and Kaiser, 2010, Zirpoli & Becker, 2011a, 2011b). Outsourcing development tasks in principle ships off opportunities for learning by doing, leaving unattended the dynamic and long-term leg of the trade-off that has not been on the radar very much so far.

[4] Co-location is considered a fundamental organizational solution for successfully implementing suppliers' involvement in NPD processes (Ragatz et al., 1997).

What then, can firms do to avoid they stop learning when they outsource development tasks, and to assure they develop their competences further and maintain absorptive capacity and integrative capabilities? In short, how can firms organize to learn despite outsourcing?

The Toyota model

Toyota is often cited as *the* example of how firms can preserve and even improve integrative capabilities while involving external sources of innovation in R&D processes. How has Toyota avoided these problems? Much attention has been focused on analyzing how Toyota governs its suppliers (Asanuma, 1992, Liker et al.,1995, Dyer, 1996, Nishiguchi & Brookfield, 1997, Edwards & Samini, 1997, Dyer & Nobeoka, 2000). Indeed, the coordination and governance mechanisms Toyota uses have inspired many other firms (Turnbull et al., 1992). However, explaining Toyota success in managing R&D outsourcing only on the basis of its exemplar implementation of coordination and governance mechanisms would be a mistake.

The seminal work on R&D outsourcing by Fine and Whitney (1996) highlights that Toyota's approach towards outsourcing differs from that of other carmakers as Toyota was careful to assure that the involvement of suppliers in its NPD process was never at the expense of the development and maintenance of component specific knowledge. Toyota has never become dependent on suppliers' knowledge and has, over time, maintained tight control of process and product technologies. These latter are never fully outsourced, but rather, are still developed in house (e.g. tools and equipment design and other component technology). This account of Toyota's approach is consistent with general advice on how to preserve system integration capabilities or architectural knowledge provided by Cohen and Levinthal (1990), Henderson and Clark, (1990) and Takeishi (2001). Indeed, involving suppliers at Toyota does not mean outsourcing R&D competences but rather sharing knowledge with suppliers and cutting cost of product development and supply chain management (Nishiguchi, 1994, Takeishi and Fujimoto, 2003, Helper and Sako, 1995, Takeishi, 2001, 2002, Nobeoka and Cusumano, 1997). For this reason Toyota developed ad hoc coordination mechanisms and techniques (Helper et al, 2000).

The Toyota case, hence, cannot be taken as a "clear cut" example of R&D outsourcing as it requires high in-house R&D investments to gain full control of component specific and architectural knowledge. As a consequence, beyond the implementation of Toyota's relational practices with suppliers, firms who want to imitate Toyota should substantially limit R&D outsourcing. This option is not only difficult to implement but also not available to firms that, having outsourced R&D, are stuck in the learning problems described above and have no time and resources to back-source design and engineering tasks. How, then, can firms organize R&D outsourcing to address the trade-off and avoid the negative consequences of R&D outsourcing without back-sourcing?

The Fiat case: a novel solution born out of necessity

This is precisely the question that Fiat Auto faced. Interestingly, it managed to find and implement an answer, and thus, to organize in such a way that it keeps learning despite outsourcing. Fiat came up with an organizational innovation that is a typical instance of a case in which "necessity is the mother of innovation" (Bolton, 1993): for reaping the benefits of *learning by doing* in a situation in which it could not increase its internal staff or back-source the design and engineering tasks, Fiat had to find another way out. It adopted a new organizational solution that goes beyond the ones known in the literature, offering a novel solution that worked in Fiat's case when others were not available. Drawing on our 15-year research project at Fiat Auto, we now describe the solution they found, and subsequently analyze it to draw lessons for other firms.[5]

Long-term consequences of R&D outsourcing hit home

From 1996 onwards, Fiat had massively stepped up outsourcing of product development tasks to suppliers. At the same time, Fiat had also given suppliers an ever increasing role in the development process: they were included earlier in the process; they were given larger responsibilities; and they were considered strategic partners[6]. Fiat was engaged in a move from co-designing components and systems with suppliers to outsourcing R&D to system and module suppliers and eventually, a tiered supply structure where ideally, Fiat had relations

[5] We collected archival data to understand the characteristics of the sector and the history of the selected companies, and carried out extensive semi-structured interviews with managers in Fiat, Fiat's two research centers, and 16 of Fiat's first-tier suppliers. Between 1997 and 2008, we carried out 79 interviews with managers and engineers belonging to 19 different companies, totaling about 145 hours (see appendix). Of particular importance for this paper is the data gathering campaign of 2006-2008. We selected information in order to provide the possibility of triangulation (e.g., by combining the perspectives of top management with fine-grained, micro-level details concerning the execution of the new product development process provided by people directly involved in this process). All interviews were taped and transcribed. Our unit of analysis was the new product development project.
[6] In a 1998 article in an academic journal, Roberto Testore, Fiat CEO at the time, provides a synthesis of Fiat's approach (Testore, 1998).

only with the system and module suppliers and only those, in turn, relations to lower-tier suppliers.

Fiat reached an exceptional level of engineering and design outsourcing: Fiat's suppliers engineered up to 85% (in terms of value) of the components of new car models value at the end of the 1990s[7]. Between 1996 and 2001, Fiat was one of the firms with the highest degree of outsourcing of design and engineering in the automotive industry (see also MacDuffie, 2013)[8]. Specifically, Fiat outsourced the design of most major components and systems with the sole exception of engines, metal sheets, chassis and suspensions. For the components and systems outsourced Fiat did not have "in-house" design and engineering facilities but only engineers responsible for dealing with the suppliers during NPD projects (e.g., for dashboards). This approach was premised on modularity[9] and completely consistent with the prescriptions in the literature at the time (Baldwin and Clark, 2000, Sturgeon 2002, Fixson et. al, 2008).

Fiat's problem was the result of (1) assuming that the product architecture was more modular than it was in reality, (2) relying, in turn, too much on the coordination properties of standard interfaces among components and systems, (3) missing exposure to learning about components and systems development tasks due to their complete outsourcing to suppliers and (4), as a consequence, gradually losing component specific knowledge (Zirpoli & Becker, 2011a, b; on modularity, its use and limits in the auto industry see also MacDuffie, 2013 and Jacobides et al. 2015). Indeed, Fiat's lack of technical skills on component technologies resulted in fuzzy and incomplete specifications to suppliers in early stages of the development process. Insufficient specifications often led to costly re-design that, in turn, resulted in longer lead times and overall poor project performance. A very high degree of design outsourcing thus did not alter system integration capabilities per se. However, extreme outsourcing led to

[7] This figure also considers NPD competences that Fiat could control through suppliers it owned such as Magneti Marelli and Teksid.

[8] See Di Minin et al. 2010 on Fiat's strategy related to basic R&D outsourcing. In Fiat, basic R&D activities were traditionally carried over by the Centro Ricerche Fiat (CRF) that was part of the Fiat Group but was not directly involved in development of new products. As observed by Di Minin et al., the CRF has itself embarked in an outsourcing process confirming the outsourcing trend also for basic R&D activities. In our interviews in the mid 2000s Fiat top management confirmed that CRF experienced a declining centrality in Fiat's overall R&D processes during the 90s and is nowadays completely peripheral in the R&D activities of Fiat Chrysler (FCA).

[9] Modularity refers to a decomposition scheme that assumes independence between modules, with interdependences confined within modules' boundaries (Baldwin and Clark, 2000). Some parts of the literature have suggested that modular product architecture can serve as a good map for the decomposition of the development task and task allocation (Sanchez and Mahoney, 1996; Baldwin and Clark, 2000).

difficulties in obtaining the desired product performance at the expected cost, lead times and quality levels, resulting in project performance that did not meet expectations.

Fiat realized that such performance problems were caused – at least to some degree – by its extreme outsourcing strategy and its attempt to pursue a modular design strategy for a product whose architecture is substantially integral. One manager explained the roots of Fiat's problems as follows:

> 'We realized you cannot integrate components performances you know very little about. ... if you have never designed a component or a system it will be very difficult to understand the subtle interactions with the rest of the vehicle" (Fiat Auto, 2006).

Fiat urgently needed to react in order to re-build lost competences and gain new competences. It is here that the Fiat Auto case provides extraordinary insights into how to learn despite outsourcing: Fiat managed to adapt its organization to learn despite outsourcing, thus recovering and providing one important component of its turnaround over the past years. We now turn to describing this novel organization of R&D outsourcing.

A new rationale for R&D outsourcing

At the beginning of 2000 when Fiat started considering the option of reversing its outsourcing strategy, Fiat's product portfolio was shrinking while other carmakers were developing brand new market segments. Moreover, its market share was declining and its financial results were so poor that the company went close to bankruptcy in 2004 (Volpato and Zirpoli, 2011). To bounce back on the markets, Fiat needed to refresh product lines and step up its introduction of new models on the market. It neither had money to invest in sufficient internal engineering resources nor much time to react. Fiat had to do more with less, and had to do it fast. But it found itself between a rock and a hard place: the two major options – building up staff or backsourcing – were out of the question. One of our informants synthesized the situation in which Fiat was in the early 2000s as follows:

> 'We should have reversed our strategy by integrating back competences that we had lost. We had two problems, however, no money and no time' (Fiat Auto, 2006).

Fiat thus had to select what to focus its engineering resources on. A solution was found only in 2005 after the appointment of a new CEO and Chief Technology Officer. Fiat started from revising the criteria to decide which development tasks its engineers would focus on, and which ones were outsourced to suppliers. First, Fiat looked at which performance dimensions of a car its customers valued most – such as overall ride comfort, road behavior, safety and so on. For any given component, it considered how important an impact that component had on the most important performance dimensions. For instance, how important is the design of the suspension system, the air-conditioning system or the braking system for overall ride comfort or road behavior? Second, Fiat considered the interdependences between any given component and the rest of the vehicle. Is the air-conditioning or safety system interdependent with the engine, the door seals, and so on? Fiat took a decision to make sure that it developed and maintained product development competences for such components that scored high on both criteria. For components that scored high on one of the criteria, it outsourced development but remained involved in different ways. For components and systems that have a high impact on a performance dimension that customers value highly but that have low interdependence with the rest of the vehicle, Fiat outsources the development but provides very detailed specifications. For components and systems that have a low impact on a performance dimension that customers value highly but that have high interdependence with the rest of the vehicle, Fiat co-designs the system with the supplier who holds the specialist knowledge on the component or system. For components or systems that score low on both counts, Fiat outsources the development, providing only broad specifications[10] (see Figure 1).

Level of interdependences between the component and the rest of the product		Prioritization of a component's impact on overall product performance: **Low**	Prioritization of a component's impact on overall product performance: **High**
	Low	Delegate the overall system development and provide broad specifications (e.g., A/C system)	Provide very detailed specifications but outsource the system development (e.g. Braking system)
	High	Co-design the system but the supplier holds the component specific knowledge (e.g. Safety system)	Develop design competences in-house (e.g. Suspension/handling)

[10] On the mapping of interdependencies between the elements of a design see MacCormack et al., 2006.

Figure 1: Criteria for outsourcing product development tasks

By matching the "level of interdependences between component and the rest of the product" and the "component's impact on overall product performance", Fiat found more differentiated criteria for the "make or buy" decision that proved more informative than the usual considerations on costs or technical interdependences it had made before. This, more generally, underlined the need for managers to elaborate a clear performance prioritization (e.g. internal learning, learning from suppliers, cost cutting, etc.) before taking decisions that are purely dictated by engineering opportunity.

This approach helped Fiat to re-focus its R&D outsourcing decisions. However, Fiat's managers realized that Fiat still had a substantial lack of engineering resources to design and engineer in house all the components corresponding to the "darker" area of Figure 1 for every project under development, starting with its bottom right quadrant. This leads us to the second building block of Fiat's recovery strategy: the template system.

The template system

To address limitations that did not permit it to take on all development work in the bottom right-hand cell of Figure 1 above, Fiat introduced a distinction of two types of products, and linked them to two different type of development projects: *template models* and *derivative models*. In developing the template model, Fiat designed and engineered all the most important systems of the model. It subsequently used that model as a template to design and engineer derivative products in the same market segment. In this way, Fiat realized it was possible to outsource the complete development of entire vehicles for derivative projects without incurring the problems it had experienced in the past. When it developed a template model, Fiat continued to involve system suppliers but it was fully responsible for the engineering and the application of all the most relevant systems in the vehicle. In both cases, system and component suppliers provide complete systems. However, the extent to which Fiat got involved in the component and system design, and the corresponding engineering and design resources invested, changed significantly between template and derivative models.

In a nutshell, economizing resources through outsourcing and at the same time learning on components and systems was made possible by the different task partitioning and allocation (Figure 2). In the old system, the overall design tasks were partitioned in components and systems, and some of those were outsourced. This task-partitioning scheme was then applied to all vehicles. For instance, dashboards were always outsourced and for no car models did Fiat design dashboards in-house. Fiat subsequently experienced erosion in its own competences in designing and evaluating such systems. With the template, the design tasks corresponding to specific components and systems were no longer outsourced for all models and, when outsourced, tasks were not allocated according to the same decomposition scheme for all models belonging to the same segment (Figure 2). Fiat assumed the responsibility and control for designing all key systems of a template model, and instead partitioned the design work to be done along the time dimension, i.e., along car models introduced on the market at different points of time: It carried out one model itself, then outsourced the complete design of component and system applications of subsequent models. Control is assured by using the model it has designed itself as a template for those that will be outsourced.

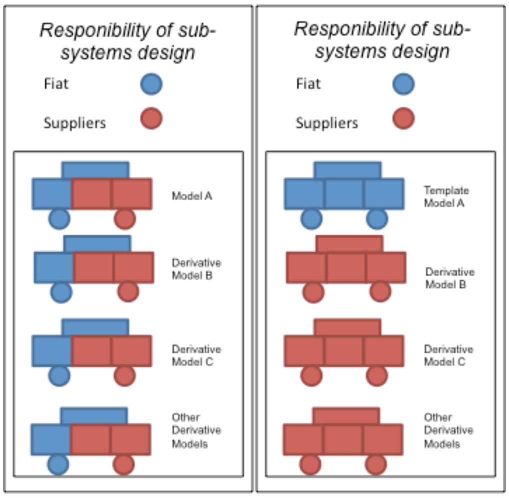

Figure 2 – Task partitioning system until 2005 (left-hand panel) and after 2005 (right-hand panel)

A template model embodies components and systems that will play the function of design archetypes (examples of design archetypes are the architecture of a suspension for small cars, the layout of the panel instruments for sports cars, or the design of the sealing system for luxury cars). A design archetype is a set of engineering solutions that will be employed in all models belonging to the same segment over time (market, dimension of the vehicle, etc.). In a metaphorical sense, this set of design archetypes defines a model that becomes the 'ancestor' which then gives rise to a family of variant models. This translates into a product development team that, for a template model, develops a new car managing the design and engineering of all – as opposed to only some – key systems and components in house.

Thereby, Fiat's engineers get exposed to opportunities for learning by doing relating to the full set of design and engineering tasks. In the words of one of the managers involved:

> 'Engineers we staff on template projects hold an above average component specific know how. This know how derives from the fact that they themselves develop the key systems. Our engineering teams continue to work with suppliers but delegation is not according to black box sourcing as before. Learning by doing plays a key role to understand the systems we are integrating' (Fiat Auto, 2007).

It is worth noting that the template platform does not only have a physical dimension (i.e. a set of components, systems and modules carried over on derived models) but also has an intangible dimension. The latter allows Fiat to achieve the goal of setting the standard of how to solve the typical engineering problems characterizing the development of a product in a given market segment, i.e. to set a bundle of design archetypes. Fiat chose to set a bundle of archetypes according to market segments because each market segment has its own characteristics in terms of the key performances that customers are interested in. Archetypical engineering solutions (e.g. how to design and engineer a suspension or the layout of the interiors) vary accordingly. This observation links back to the quote reported above emphasizing the centrality in system integration of overall product performance integration. The description of what characterizes template projects adds further evidence on this point:

> 'Template projects are a means to learn about key technological interdependences and on how to manage key performance trade-offs' (Fiat Auto, 2007)

Following a template also has the implication that every time a derivative project is started within a segment, engineers will have to apply the template solution from the template model (the segment's 'ancestor'). By using the template system, hence, Fiat also pursues the goal of increasing component and system standardization, i.e. designs systems and components of a template model to be carried over to derivative models. In practice, however, even though engineers should carry over the same components as much as possible, they often just scale the archetypical solution up or down (i.e. implement the same archetypes – e.g. the shape of a door closure system – but in a different physical dimension, in the engineering jargon "component mathematics"). Scalability is a feature that distinguishes templates (archetypical solutions) from platforms understood as, for instance, standardized under-bodies for cars[11]. As

[11] Nobeoka and Cusumano (1997), for instance, describe a car platform as consisting of the floor panels, suspension system, firewall, and rocker panels.

the quote above highlights, templates serve the primary goal of providing learning and competence development and are not always used for leveraging economies of scale through standardization.[12]

The impact of the template system on Fiat's NPD performance

In the words of one of our interviewees, "template projects are a means to learn". Do they also contribute to boosting NPD performance? Following the literature, we have assessed the impact of the new system on costs and lead times (Clark and Fujimoto, 1991). Our interviews and data indicate that the move towards the new logic for assigning development tasks held the key to economizing on the overall amount of resources invested in the product development process and, at the same time, to achieving unprecedented time-to-market in all product development projects, both template and derivative. In Figure 3 we show the impact of the new strategy on R&D spending at Fiat taking the comparison of four models belonging to the same market segment (the "C" segment) as an example. The Fiat Stilo, launched in 2001, was the baseline and the template for the development of the Fiat Bravo and of the Lancia Delta. The Giulietta was the template car for the C segment, replacing the Stilo after approximately ten years (this also explains why the cost of development increased), and was the baseline for the development of the Dodge Dart. As far as the lead-time performance is concerned, the development of the Bravo took just 18 months, 8 months less than the Fiat Stilo. Similar figures regard the Lancia Delta and the Dodge Dart.

[12] In selecting the car model that will become a template model, factors such as profit margins per unit do, of course, also matter. As we describe, the predominant criteria in the choice of template models that we observed were the characteristics of the model with regard to what are the key systems for the performance dimensions that customers value in that market segment, and whether new competences needed to be acquired in order to design models with high performance in these dimensions.

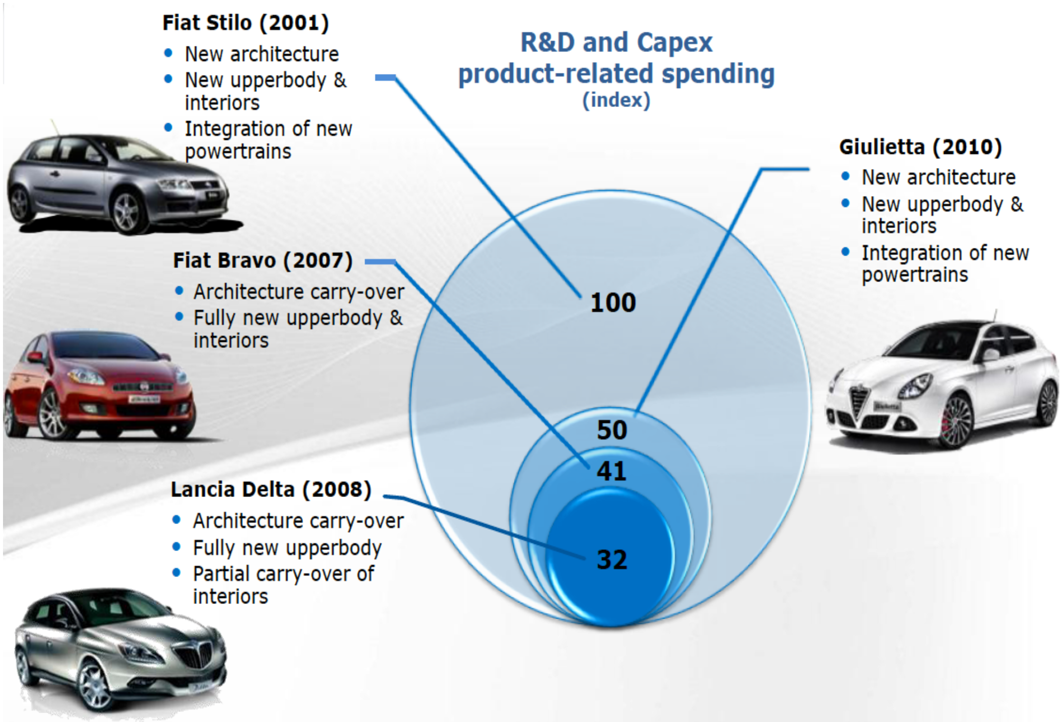

Figure 3 – R&D and Capex product-related spending (Source: Fiat Auto Investor's Day Presentation)

How did the template system contribute to such performance improvements? The answer is that Fiat managed to combine a "scale effect" and a "learning effect". The first originates in the possibility of standardizing components. The second derives from the allocation of design tasks and responsibilities in template projects. This provides learning opportunities regarding the integration of systems and components that have high impact on performance dimensions that customers value highly but that are also highly interdependent with the rest of the car (see Figure 1 above). These learning opportunities concern exactly the competences of developing those components and systems that have the strategically most important impact on the performance of the car. Thus, the template enabled Fiat to take more influence in technical discussions and leave less influence to suppliers in decisions that have important consequences regarding the technological trajectory[13]. Fiat also took other organizational provisions to ensure that it uses the learning opportunities it has in template projects. For instance, a novel type of contract paid suppliers for teaching Fiat specific things, rather than by engineering hours or to develop and engineer a certain component.

[13] In this way Fiat manages to cope with two problems it experienced before, which contributed to raise NPD costs: (1) component over-specification (suppliers were asked to design components with performance higher then actually needed); (2) suppliers' cost and quality monitoring.

Discussion: Towards a new frontier of development performance when engaging in R&D outsourcing

The first measure that Fiat took to recover from lost competences following R&D outsourcing was premised on a change in the rationale according to which make or by decisions were taken: component and system interdependences and their impact on key product performances became the most important driver in the make or buy decision. This move followed Fiat's acknowledgement that outsourcing component specific knowledge had been pushed too far considering the "integral" nature of the car's product architecture and the impossibility of managing coordination with external sources of innovation just relying on relational practices and modularity, without a cutting-edge level of component specific know how (see on both points Mac Duffie, 2013, Zirpoli and Becker, 2011a, b). According to these considerations the standard reaction should have been to back-source. However, as we reported above, Fiat did not have the time, engineering and financial resources to do so.

The template system was the way that Fiat found to cope with such constraints, i.e. to keep R&D outsourcing at high levels, and re-build its integrative capabilities at the same time. The template system, hence, played a central role in significantly mitigating the outsourcing/learning trade-off, while improving Fiat's new product development performance. In a nutshell, this was possible because Fiat started distinguishing between two types of product development projects, corresponding to the development of "template models" and "derivative models". Then Fiat associated to each type of product development project a different task allocation *along the time dimension*. The novelty of Fiat's approach consists in explicitly applying different task allocation schemes over time, and thereby, explicitly employing the time dimension in the division of labor, thus making it dynamic rather than static.

In synthesis, Fiat started leveraging two mechanisms: (1) *distinguishing* project types and (2) *sequencing* project types *over time* in order to alternate between them:

1. *Distinguishing project types*. The two project types differ with regard to a number of characteristics: (a) the criterion for task allocation (learning vs. exploitation of existing knowledge), (b) the allocation of development and integration responsibility to the focal firm vs. suppliers, (c) the allocation of decision-making authority (Fiat takes decisions on architecture vs. on all components that have an impact on key product

performance), (d) the competences in focus (competences regarding key interdependences between components leading to overall product performance), and (e) the learning benefits for the focal firm (on architecture or components vs. on key interdependences between components, and on architecture and integration). Viewed from the perspective of building component specific and architecture knowledge (Takeishi, 2001 and Henderson and Clark, 1990), this shift means that distinguishing these two different project types can be used for extending the range of learning opportunities across the whole product architecture, thus providing a lever for directing learning opportunities towards architectural vs. component-specific knowledge.

(2) *Alternating between learning and derivative projects.* Fiat sequentially alternates between the two types of project over time, an idea proposed in prior literature in the context of attaining ambidexterity (Gulati and Puranam, 2009, Nickerson and Zenger, 2002, Siggelkow and Levinthal, 2003, O'Reilly and Tushman, 2008). In combination with the lever of distinguishing the two types of project described above, the sequencing mechanism provides a project-level mechanism for combining the access to specialized knowledge of suppliers and internal learning.

By jointly implementing the distinction of project types and project sequencing, Fiat managed to extend the range along which learning can take place – in order to provide learning opportunities concerning the development and integration of components and systems – and implement such an extension of the range of learning selectively (i.e., only in some projects). Because learning once in a while is sufficient, implementing and adapting project sequencing can enable attenuating the trade-off[14].

[14] In this respect our findings suggest that differentiating template projects and derivative projects and sequencing these two project types to alternate between them enables implementing 'concurrent sourcing'. This mechanism has been suggested by Parmigiani (2007). The core insight of 'concurrent sourcing' is that it can be explained by the fact that a small degree of engaging in an activity is sufficient to get the full benefit associated with it (e.g., outsourcing a little suffices to get the full benefits of benchmarking, Parmigiani, 2007). The data presented here show this benefit also applies in the context of new product development, where learning once in a while can be sufficient to acquire certain competences. Thus, our findings suggest that concurrent sourcing extends beyond the manufacturing context it was originally documented in (Parmigiani, 2007). They also extend prior research on concurrent sourcing by suggesting that the principle that explains concurrent sourcing is the causal mechanism by which project sequencing between learning projects and derivative projects generates benefits both for accessing specialized knowledge of suppliers and for internal learning. The learning/derivative system thus provides an organizational design parameter that acts on the theoretical construct of project sequencing.

Fiat also discovered that the learning/derivative system is an organizational mechanism for managing linkages between projects that cross firm boundaries. As the evidence suggests, it is suitable for projects that cross firm boundaries because (a) engaging in learning projects can strengthen firm's component-specific and architectural knowledge, as well as its skill of technical communication with suppliers; (b) developing a template model leads to codification of the archetypical solutions, which makes it easier to communicate technical details to suppliers; (c) having the finished template model out on the market when the development of a derivate is being outsourced to an engineering supplier provides a further reference point to clarify the objective of the product development project; and (d) increased technical competences as well as communication skills improve monitoring, which enables the outsourcing of the development of a whole car model to regional subsidiaries (e.g. Brazil) or engineering suppliers[15]. Figure 4 shows the three-step logic of the new organization for product development that Fiat implemented (part 1 and 2) and its impact on project performance (part 3).

[15] From the perspective of the project and inter-project learning literature, identifying the learning/derivative system and its component parts thus also extends prior research by identifying features from inter-firm projects that can be used to generate inter-project learning (Prencipe and Tell, 2001, Nobeoka,1995).

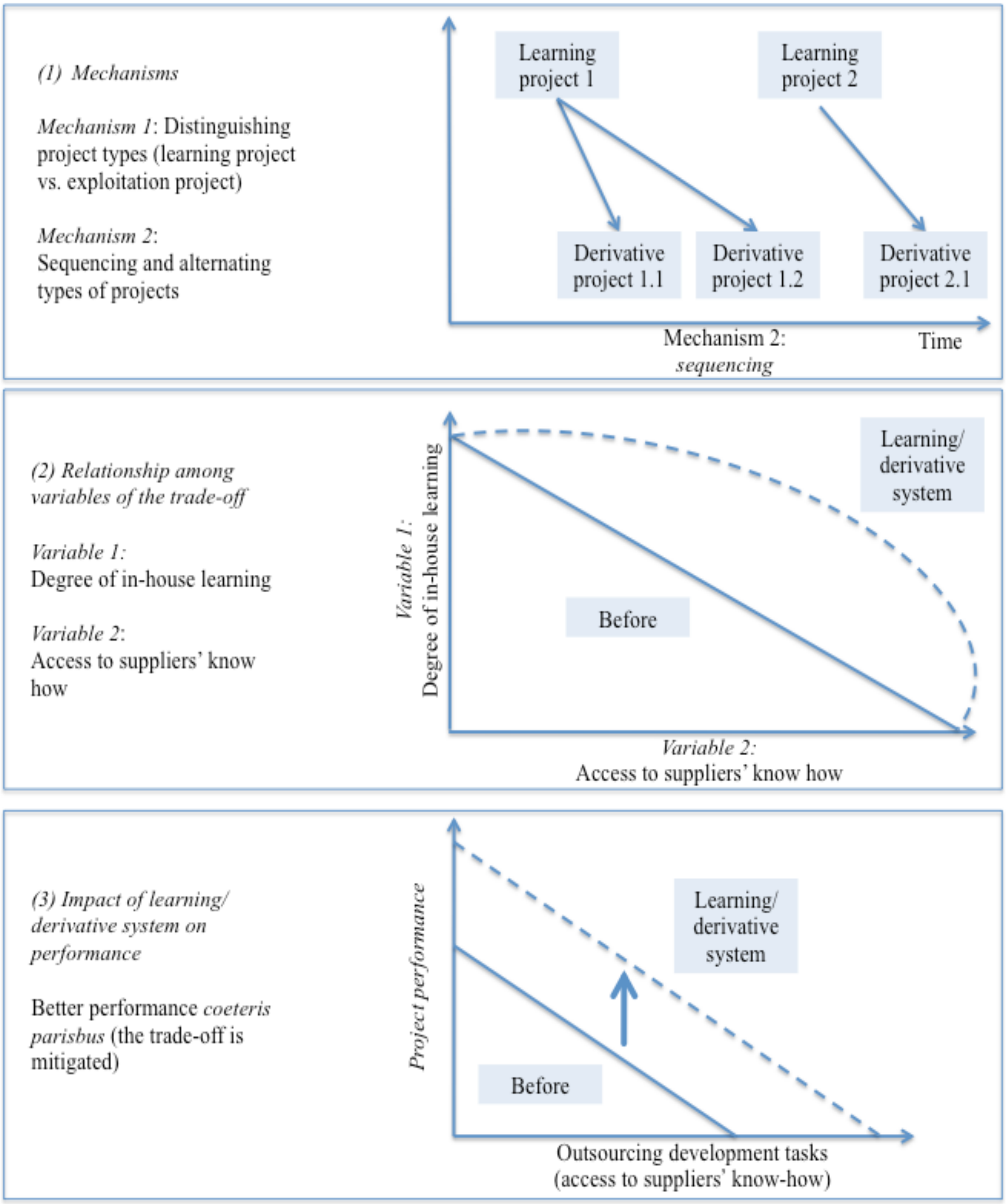

Figure 4 – New learning mechanisms in R&D outsourcing and a new viable frontier

Panel 3 of Figure 4 illustrates that moving the frontier enabled Fiat to do more with less. But how could this happen? What are the fundamental changes underlying the new approach? Fiat acknowledged that in order to improve the performance of its product development without insourcing design activities, it had to radically change its interpretation of the challenges of R&D outsourcing, and the organizational approaches used to tackle them.

Implications for implementing R&D outsourcing to avoid negative consequences: Moving beyond the "make or buy" choice

Four take-away lessons can be learned from the novel organization Fiat had implemented as a response to the negative consequences it had incurred from massively outsourcing product development.

The state of the art in research has moved beyond the short-term advantages of outsourcing such as access to the specialized competences of external parties, to recognize that competence decay due to lack of learning opportunities represents a crucial risk of outsourcing. Taking into account long-term consequences on the firm's competences because of missed learning opportunities means to recognize a trade-off between short- and long-term consequences of outsourcing (Grimpe and Kaiser, 2010). Acknowledging this trade-off makes it an obvious challenge to address the long-term leg of the trade-off (Jacobides & Winter, 2005). The first take-away is that to do so, the list of criteria for deciding about which tasks to outsource needs to be extended by the criterion of learning needs: keep in-house or in-source the tasks on which you need to develop and maintain competences.

Overlooking this criterion risks incurring competence decay in the long-term. Always making it the dominant criterion, however, means to reduce outsourcing. This poses a seeming paradox: in the light of this paradox, it appears that the choice is only the degree of short-term benefits and risk of negative consequences in the long-term, which are tightly coupled. The second take-way is that the coupling can be softened up by allocating R&D tasks in-house vs. to suppliers along the temporal dimension. For instance, alternating between template and derivative development projects over time (which involved different organization of teams, different relations to suppliers, etc.), it is possible to draw on the short-term benefits of outsourcing while mitigating the risk of negative long-term consequences due to competence decay because of missed learning opportunities. The temporal dimension has been mentioned in prior research (Tushman and O'Reilly, 1996, Boumgarden et al., 2012), but has not received much attention so far in theories of outsourcing.

Considering temporal sequencing of different schemes of division of labor across firm boundaries is not just novel in the outsourcing literature. It represents a way to change the allocation of resources to development tasks, as well as of development tasks to suppliers, in ways other than adapting the range of tasks carried out permanently by the firm. Thus, it enables changing the allocation of tasks within vs. beyond firm boundaries *without* changing vertical scope. This possibility is of great theoretical and practical importance because it represents a possibility for changing the allocation of tasks and resources without having to acquire supplier firms or teams of supplier engineers with the desired competences. It provides an important new alternative for managers, because adapting vertical scope is very costly.

The final take-away is that managers would benefit from focusing their R&D outsourcing decisions not only on the 'make or buy' question. Framing the main issue in 'make or buy' terms carries the danger of overlooking one major risk, i.e., competence decay because of loss of learning opportunities or excessive insourcing of R&D activities in order to avoid such loss. As we have shown in the evidence from the case, such novel possibilities can also be very effective.

Conclusion

For the theoretical discussion concerning firm boundary design, the insights from the Fiat case add to the growing evidence of more differentiated boundary designs. In particular, they add a lever that firms can pull in firm boundary design which has not yet been identified in the discussion of the boundaries of the firm: shifting between different schemes of division of labor with suppliers over time. As we have described above, this particular form of 'make-and-buy' (Parmigiani, 2007) has enabled Fiat to enjoy learning benefits as well as the benefit of being able to outsource the development of complete models to suppliers while making sure the final product conformed to Fiat's ideas, so that the resulting models really felt like a Fiat.

The novel solution, of course, is not a panacea and comes with its own negative side effects. The most notable one is that alternating project types over time might expose the firm to technological obsolescence of components and systems when they are applied in derivative projects. This problem can be particularly pronounced in industries characterized by faster technological obsolescence. This brings us to considerations concerning the boundary conditions of our findings.

The novel organizational system that Fiat implemented showed a strong impact due to the fact that (1) Fiat develops products that are complex and whose design tasks are highly interdependent (overall performance cannot be achieved through ex ante specifications of each single component/sub-system performance), (2) few standards have emerged in the industry (with the consequence that Fiat could not rely on standard interfaces to govern suppliers' involvement after R&D outsourcing), and (3) Fiat can exploit the investments made on a template platform throughout a range of derivative products.

Further empirical analysis in different industrial contexts can add richness and precision to the research on novel ways of implementing make-and-buy and on how firms adapt their boundaries over time.

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