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THE EVOLUTION OF KNOWLEDGE ORGANIZATION: THE EMERGENCE OF INNOVATION PLATFORM IN THE TURIN CAR SYSTEM[1]

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Abstract. The paper aims at explaining the changes in how economic actors and their organizations acquire and coordinate innovative and productive capabilities. Through the illustrative evidence of organizational change occurred in the automobile industry in the area of Turin over the last 50 years, the paper describes how transformations in the structure of interactions between firms are steered by the modification in the pattern of specialization and differentiation in the capabilities and technological skills of economic actors. The automobile system in Turin is characterized by the emergence of a distributed innovation platform, which is seen as a major innovation in the organization of innovation and technological knowledge in the system.

Keywords: Coordination; Networks; Organizational change; Platforms; Technological knowledge
JEL Classification: O31; O32; O33

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1. INTRODUCTION

A large range of contributions in the economics and management of innovation highlighted the virtues of vertical integration versus modularization and outsourcing as efficient solutions for the problem of how economic agents acquire and coordinate innovative capabilities and technological knowledge.

In particular, what can be called "the three hands debate" identified three main and well distinct modes of coordination of production and knowledge occurring along economic history: 1) the invisible hand of the market well understood a long time ago by Adam Smith, 2) the visible hand of the corporation described by Alfred Chandler (Chandler, 1962, 1977 and 1990), and 3) the vanishing hand of modularization, outsourcing, networks and contracts deeply analyzed by Richard Langlois (Langlois, 2003, 2004; Langlois and Garzarelli, 2008) among others.

This paper argues that, although both the vanishing hands of networks (for recent reviews of this phenomenon, see for instance Ozman, 2009; Bergenholtz and Waldstrøm, 2011) and the invisible hand of the market (e.g., Arora, Fosfuri and Gambardella, 2001) are nowadays persistent and increasingly used as mode of production and knowledge coordination because of the growing complexity of technologies, precise and well identifiable forms of hierarchy and managerial control characterize the use of interactions and transactions as means to source technological and productive knowledge externally. In other words, both networks of innovators based on interactions and cooperation (Helper et al., 2000; Lamoreaux et al., 2003; Grodal and Powell, 2006) and the markets for knowledge and technology based on transactions (Chesbrough and Teece, 1996; Sanchez and Mahoney, 1996; Langlois, 2002; Sturgeon, 2002) are coordinated by quite visible hands more similar to the

Chandlerian vertical hierarchy rather than to the spontaneous and anonymous coordination of markets as they are described by traditional approaches.

To do so, the paper describes innovation platforms as hybrid coordination modes that combine both interactions and transactions with hierarchical coordination and management of the networks. The notion of innovation platforms elaborated here differs from that of technological platform. The latter accounts for ICT-based innovations like virtual networks, and the associated infrastructures, and interfaces and standards (e.g., Gawer and Cusumano, 2002; Gawer, 2009). Technology platforms facilitate interoperability and coordination between different firms and technologies in the context of, for instance, high-tech industries (e.g., Consoli, 2005 and 2008) as well as scientific clusters (Robinson et al., 2007). Innovation platforms are instead strategic organizational vehicles for coordinating specialized and complementary actors. Common to both technology and innovation platforms is the notion of directed and coordinated organization as opposed to spontaneous and anonymous organization typical of market processes.

Moreover, contrary to the management literature that often presents a specific organizational solution as the more efficient or effective when compared to others and thus adopts a normative approach, this paper describes innovation platforms as the result of a path dependent and historical evolution where different types of organization occur in turn. The paper illustrates this emergence also through the case study of the long-term evolution of production and technological coordination in the Turin car system in Piedmont, distinguishing different historical phases characterized by specific organization forms and identifying which are the drivers and factors that force the system to change type of coordination. The characteristics of innovation platform, its advantages and disadvantages are compared to the other modes of coordination.

In this perspective the paper deals with an issue of economics of organization: and more precisely with the question of how economic agents and their organizations acquire and coordinate innovative capabilities and new knowledge. The illustrative case of the evolution of the organization of innovative and technological competencies in the car production system in Turin over the last 50 years, and the emergence of an innovation platform, is presented in order to explain the properties and effects of the introduction of transformations in the organizational structure of the innovation process, and more precisely in the way in which firms acquire and coordinate innovative capabilities and new knowledge.

In order to frame and guide such illustrative evidence, the paper builds upon the theoretical contributions that analyze innovation as the result of the exploitation of technological complementarities among a variety of actors.

Innovation platforms coordinate different resources and actors combining the benefits of large coalitions implemented with the scope of mutual learning and the acquisition of technological and productive competencies sourced externally, with those of centralized decision making. Some elements of a hierarchy characterize such models since directedness and authority is required in order to both guarantee the cohesion of the network and the convergence of the complex system of goals, incentives and interactions that are typical of a collective innovation processes.

The paper is structured as follows. Section 2 reviews and compared the different organizational forms for the coordination of knowledge and innovation that have occurred in the literature. Section 3 puts forward innovation platforms as specific governance forms for organizing technological knowledge and innovation. Section 4 describes the methodological approach used to collect and organize the empirical material about the evolution of the organization of innovation in the Turin car industry.

Section 5 illustrates and articulates the emergence of an innovation platform in the case of the Piedmontese car system. Conclusions summarize and put into perspective main results.

2. CHANGING STRUCTURES FOR THE ORGANIZATION OF KNOWLEDGE

The tradition of industrial economics and economics of innovation in the last century supported the thesis of the vertically integrated Fordist company, considered the most efficient organizational model for the production of technological innovation thanks to the benefits from the economies of scale, scope and learning that the vertical integration of R&D activities makes it possible to obtain (Chandler, 1990; Penrose, 1959).

Since the 1990s, however, various factors have emerged that have led to a rapid and radical transformation of the context in which firms compete, raising doubts about the applicability of this model in the new picture. Firstly, the growing turbulence of the situation and the intensification of global competition reduce the efficiency of management and control planning. Secondly, the greater complexity of innovative dynamics reduces firms' level of autonomy. No company is able to completely dominate all the technological and organizational competencies nor does it have the financial resources needed to develop new knowledge on its own. Lastly, the scientific-technological system has expanded. This means an increase in the sources that companies must investigate to seek out new knowledge to use in their innovation operations (see for example, Davenport and Prusak, 1998; Herrigel and Zeitlin, 2004; Foray, 2004).

The vertically integrated corporation and its R&D laboratories see their margins of autonomy and self-sufficiency shrink. In particular, large companies lose their prime position as the place par excellence for the production of innovation. In fact, in a

complex environment, characterized by continuous changes in the features of the products and production technologies, by radical uncertainty and by ever more extreme scientific and technological specialization, the individual company has difficulty in managing, purely through the capacities produced internally, all the competencies needed for the process of the generation of new knowledge.

The picture summarized above thus questions not only the model of the integrated corporation, but also the traditional schemes of the organization of innovation. This implies that the linear and closed model must be replaced and firms must structure themselves so as to be able to draw advantage from the external knowledge available integrating it effectively with the knowledge produced internally (Chesbrough, Vanhaverbeke and West, 2006).

As a consequence, consensus has grown in recent times amongst innovation scholars around the idea that, if firms are not able to develop independently a sufficient innovation capacity on their own, they can implement a variety of solutions that goes from one extreme (vertical integration), to another (the market), passing through a variety of hybrid strategies, forms of strategic alliances and inter-organizational relations aimed at minimizing the costs of external co-ordination and the maximization of the creative contribution of the individual companies. This has opened the way to the analysis of the various forms of decentralization, specialization and division of innovation and production that emerged following the crisis of the vertically integrated corporation.

Thus, on the one hand, a broad thread of studies on the organization of knowledge and technological innovation has directed its attention to modular systems, based on outsourcing and market transactions as the co-ordination mechanism of the division of labor in innovative activity (e.g., Arora, Gambardella and Rullani, 1998;

Baldwin and Clark, 1997; Langlois, 2002). When a system is extensive and complex, and the interdependency between the elements and subsystems becomes particularly numerous, co-ordination through an integrated structure is almost impossible, and as is upheld, for example, by Baldwin and Clark (1997) and Langlois (2002) the organization of production and innovation through modular strategies is the most efficient way to organize and co-ordinate complex technologies and production systems.

According to this approach, firms can decide to adopt an integrated or modular organizational structure on the basis of the technologies and competencies that are the foundations for the introduction of innovation: the more the knowledge and technological competencies needed for innovation are varied and interconnected, the more the adoption of a modular architecture and the recourse to formal contracts and market transactions will be efficient (Chesbrough and Teece, 1996).

The so-called loose coupling strategy does, however, show some limits. In particular, activities that demand exchanges of complex technological knowledge require the presence of integration mechanisms much more rigid, frequent and persistent than a modular organization usually guarantees (Schilling, 2009). If the activity demands an intense form of co-ordination and continuous in time, a more hierarchical organizational structure maintains closer integration between the partners involved.

Furthermore, innovation systems cannot always be broken down into discrete and distinct components as the modular structure suggests (Consoli and Patrucco, 2011). One of the main characteristics of those systems lies in the complexity of the interdependencies between their individual elements and sub-systems, where the changes in the conduct or the characteristics of one company also determine – through feedback processes deriving from the interaction between the elements –

transformations in the other organizations belonging to the system. Such systems are characterized by simultaneous change and reconfiguration in different stages of production that make obsolete existing know-how, require new knowledge to be applied and force embedded firms to acquire and develop new capabilities.

Also empirical evidence shows that, in tackling choices linked to the organization of their own innovation activity, companies do not have to hand purely modular or purely integrated solutions. Instead, the characteristics of the two alternatives co-exist and firms are able to use a broad spectrum of inter-organizational solutions in order to combine the advantages of both options (Brusoni and Prencipe, 2001; Zirpoli and Camuffo, 2009; Consoli and Patrucco, 2011).

In this direction, a growing literature has put increasing emphasis on networks as the place of production of innovation: the networks facilitate the co-ordination and integration of complementary technological competencies in contexts characterized by complexity, uncertainty and the dispersion of these competencies between heterogeneous sources, avoiding the costs and inefficiencies of full integration (for example, Powell, 1990; Uzzi, 1997; Burt, 2000; Kogut, 2000; Helper, MacDuffie and Sabel, 2000; Love and Roper, 2009; Ozman, 2009).

In particular, innovation studies have progressively asserted the idea that inter-organizational links and hybrid forms of organization are more effective solutions for the management of innovation, in that collaboration aids the access to a wide range of complementary technological competencies, representing an opportunity to recombine existing resources and competencies developed by individual companies in new knowledge. Combining the flexibility typical of market-based solutions with the visible hand of the organization, the inter-firm links reduce the access costs to different and

scattered sources of knowledge, a circumstance that in turn represents the basis for the creation of new knowledge and thus of the innovation process.

Much analysis on the effectiveness of the networks as models of governance of innovation has focused on the nature of the relations and roles played by the various actors within the networks. The structure of the network influences in fact the learning curves of firms and the analyses concentrated on the respective advantages of the various structures of relations that occur within a network, and in particular for two contrasting configurations: on the one hand networks characterized by strong and abundant ties, and on the other networks characterized by structural holes and weak ties.

According to Coleman (1990), for instance, the networks characterized by strong ties would generally be associated with an intense exchange of information, effective mechanisms of transfer of tacit knowledge, and reciprocal trust between partners. For this reason, these links would be more efficient for the exchange and communication of complex knowledge, in that they would allow the establishment of more efficient co-operative attitudes thanks to the repeated exchanges and a balanced distribution of power within the network. In contrast, according to some other authors (Granovetter, 1973; Burt, 1992), the networks characterized by weak connections and by structural holes that play a role as broker, directing and coordinating the flows of knowledge between companies or groups of companies not directly linked to each other, would represent more efficient solutions due to the advantages stemming from a partially hierarchical organizational form.

It is in exactly this context that the concept of innovation platform expresses its potential for interpretation.

Innovation platforms are specific governance forms through which economic players and their organizations acquire and co-ordinate innovative capacities and new knowledge (Patrucco, 2012).

The platform appears as a new and specific form of governance of knowledge that emerges as an effect of the dynamics of collective systems, i.e. because of the interactions between interdependent and learning actors (Patrucco, 2012). In particular, they can be defined as hierarchical networks, i.e. as networks in which the interactions do not emerge and evolve spontaneously, but in which key players (the platform leaders) exercise a guiding role on the behavior of the other actors, selecting the members of the platform itself and directing the behavior and the evolution of the system as a whole (Consoli and Patrucco, 2011). A second distinctive element of these organizational forms is represented by the active search for knowledge complementarity and exploitation of variety (contrasted to mere agglomeration) between different activities; in other words, the innovation platforms are structured and designed with a view to precise and pre-determined innovation objectives (in contrast to spontaneous phenomena such as some types of networks such as districts) (Consoli and Patrucco, 2008).

In this sense, the platform represents a significant organizational innovation, different to the integrated company, the market and the networks themselves with respect to both the type of coordination and the assumptions about the characteristics of knowledge. Table 1 summarizes these differences.

INSERT TABLE 1 ABOUT HERE

Next section will define the concept of innovation platform and provide an account of its characteristics.

3. INNOVATION PLATFORMS: THE BUILDING BLOCKS

Given the growing spread of the phenomenon in various industrial sectors, innovation platform stirs an intense debate across disciplines. Management scholars connect the latter to the challenges and the strategic implications associated to the emergence of open systems for production, exchange and govern competencies (Gerstein, 1992; Garud and Kuramaswamy, 1996; Ciborra, 1996; Ethiraj and Levinthal, 2004; Jacobides and Billinger, 2006). In the policy realm innovation platforms are looked at as a key reference model for the creation and management of mixed (i.e. public and private) coalitions (European Commission, 2004). In the context of innovation studies Antonelli (2006) argues that platforms are especially appropriate when technological knowledge exhibits levels of compositeness and cumulability that imply too high coordination costs for a single firm. Recent contributions by Baumol (2002) and Von Hippel (2005) further stress the incentives of knowledge sharing for firms within a platform. Efficiency in knowledge creation, they observe, stems from both internal investments and external learning and is higher than if it relied exclusively on either internal creation (i.e. vertical integration of R&D) or external acquisition (i.e. outsourcing of R&D and design).

Innovation platforms are systemic infrastructures for the organisation and coordination of collective innovation processes that feature high degrees of complexity[2].

The creation of innovation platforms consists in the design and establishment of architectures for inter-organizational coordination (Sah and Stiglitz, 1986 and 1988): these define the levels of engagement of each peripheral units, the characteristics of the

[2] The discussion that follows draws on Consoli and Patrucco (2011).

flows (i.e. unidirectional or bidirectional) of information and knowledge, and the extent of exchange across organizations.

In this sense, Kim and Kogut (1996) first talked about platform technologies referring to models for the coordination of complementary components such as computers, while Rochet and Tirole (2003) first ventured beyond the physical features of artifacts thinking of platforms as a design concept.

Innovation platforms are characterized by a variety of actors that participates to the production and supply of products and services; each unit exists independently according to own goals and capacity but, at the same time, responds to a collective goal through shared communication rules. The point, though, is that such differences across agents matter to a great degree. In turn, the architectures in which they operate are flexible and can be configured in different ways for different uses. A central component for the rationale underpinning platforms is maximising the variety of contributions stemming from a variegated knowledge base while maintaining coherence though a minimum level of hierarchy. As will be discussed further, innovation platforms are purposefully open to entry of new actors and, thereby, of new competences: the extent of contribution by each additional unit depends endogenously on the relative value of internal competences measured against the collective goal.

Relevant dynamics within platforms span technological and organisational levels, and bear upon both the static and the dynamic coordination of knowledge. From a static viewpoint, platforms connect and integrate activities and capabilities of relevant agents within an industry, thus supporting specialisation and favouring the accumulation of specific knowledge. From a dynamic viewpoint, platforms stimulate changes in both the structure of the network and the mechanisms for the governance of technological knowledge.

Let us now draw attention to some of the dynamic properties that characterise innovation platforms, namely: hierarchical causation; coordinated variety; and selective openness. The juxtaposition of these three gives way to the texture of connections that make up innovation platforms.

3.1. Hierarchical causation

What stimulates the emergence of collective structures such as innovation platforms? Let us, in answering this question, adopt a functional approach and argue that platforms are purposive responses to specific problems that no individual firm can solve in isolation. The general phenomenon is very common across most modern industries. Each firm possesses a knowledge base, which is usually accumulated by blending information inputs, know-how and capabilities while searching for and developing innovative solutions (Nelson and Winter, 1982; Teece, 1986; Cohen and Levinthal, 1989). Industries with a complex knowledge base accelerate the obsolescence of firm-specific knowledge assets thus forcing them to either invest in internal competencies or sourcing knowledge externally. Each of these solutions however carries its own risk. On the one hand, highly specialized knowledge is sticky and may differ considerably from the skills already possessed by a given firm (Pisano, 1996). On the other hand significant communication costs stand in the way of latent knowledge spillovers among firms. Such costs are affected by specific characteristics of the competitive environment in which firms operate (Patrucco, 2008). Either way, a firm under pressure needs to adopt effective governance mechanisms to overcome the barriers to creative reaction.

As we will see in details in section 5, in the auto industry in the Turin area, Fiat risked failure due to both strong competitive pressure and wrong organizational strategy. As a reaction, Fiat adopted a new governance mechanism to reconfigure the organization

of internal as well as external competencies. In this new system, Fiat retained hierarchical control over the net of suppliers and partners.

As Burt (2008) remarks, learning is not an optional attribute of collective structures: in dynamic environments where the scope of collaboration and the operative rules are liable to change, inclusion depends on the ability to remain relevant. That is to say, participation is contingent to learning and adaptation and platform leaders retain the control over "entry and exit" in the network of partners.

In this respect, the notion of platform expresses the vision that innovation occurs efficiently and successfully when partnerships are implemented based on the convergence of incentives and structured complementarity of the competencies of a variety of heterogeneous actors, so as to increase the cohesion of the group and organize the intrinsic complexity of the system around common purposes and shared goals. Efficient platforms emerge, in fact, when the various incentives and the complementary capacities of a multitude of heterogeneous actors involved in a network are organized and aligned so as to ensure the cohesion of the network and the co-ordination of the division of technological knowledge and labor in the innovation process.

3.2. Coordinated variety

Innovation scholars advocate that the growth of knowledge is rarely, if ever, the outcome of isolated action but rather of collective learning and cumulative interactions. On the one hand, the development of tacit knowledge moulds individuals' responses and is a source for new ideas and solutions; on the other, codified and practical knowledge are crucial to facilitate exchange and interactions across individuals. Contrary to the common view that these dimensions are dichotomic, we stress their complementary aspects: new knowledge grows as a result of coordination across individual experiences

and the development of shared understanding. At the same time, variety and heterogeneity are not sufficient to replenish the knowledge base and individual specialization is most effective when coordinated through formal and informal mechanisms (Gilson et al., 2009). The collective character of knowledge, in turn, elucidates on the importance of establishing sound governance mechanisms (Antonelli 2006). Previous literature sidestepped these points by assuming implicitly that agents learn and adapt swiftly to collective environments.

Instead, innovation and the creation of new technological competencies are more and more frequently seen as a collective and distributed phenomenon, based on a high degree of complementarity between internal investments in R&D and the learning of technological resources acquired externally from other companies (for instance, customers and suppliers, competitors), and from research bodies (e.g. universities, public laboratories, technology transfer centers) (Allen, 1983; Cowan and Jonard, 2003).

In line with the pioneering contribution of Nelson and Winter (1982), in which economic change is the product of the action of actors who possess idiosyncratic and highly specialized abilities, technological competencies, are therefore characterized by rather limited degrees of interchangeability and substitutability, but on the contrary high levels of complementarity (Patrucco, 2008): screening and learning strategies are conditions required for accessing knowledge sourced externally and to render the exploitation of externalities efficient in the creation of new knowledge .

Some authors (Cohen and Levinthal, 1989) talk on this point of the ‘two faces’ of R&D and of the importance of investing in internal R&D so as also to be able to use knowledge arriving from outside. This implies, for instance, that R&D activities run internally assume new functions: their role is no longer limited to the production of new technological knowledge, but includes the identification and understanding of the

external knowledge available, the selection and integration of the significant portions with internal knowledge in order to produce more complex combinations, as well as the production of further profit through the sale of in-house research work to others so as to be able, in the same way, to integrate and use it in their own innovation process (Cohen and Levinthal, 1991).

A clear trade-off is involved in the pursuit of specialization when a large knowledge base is available (Kogut, 2000; Crémér, Garicano and Prat, 2007). Such a trade-off defines the scope, the boundaries and the forms of inter-organizational relations within a platform. On the one hand specialization favours efficient communication within a narrow set of partners but limits both the scope for coordination and accessibility to innovative opportunities. On the other hand the coordination of a bundle of inter-firms and inter-organizations linkages opens up new opportunities but lowers the scope for specialization and the benefits of communication (see Kogut and Zander, 1992). The implementation of innovation platforms contributes to reduce the inefficiencies associated to these trade-offs.

3.3. Selective Openness

To be viable infrastructures like innovation platforms require on the one hand a degree of stability that confers coherence to shared goal and, on the other hand, room for further novelty. From this it follows that a necessary condition for the emergence of novelty is that a system maintains a degree of openness to be able to adapt to modified circumstances.

The key point is that the implementation of major technical changes generates new opportunities for learning but in so doing also leads to skill shortages. For instance, empirical works such as those by Brynolfsson and Hitt (2000) demonstrate that the

large-scale diffusion of Information and Communication Technologies (ICTs), often the backbone of innovation platforms, stimulates the emergence of new tasks and competencies required. In turn, where new knowledge comes from and the costs for this knowledge to be absorbed, integrated and used by different members of the network depends on the degree of openness of the platform.

As anticipated by Richardson (1972) and reiterated by many others, when coordination between closely complementary activities and competencies is essential for the success of innovation, firms rely upon a variety of inter-organizational arrangements – such as joint ventures, equity agreement, R&D partnerships, coalitions and consortia – to blend market- and contract-based and integral solutions, strong and weak relations, in order to acquire and coordinate the necessary productive and innovative knowledge. Complex and articulated governance forms emerge when the task is the coordination of knowledge sourced both internally and externally, and multisided learning.

Concepts like architectural knowledge (Henderson and Clark, 1990) or architectural capability (Jacobides, 2006), or that of system integrators (Prencipe, Davies and Hobday, 2003) have been introduced recently to describe precisely that decisive capacity, possessed by the platform leaders, to co-ordinate and manage the work of complex organizations, and more precisely to combine elements typical of the integrated models (such as authority and control), with characteristics typical of networked structures (such as a sufficient degree of openness) in order to select the significant competencies and knowledge to include in the network.

In the car industry, for instance, this seems precisely to be the case of the design and development of Electric Vehicles (EVs), where large partnerships, often embedding public actors and new comers have been implemented with the scope of learning and acquiring selective technological and market competencies developed outside the car

industry strictly considered (Aggeri, Elmquist and Pohl, 2009; Beaume and Midler, 2009). The introduction of electric vehicles (EVs) can be depicted as a collective innovation wherein different actors such as traditional OEMs, automobile batteries producers, utilities and system integrators contribute with complementary resources as well as technologies, and converge towards common goals and incentives. At the same time, some elements of managerial authority are still likely to characterize such models in that directedness is required in order to guarantee both cohesion within the network and the convergence of the complex system of goals, incentives and interactions that characterizes such an articulated innovation process (Enrietti and Patrucco, 2011). The integration, coordination and direction of the different strategies and goals of various organizations that take part in the platform should be a central issue the platform management.

In sum, Table 2 compares the different main coordination forms and summarizes the main characteristics, costs and benefits of the market, the vertical corporation, the network and the platform.

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4. METHODOLOGICAL APPROACH

When accounting for the evolution of the organizational structure in the car system in Turin, the methodological approach adopted can be defined as 'appreciative theorizing' (Feldman, 2001; Malerba et al., 1999; Nelson, 1994 and 1998). Appreciative theorizing is appropriate in the analysis of the organization of innovation and knowledge because of the high level of social embeddedness of the collective process of knowledge generation and distribution, where interaction and evolutionary processes cannot be

fully captured by formal models and may often be expressed only in qualitative terms. As Nelson put it, 'appreciative theorizing tends to be close to empirical work and provides both interpretation and guidance for further exploration. Mostly is expressed verbally and is the analyst's articulation of what he or she thinks really is going on. However, appreciative theory is very much an abstract body of reasoning. Certain variables and relationships are treated as important, and others are ignored. There generally is explicit causal argument. On the other hand, appreciative theorizing tends to stay quite close to the empirical substance' (1994, p. 500).

In this perspective, our methodological approach is an analytical interpretation of the evolution of the organizational form that coordinate innovation and technological knowledge in the automobile industry in Piedmont over the last 50 years.

In practical terms, we conducted a set of interviews with corporate managers who directly contribute to that evolution, as well as with local policy makers, expert analysts and members of collective bodies knowledgeable about the process of organizational change experimented in the local car industry.

More precisely, reiterated focused groups of open and vis-à-vis interviews with 16 interviewees (see Appendix for a synthetic description) have been carried out, gathering selected members of the local car industry and organizing the collective discussion around the following broad issues: the origins of the system, the industrial dynamics that characterized it over the last 50 years, the characteristics of innovation process over the last 50 years, the forms of its organization and coordination. Interviews were guided in order to gather information about: a) which firms command technological competencies key to innovation along the evolution of the car system; b) which where the forces that drove the system from one stage to another; c) which are the structural characteristics of the different "architecture" in the different stages of its

evolution, with a special attention to d) which are the knowledge interactions and flows that support the innovation process.

Since issues such as interactive behaviors, knowledge sharing and co-operation are extremely complex, open and face-to-face interviews allow capturing the very qualitative nature of such interdependences. Moreover, the organization of very close interview groups of selected members of the local "car community" allows the gathering of information benefiting from collective, interactive and in-depth discussion on the topics proposed in the trace of the interview, at the same time leaving room for unexpected issues emerging from the discussion, and in turn also strongly motivating the commitment of the participants in the research work.

Next section will present, in an organized and articulated way, the result of such methodological approach with the aim of emphasizing the emergence of an innovation platform as an appropriate governance mode for technological knowledge and innovation.

4. THE INNOVATION PLATFORM IN THE EVIDENCE OF THE TURIN CAR SYSTEM

The automotive industry has many characteristics of collective systems from both a structural and a dynamic viewpoint.

The technological and knowledge base required in car production has been characterized by a knowledge base that requires the understanding of different and complementary technological fields from its very beginning. This complexity is however recently increasing from both the static and dynamic viewpoint. Car production requires the full understanding of the complementarities within a wide range of different technologies and materials, and therefore the command of a very diversified

set of knowledge modules in engineering, electronics, chemistry, plastics technology, robotics, informatics and telecommunications. Each of these modules however cannot be fully commanded internally by the firm. Knowledge requires the integration and recombination of external and internal knowledge via the supply and demand of products, components and process technologies.

Historically, the integration, recombination and in turn the coordination of such a growing number of components, technologies and modules of knowledge has been achieved through an increasing division of labor, specialization and outsourcing. These are the results of the intertwining effects of market saturation, product differentiation, demand uncertainty and financial pressure that bring about increasing needs of operational efficiency and therefore organizational and technological change. From the organizational viewpoint car production is therefore clearly characterized by strong specialization, strong division of labor and therefore important coordination costs.

Such increasing specialization and fragmentation cause a range of ways and paths along which Original Equipment Manufacturers (OEMs, i.e. car-makers) decide to outsource production processes and activities. Know how and capabilities are distributed quite differently across both OEMs and suppliers. Product architecture in the car industry can differ substantially from model to model and the notion of interchangeable modules, components and activities across models, OEMs and suppliers is limited due to significant variations in know how and competencies. Different suppliers are characterized by different capabilities: providing even the same activity or component to different clients implies for the same supplier, different competencies. Selection among suppliers and the emergence of preferential relationships are important in this context. Suppliers' activities and capabilities are not fully interchangeable and modular, nor fully reversible. Knowledge modules are not completely interchangeable

because of the specific, idiosyncratic and non-disposable part of know-how. This in turn bears important costs for OEMs. Important switching costs are associated to shifting from one supplier to another, and related high costs are due to changes in the technology modules and in the design of the system and the architecture of coordination. Preferential interactions between OEMs and suppliers emerge in turn as an effect of such costs (Sako, 2003).

Interaction between actors is crucial for such coordination, and successful product innovation (i.e., the introduction of a new car) implies the ability to coordinate in the more appropriate way the wide networks of specialized suppliers and partners. In other words product innovation is directly related to the ability to introduce and manage changes in both the organization and production processes.

In this regard, the Piedmontese automotive sector underwent and is currently undergoing a phase of strong structural and organizational change due to the difficulties experienced especially in the '90s by the main actor, namely FIAT. As the mingled result of increasing complexity in the knowledge base and the crisis of FIAT, car production in the Piedmontese system has been characterized by progressive vertical disintegration and strong externalization of more and more complex and specialized components and processes. This results into the stronger and stronger need of coordination of the division of labor and communication between specialized producers and users. Such a need for coordination mechanisms is paralleled by the declining role of FIAT as the traditional "hub" of the network of small and large suppliers and R&D institutions. The lack of centralized coordination was one of the main problems due to the crisis of FIAT, which was instead by no way a crisis of the Piedmontese automotive system as a whole. This is in fact today a sophisticated multi-firm productive system characterized by a complex network of highly specialized suppliers for the international

market, design firms (such as Pininfarina and Giugiaro), machine tool firms, research and training organizations (CRF and ISVOR), and university programs (Enrietti and Bianchi, 2003).

The evolution of the organization and coordination of innovation in car production[3] paralleled the disappearing of technological capabilities internal to FIAT (at least in the first three phases) and can be articulated in four phases (Table 3): 1) coordination through vertical integration, 2) coordination through a centralized network of local suppliers, 3) coordination through a decomposed network and 4) coordination through innovation platform (Table 1). FIAT moved from a vertically integrated production structure to the outsourcing of manufacturing activities and the production of components to local small suppliers, to the decomposition of the production and innovation processes, together with the outsourcing of strategic and high-valued activities such as design and R&D, and the adoption a modular architecture, and finally to proper co-innovation and co-design.

Major implications for the coordination of the innovative activity of the firm can be specified in this context, taking into account the role of organizational change, i.e. the evolution of the architecture according to the characteristics of the business environment in which firms are playing. We can specify the characteristics of the changes in the organization of innovation as follows:

1. Coordination through vertical integration was typical in the '60s and '70s. Coordination of innovative and productive activities takes place through the Fordist firm and is based upon internal accumulation of R&D, capabilities in the design of

[3] A key source on the history of the Turin car industry and FIAT has been Volpato (2004 and 2008).

cars models, and capabilities in technology design. In this model innovation do take place exclusively within FIAT and in isolation.

2. Coordination through centralized networks of local suppliers progressively takes place during the '80s, as a reaction to uncertainty in both demand characteristics and the supply strategies appropriate to meet the changes in consumers' needs and requirements. The vertically integrated carmaker is induced to change its coordinating structure. Here FIAT outsources manufacturing activities and the production of components to local small suppliers, creating a local and closed productive network of suppliers still dependent on and coordinated centrally by the OEM. R&D and design are defined ex-ante by FIAT and the results of such activities transmitted in a top-down and unidirectional fashion to suppliers.
3. Coordination through decomposed network arises more and more importantly in the '90s[4]. Suppliers able to benefit from economies of specialization and learning, accumulated competencies that make these firms emerging as first-tier suppliers. On the one hand, these first-tiers suppliers are also able to integrate themselves into international productive networks and become international suppliers of carmakers. On the other hand, they are able to move from the mere provision and supply of simple components to the provision of product design services. Now FIAT chooses to outsource those strategic activities such as design, and to transfer to supplier not only activities, but also autonomy and key decision processes in terms of the design features. This is clearly possible only in that suppliers accumulated specialized competencies with regard to product design, and more generally innovative skills. Innovation takes place in a bottom-up manner, driven by the competencies of first-tier suppliers, yet progressively spoiling the OEM of both its innovative

[4] On this phase, see Becker and Zirpoli, 2009; Zirpoli and Becker, 2011.

competencies and its coordinating role in the network. One can argue that new Burt-type structural holes emerge (i.e., First Tier Suppliers) because of the coupled effects of positive economies of learning and specialization of the FTSs, and negative effects of the declining organizational and innovative capabilities of the OEMs.

4. Finally, coordination through innovation platforms became possible only when in 2001 FIAT decided to start bringing back R&D and design in house, reacting to the loss of innovative capabilities experienced in the previous phase, and yet being still able to rely on the complementary R&D and design competencies developed by first-tier suppliers. FIAT can now combine its internal know-how with that of the first-tier suppliers, thus being able to take advantage from synergies and technological partnerships through appropriate collaborative strategies. Moreover, FIAT is now again able to coordinate the innovation process because of new internal R&D and design activities. In parallel, coordination strategies support the introduction of a variety of "de-layered" organizational relations, which benefit from a wider pool of resources and knowledge, where technological cooperation can take place vertically (i.e. within FIAT supply chain), horizontally (i.e. between FIAT and different OEMs, such as the alliance with Chrysler in 2009) and diagonally (i.e. through different supply chains by means of first-tier suppliers that cooperate with different OEMs). Innovation is the result of the integration of top-down and bottom-up innovative processes and takes place in a truly cooperative way, through the bidirectional exchange and communication of technical information, innovative capabilities and the results of R&D and design activities developed both by FIAT and the first-tier suppliers. Here, transformation also includes changes in the number and quality of actors, integrating in the platform

new suppliers and partners according to new emerging technological needs, and excluding old ones. It's seems plausible to affirm that a Coleman-type of relationships emerge in this context, where redundant connections as well as technological competencies effectuate a collective model of innovation based upon the exploitation of the complementarities between the skills of the different players.

INSERT TABLE 3 ABOUT HERE

Four models of organization of innovative activity can be identified according to the different scope of communication and transmission of knowledge (Figure 1). Important changes involve the structure of relations between actors. The network transforms from centralized, limited in the number of connections and characterized by one-way relations (in phase II – The centralized network), to vertical and yet limited (to OEMs and FTSs) cooperation (phase III – The decomposed network), to distributed, horizontal and vertical communication strategies (in phase IV – The innovation platform).

INSERT FIGURE 1 ABOUT HERE

As a matter of fact, important changes involved not only the choice between make and buy, between internal production and external provision, but also the way in which FIAT coordinates and manages external supply. A straightforward example of such changes is the adoption by FIAT of the so-called Advanced Product Quality Planning (APQP) methodology in managing the suppliers network and their activities. Prior to the adoption of APQP, the definition of new cars and component characteristics and the process of their acquisition from suppliers was defined ex-ante and dominated by the

design centrally specified by FIAT: given ex-ante characteristics of components, FIAT set prices and identified the appropriate suppliers. With the adoption of APQP and progressive decentralization of activities also engendered by the accumulation of competencies by suppliers, the process reverted. Now Fiat defines the general design and characteristics of a new car model and communicates such information to the network of suppliers. Each supplier, according to its specific technological knowledge and to the price/quality requirements, elaborates a project for the production of the given component or system. The competition among suppliers makes the more appropriate projects emerged and allows FIAT to select the more appropriate suppliers. Only after such competition and selection processes, the negotiation between FIAT and the selected suppliers defines ex post and precisely the characteristics and the prices of the given component or system.

Such a change contributes to the emergence of an innovation platform (Figure 2) where medium sized suppliers acquired new centrality in both the organization of and innovation in car production in Piedmont, thanks to their ability to accumulate and create new internal technological knowledge. The performance of the system now is very much dependent upon the performance of these first-tier suppliers, together with the restored innovation and coordination capabilities of FIAT, especially in terms of higher efficiency in production, better quality of components and modules and innovative capabilities brought into the process.

Paralleling the difficulties FIAT went through in the ‘90s, a new organizational structure in the sector emerged, where medium firms are more and more key actors both in productive terms and in terms of their innovative and design capabilities, as well as actors that progressively acquired coordinating functions that were previously demanded only to the large firm.

From the viewpoint of the external governance and the coordination of the network of suppliers, the process of progressive transfer of upstream strategic activities and autonomy from FIAT to suppliers (Whitford and Enrietti, 2005) put in place in the '90s involved not only first-tier suppliers but also, nowadays, second-tier suppliers and can be seen as an effective mechanism of the dynamic coordination of the division of innovative labor.

Although the decision to adopt and the implementation of the innovation platform has been decided centrally by FIAT, the new mode of coordination implies the integration of top-down resources and capabilities provided by the OEM (i.e. the general and macro "template" of a new car, to use the terminology introduced by Becker and Zirpoli, 2007)[5] with the bottom-up innovative activities provided by specialized suppliers (i.e. the actual implementation of modules and components with new features and performances). This integration is especially relevant in terms of the dynamic coordination of the production of new car models. A given new car model is now an emergent property of the cooperative efforts of FIAT and suppliers along the entire production chain, aiming at the development and exploitation of complementarities in different activities, technologies and spaces of competencies. The introduction of a new car model is now possible only in that the OEM and the specialized suppliers co-design the features of the variety of components and modules that need to be integrated into the new final product. The effective coordination of this innovative process, and the successful introduction of new cars, is now possible only

[5] Becker and Zirpoli (2007) articulate an in-depth analysis of the corporate strategy implemented by Fiat in the last phase described by this paper. In particular, Becker and Zirpoli focus on and develop the implications for the strategic management of product innovation. Their emphasis is on the changes introduced in the product architecture as a consequence of organizational transformation at the supply chain level, while this paper is focusing on the transformation of the structure, or architecture, of the innovation network in which Fiat is embedded.

because of the adoption of a distributed platform that supports the interaction between the different organizations.

INSERT FIGURE 2 ABOUT HERE

In sum, in the case of the Piedmontese automobile cluster the emergence of a new organizational form for the coordination of innovation is the result of the matching between bottom-up processes of differentiation in the specialized activities of suppliers firms, and top-down implementation of new organizational principles and a new management of the suppliers network. The latter is developed by FIAT as a reaction to two main factors: 1) the differentiation process put in place by FTSs in particular – i.e. their accumulation and acquisition of new technological competencies in R&D and design, that are added value and knowledge-intensive activities, contrary to their previous focus on mere supply of components, and 2) the diminishing innovative competencies of FIAT, as a result of the adoption of strong outsourcing strategies in the '80s.

The new structure of relations we finally observe is the emergent outcome of the interaction between micro behaviors and macro elements of the system. As a consequence of the renewed business model and recovered innovative competencies at the level of the entire system, FIAT is experiencing a remarkable turnaround (The Economist, 2008).

5. CONCLUSIONS

This paper stresses and reconciles two aspects that have been often underestimated in the debate on the organization of innovation, and yet well known in innovation studies:

1) the fragmentation and dispersion of technological capabilities, which is directly derived from the distinctiveness and specificity of the knowledge each organization commands (Nelson and Winter, 1982); 2) the interdependence and non-decomposability of socio-economic systems, which implies that socio-economic systems cannot be completely modularized (Hanusch and Pyka, 2007).

The paper proposed innovation platforms as governance forms historically alternative to the market and the vertical corporation, able to overcome the trade-off between the fragmentation of knowledge and the interdependence of innovators, and appropriate for coordination of distributed innovation processes characterized by high degree of complementarity, division of labor and specialization of activities and competencies.

The emergence of and innovation platform as a path dependent process is clear through the changes that occurred in the organization of technological knowledge and innovation in the Piedmontese automobile system. The system has been characterized by important transformations in its structure as the effect of three intertwining elements: a) the progressive vanishing of FIAT's organizing and innovative capabilities in the '90s; b) the gaining importance of first-tier suppliers in terms of both coordinators and innovators in the networks because of the advantages derived from economies of scale and specialization; c) the re-accumulation of internal R&D and innovative skill within FIAT from 2001. The innovation platform derives as the emergent result of complex dynamics that are based upon the interaction of these three processes. In particular, the organizational form emerging in the Turin car system in the last decade combines elements of hierarchical co-ordination with elements of openness and decentralization, sees innovation as the result of processes and activities conducted collectively, and sees new players (i.e., first-tier suppliers) taking position at the center of the innovation

process both as suppliers and as integrators. The acquired centrality of those players entails not only the introduction of new competencies and technologies, but also the redefinition of roles and power relations within the sector. The analysis of the entire system of complementarities becomes fundamental at this point to understand how the introduction of new organizational form change the architecture of the relations between OEMs and suppliers of various levels, and consequently the structure of the relations of collaboration between different actors, which we have seen is decisive for the success of the introduction of new technology.

Such a systemic reconfiguration is driven, in a truly Marshallian fashion, by the differentiation of the activities of actors and the changes in the organization that coordinate the division of labor among those actors. In other words, two kinds of differentiation are at works here: 1) differentiation in the functional and technological specialization of firms; 2) differentiation in the architecture of the system. In particular, changes in the functional specialization of firms makes individual actors non independent and not even nearly independent of one another. Differentiation changes the structure of the system since new characteristics and capabilities of the firms are introduced. These transform the relationships between actors, in turn transforming the structure of the system, i.e. the structure of interactions between actors. This in turn affects the role and position of single firms in the network, with firms unable to adapt and react to the new technological requirements becoming peripheral and possibly exiting the network, while firms able to redirect resources and create new capabilities acquire new centrality and leadership.

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Table 1. Knowledge and coordination in different types of organization

Coordination *Knowledge*	**Spontaneous**	**Directed**
Complete	Market	Vertical integrated firm
Fragmented	Networks Industrial districts	Innovation platforms Modularized networks

Table 2. Characteristics, costs and benefits of the different coordination forms

COORDINATION FORM **FEATURES**	**THE INTEGRATED FIRM**	**THE MARKET**	**THE HORIZONTAL NETWORK**	**THE PLATFORM**
Coordination	Managerial control	Price mechanism	- Spontaneous interactions (districts) - Market transactions (modularized networks)	Directed
Inclusion	Limited	Free (no barriers to entry)	Open and diffused	Selective variety
Design costs	High	Null because of emerging order	Low because of spontaneous coordination	High
Networking costs	Low	Null because of perfect information	High due to redundant connections	Limited because of platform leader(s) gatekeeping
Production costs	High	Low because of the division of labor	Low because of the division of labor	Conditional to the mix of internal production and external sourcing
Transaction costs	Low	High	- Low (districts) - High (modularized networks)	Conditional to the mix of internal production and external sourcing
Switching costs	High	High	- High due to sticky information (districts) - Low because of efficient interfaces (modularized networks)	High because of long-term collaborations between different tiers of the system and asset specificity
Product design strategy	Top-down and ex-ante	Bottom-up and ex-post	- Bottom-up and ex-post (district-like networks) - Top-down and ex-ante (modularized networks)	Co-design
Flexibility of production	Low	High	High	Limited
Economies of specialization	Limited	High because of the division of labor	High because of the division of labor	High because of competences variety
Economies of scale and scope	High	Null	Internal to the network	Internal to the platform
Learning economies	Bounded to firm competencies	Competencies sourced externally	- Collective learning (district) - Competencies sourced externally through transactions (modularized networks)	Search for complementarity and collective learning
Circulation of knowledge	Limited to the firm boundaries	Free	- Open and diffused (district) - Conditional to IPRs (modularized network)	Selective
Innovation process	Internal R&D	Creative destruction	- Knowledge externalities (district) - Private R&D (modularized network)	Collective (integration of internal R&D and external sourcing)

Table 3. Organizational changes in the coordination of production and innovation the Piedmontese automotive system

Phase	Coordination structure	Organization characteristics	Innovation process	Drivers to change
Phase I: '70s	The firm	- Vertical integration of production - Internal accumulation of R&D - Internal accumulation of capabilities in the design of car models - Internal accumulation of capabilities in technology design	- Innovation in isolation	- Diseconomies of scale
Phase II: '80s	The centralized network	- Outsourcing of small components and spare parts - Central coordination of suppliers by the OEM - Exclusive supply from small suppliers to the OEM	- Ex-ante and top-down design of car models, components and technology - Innovation undertaken internally by the OEM	- Diseconomies of scope (OEM) - Decreasing returns to R&D (OEM) - Financial constraints (OEM) - Economies of specialization and learning (suppliers)
Phase III: '90s	The decomposed organization	- Suppliers benefit from economies of specialization and learning - First-tier suppliers emerge as innovators at the local and international levels - Outsourcing of components - Outsourcing of design in both components and modules - Modular product and system architecture design	- Outsourcing of R&D and design - Bottom-up (first-tier suppliers driven) innovative process	- Losing control (OEM) - High transaction costs - High levels of hold-up problem
Phase IV: 2001 – ongoing	The innovation platform	- In-sourcing of innovative and value adding activities - Acquisition of external resources built in phase III - Vertical cooperation between OEM and FTSs - Horizontal cooperation between OEMs and between FTSs - Internal to the OEM product and system architecture design	- Integration of top-down (OEM) and bottom-up (first-tier suppliers) innovative process - Co-design - Co-innovation	

Source: systematically updated and changed from Consoli and Patrucco (2008)

Figure 1. The evolution of the coordination of innovation activity in the Piedmontese automotive system

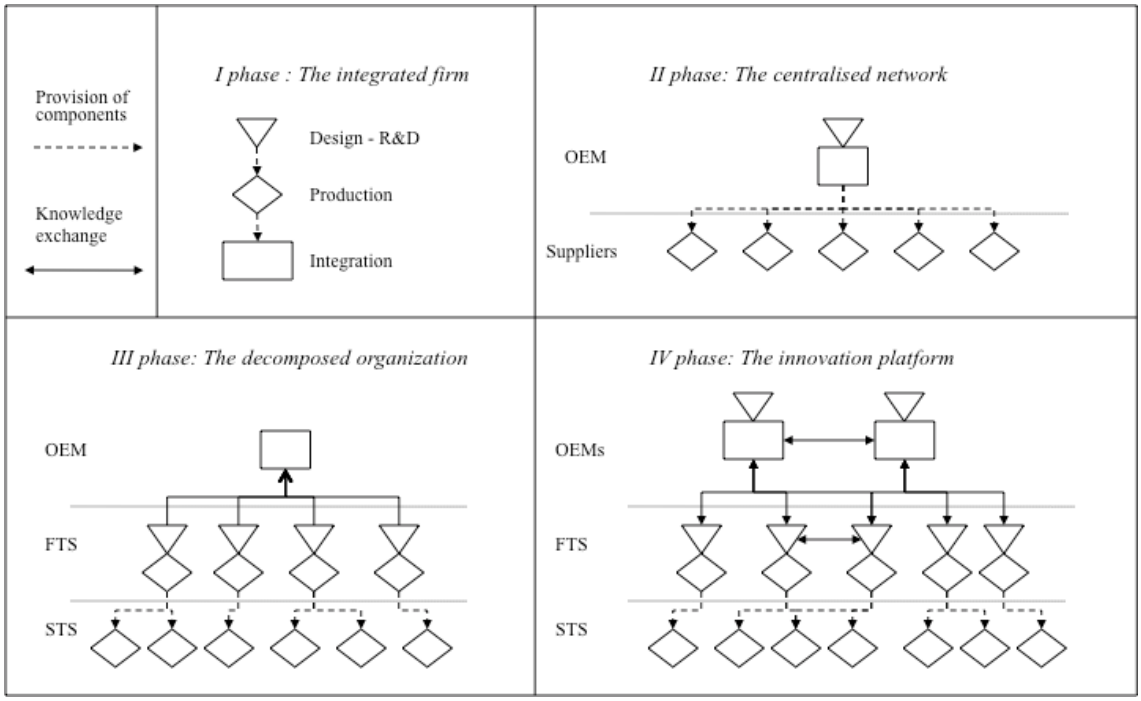
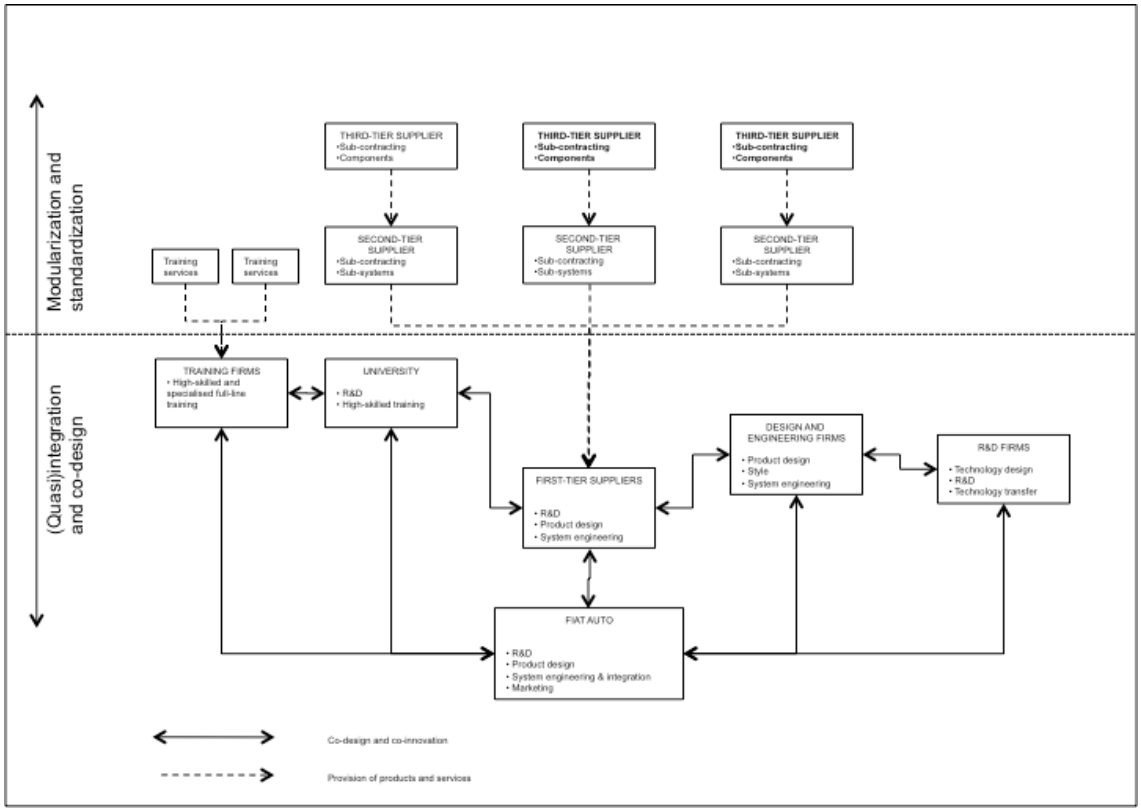


Figure 2. The innovation platform in the Piedmontese automotive system



Appendix. Sources and type of interviews

Interviewee	Position	Date(s) of interview	Type(s) of interview	Key elements explored during the interview(s)
I1	Purchasing senior manager at OEM	June 2007 May 2008 January 2009	Direct and open interviews Focus group	- Relations with suppliers - Characteristics of platform - Shift from phase III to phase IV
I2	Purchasing senior manager at OEM	October 2007 May 2008 January 2009	Direct and open interviews Focus group	- Relations with suppliers - Characteristics of platform - Shift from phase III to phase IV
I3	IT senior manager at OEM	November 2008 February 2009 January 2009	Direct and open interviews Focus group	- Organization of internal and external information flows in phase III and IV - Shift from phase III to phase IV
I4	IT junior manager at OEM	November 2008 February 2009	Direct and open interviews	Organization of internal and external information flows in phase IV
I5	R&D senior manager at OEM	November 2008 February 2009 January 2009	Direct and open interviews Focus group	- Organization of innovation in phase III e phase IV - Shift from phase III to phase IV
I6	Production senior manager at OEM	November 2008 February 2009 January 2009	Direct and open interviews Focus group	- Characteristics of platform - Shift from phase III to phase IV
I7	Strategy senior manager at OEM	November 2008 February 2009 January 2009	Direct and open interviews Focus group	- Characteristics of platform - Shift from phase III to phase IV
I8	Production senior manager at first-tier supplier A	February 2009	Direct and open interview	- Collaborative strategy with carmaker in phase III and phase IV
I9	Production senior manager at first-tier supplier B	February 2009	Direct and open interview	- Collaborative strategy with carmaker in phase III and phase IV
I10	Strategy senior manager at first-tier supplier C	February 2009	Direct and open interview	- Collaborative strategy with carmaker in phase III and phase IV
I11	Senior policy maker	March 2009	Focus group	- Different stages of long-term evolution of the system - Drivers of change from stage to stage - Limits and advantages in terms of knowledge sharing and innovation of phase III and IV
I12	Senior policy maker	March 2009	Focus group	- Different stages of long-term evolution of the system - Drivers of change from stage to stage - Limits and advantages in

				terms of knowledge sharing and innovation of phase III and IV
I13	Senior expert analyst	March 2009	Focus group	- Different stages of long-term evolution of the system - Drivers of change from stage to stage - Limits and advantages in terms of knowledge sharing and innovation of phase III and IV
I14	Senior expert analyst	March 2009	Focus group	- Different stages of long-term evolution of the system - Drivers of change from stage to stage - Limits and advantages in terms of knowledge sharing and innovation of phase III and IV
I15	Senior expert analyst	March 2009	Focus group	- Different stages of long-term evolution of the system - Drivers of change from stage to stage - Limits and advantages in terms of knowledge sharing and innovation of phase III and IV
I16	Senior member of small firm business association	March 2009	Focus group	- Different stages of long-term evolution of the system - Drivers of change from stage to stage - Limits and advantages in terms of knowledge sharing and innovation of phase III and IV

Note: all interviews and focus group were based in Turin