

## **Modularity and extended N-Form**

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### **Purpose of research**

Society has dramatically changed in the last decades, and so has the economic landscape, addressing new ways of organizing the firm's core activities. The advent of the "Lean" philosophy, firstly in production, then extensively adopted to the whole organization, has changed the role that consumers and suppliers play in shaping new product's design and the main processes of value generation, while the evolution of the ICTs and the most recent "Digitization" profoundly affect, among the others, the firm innovation process, having a strong impact on the organizational form and design.

The purpose of the paper is to analyze the role that the modular production plays in the decision-making about the organizational form's design. Product/service linked to customer's requirements, production and supply chain represent the starting points around which the business idea develops and the organizational form is shaped, coherently to the firm's value proposition and value creation. At theoretical level, by analyzing those links from a modular perspective, we aim to stimulate a reflection about a modular inter-organizational form as an extension of the N-Form.

The main research question refers to the ability of this organizational form to better suite the need for a more customized product/service, at the same time ensuring the search for higher efficiency, scope and scale economies, made possible by the standardization of modules. In ICT business, for example, the product customization is achieved by giving rise to a digital modular network (Chadwick, 2007). In order to reach our aim, we used both desk and field analysis. The former concerns an overview of the main literature on the topics of three interconnected research streams: 1) the link between production models and organizational design; 2) the role of modularity and innovation in organizational design; 3) the evolution of N-Form, built on modularity architectures and interfaces. The latter draws interesting insights from the case of the Italian Group "Reply".

## **1. Literature Review**

### ***1. Modularity and organization-design***

The theoretical background refers to the role that modularity plays in organizational design choices. This topic has been central to different studies, mainly based on the relationship between product/service innovation, operational processes and work organization, although most references are basically product/service innovation oriented (Fixson, 2007). Our analysis starts from a work of Henderson and Clark (1990), based on the relationship between the modular production and the organizational architecture. Specifically, this link is extensively tested, for example by authors stating a «process of dynamic interplay between search processes, organizational change and learning outcomes» (Brusoni et al, 2011: 69) or the impact that product design has on supply chain coordination (Zirpoli et al, 2009), alliances (Tiwana, 2008) and cooperation (Pittino, et al, 2011). Other studies on the industry structure (Fixson, 2007), on the hierarchical control (Hoetker, 2006) and on the organizational strategy (Helfat et al, 2004) highlight a link between product/service design choices and the organizational structures in which different actors or organizations are involved (MacCormack et al, 2006), strongly affecting the system's architectures and the innovation processes (Miraglia, 2014). Other authors (Campagnolo, et al., 2010) have particularly studied the emergency of modularity in networks, and innovation in modular systems, and their work has brought to some considerations about the benefits of the modular system on both the demand and the supply side (Langlois et al, 1991: 1-17; Pittaway, et al., 2004). Sanchez and Mahoney (1997) considered how the modularity and flexibility in product/service are strongly interrelated with organization design through the development of the modular architecture design that represents the glue that codifies all requirements each actor should attain to, following a hierarchical ordering. Tee (2011) shows the importance of multi-level analyses to understand under what conditions systems become more modular at a product level, at organizational and industry levels.

Literature then shows that the interdependencies among sub-problems are the key variables firms have to consider in building the extended N-Form (Brusoni et al, 2011: 67): thus, interdependences are managed by strengthening linkages and connection between multiple actors and interfaces among modules (MacCormack et al, 2006).

The study considers how the organizational form is built around the product/service, similarly, in order to understand this approach, we must consider how the modularity affects the organizational design. The modularity is «a specific pattern of decomposition that defines a precise mapping between functions and components, as well as set stable and codified interfaces» (Brusoni et al, 2011: 67). The research gaps we want to fill is derived from a lack of extended N-form's definition and the one related to combining the ostensibly dichotomy of de-verticalisation induced by the N-Form with those of hierarchal mechanisms present in modularity. The extension of the modular organization concept to networks and the digital innovation allow thinking that the extended N-form is evolving into digital modular networks, based on platforms (Enrietti et al, 2013).

### **1.2. *The extended N-Form***

Wellman and Berkovitz (1988) define a network as a set of nodes, linked by relationships or connections; the network can point out both an analytic instrument of representation of relationship and a synthetic expression of the organizational form.

The N-form takes place considering the relationships between focal enterprises and their transactional environmental; its internal operational framework is based on almost-independent module. The double net requires considering «the configuration of internal units as well as the inter-organizational relationships that can include the development of enterprises» (Perrone, 1997: 621).

Borgatti, Everett and Johnson assert that networks «are a way of thinking about social systems that focus on the relationships among the entities making up the system, which we call actors or nodes» (2013: 1-2). N-form is a «(...) soft form that can be able to comply, to support and to take advantage of economies of scope, the social relationship (...) between social actors, and therefore between economic actors» (Perrone, 1997: 616). The author highlights that the main advantage of the network lies in the opportunity to reduce the hierarchical processes into the coordination, amplifying the processes that are based on collaboration/confidence. Perrone (1997: 629-630) also explains how the N-form is a one that strongly adheres to the new features of environment, in particular, the evolution of market and technologies, aiming to involve customers and suppliers in the product design of decision-making. The network, thus, must today operate into a much more virtual environment, since the digital revolution affects networks proliferation in liquid bi-directional web. That gives

rise to the opportunity for all to «participate actively» (Mell, 2008), and to “modularize” the networks’ organizational structure (Braccini et al, 2011). New procedures, routines and conditions, thus, affect organizational model, carrying to new forms of work division (Orlikoeski, 2001).

Different studies (Cabigiosu, et al, 2012) have also considered how the modularity concept can also apply to architecture and modularity service (Voss, et al, 2009). In particular, Pekkarinen and Ulkuniemi (2008) proposed a study on modularity in developing business services by using platform approach. This approach opens a new research line on digital network, as those enabled by innovation platform. Patrucco defines innovation platform as «hybrid coordination modes that combine both interaction and transactions with hierarchical coordination and management of the network» (2011: 3). In this perspective, Consoli and Patrucco state the presence of hierarchical networks, defined «as networks in which the interactions do not emerge and evolve spontaneously, as in the traditional literature on the industrial districts, or as hypothesized by complexity theory, but in which the key nodes (the companies) exercise a guiding role on the behavior of the other actors, thus influencing and directing the behavior and the evolution of the system as a whole» (2008: 699-716).

In different perspective, Schilling and Steensma (2001) studied how, in many industries, integrated hierarchical organizations have been replaced by nonhierarchical entities that are permeable, interconnected and modular. The authors verified that in some industries there is a greater use of modular organizational forms, including alternative work arrangements and alliances, than in other industries. The innovation services sectors need nonhierarchical entities that are permeable, interconnected and modular.

Garud, Kumaraswamy, Langlois have worked on managing in the modular age: architectures, networks, and organizations define the complexity as «a matter of both the sheer number of distinct parts the system comprises and the nature of interactions among those parts» (2009: 5-20). These authors highlight the role of single components and the interactions among them: networks constitutes organization model that can properly manage high complexity. Furthermore, the functional coordination is more connected to modularity and to mass customization (Ahmad, et al, 2010). At the same time, Heydari and Dalili, by assessing «modularity as a phenomenon in networked systems that emerges in response to heterogeneity in the environment» (2015: 224), consider that the environment and the neighbors of a node, in turn, influence its internal state via resource exchange; thus

“modularity-index” should increase with environmental heterogeneity; therefore, environmental factors play significant roles in the dynamics, direction, and survivability of cooperative clusters in networked systems. Interesting aspect of this work is the formation of clusters and modules of autonomous agents as a mechanism that can enable and facilitate cooperation in flexible systems. So, our work puts in evidence that extended N-form requires modularity, since «modularity is the emergent property of complex, evolving, and networked systems» (Heydari et al., 2015: 224).

By combining the first literature about the N-form with the more recent developments on modular production, this paper aims to verify the typology of the extended N-form by using the innovation perspective. So, the research question would be if the extended N-form could better suite innovation processes by adopting a pure non-hierarchical network form or by combining non-hierarchical and hierarchical mechanisms, as in innovation platforms. In the following case study, we propose an analysis of the extended N-form.

## **2. Case Study**

In this work, we analyze the organizational form and innovation process in a Group operating as consultant in system integration and digital services. The Group consists of a network of about 75 firms, each of them being specialized on design and implementation of specific tools, applications, software and digital-platforms that are directed to specific customers involved in partnership relations. Those firms represents modules of a constituent double network, internal and external, that are engaged in cooperative (for knowledge exchange and combination) as well as competitive (when confronting the same customer with different offers) interactions with all other firms belonging to the Group. In so doing, they could be considered as different modules of the internal network, whose structure intends to reduce verticalisation and hierarchy, though a very tight financial control from a Headquarter staff unit symbolizes a strong centralized surveillance. At the same time, they could be considered as modules of an external network when the offering product represents a component of a broader digital architecture serving a specific customer.

The value Reply delivers to customers is based on strong competences, high specialization and multi-year experiences in the digital sector; moreover, creativity and excellence in building technological and partnership cooperation build on modular network framework covering different business and markets. This value was the main strength of Bitmama and

Forge-Reply products, which constitute focal enterprises of an extended network working on the “Smart-Glasses” project. This project involves Magneti-Marelli as main partner. In the light of these statements, we consider interesting to explore this case study to verify if the organizational form aimed at building the extended N-form form Reply could be or not generalizable.

The objective of this paper, according with the aforementioned literature, is to validate the typology of the innovative N-form in a modular perspective.

The research questions by analyzing the case study are:

1. To identify the main characteristics of extended N-form.
2. To analyze the coordination and integration mechanisms used in this organizational form.
3. To verify if the extended N-form represents a pure non-hierarchical network, or hierarchical network or a combination of both.

The units of the case analysis are Reply network and its partner.

### **3. Discussion and future directions**

The main findings consist in building a general framework on extended N-form that will adhere to reality. The research that we have here tracked allows considering to «think» around customers need, product and production model as the starting point to define new forms. Along this line, the organizational form design should consider modules and modularity as an emergent property of complex systems. Every module can be replicated; the repetition of the same form or structure - through devices or expedients - allows various composition opportunities. For the extended N-form to take place, the relationships between the focal firms and their transactional environment would be crucial.

The main contribution is to verify if the extended N-form adopted Reply would be one of limited interest of the ICT’s industry, due to the specificity of production and products, or whether it can be generalized when applied to any modular production.

The managerial implication would focus on a wider definition of the extended N-form and its characteristics, considering the relationship between the modularity and the hierarchical/non-hierarchical level or a different degree they could combine for the network coordination. The limit of research lies in that the desk analysis consists of a simple research track, which needs to be analyzed more in depth; the field analysis will be further developed in the full paper.

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