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Semantic Innovation as Design Strategy for Sustainability and Ergonomics – A Case Study

Julianna Faludi [a]

[a] Corvinus University of Budapest, Institute for Marketing.
Corresponding author: julianna.faludi@swansea.ac.uk

ABSTRACT

This study deploys the framework of architectural innovation (Henderson and Clark 1990), demonstrating that a design-driven strategy leverages incremental and radical innovation through a system of core design concepts. The presented case study of an Italian high-end kitchen producer, Valcucine, is particularly interesting due to its track of innovation in sustainable and ergonomic systems with high aesthetic quality. Findings reveal how meanings are encapsulated in the core design concepts and explored in the strategy of technological innovation from architectural to modular, radical to incremental. The findings also support previous studies arguing that semantics in design-driven industries are nested into technological innovation.

Keywords: design innovation; radical innovation; modularity; architectural innovation; sustainability; ergonomics; meaning.

INTRODUCTION

The location of design and innovation within the activity of the firm is an extensively discussed area of management literature. The problem of aligning organizational capabilities, technological innovation and design strategy has been in the fore since research on industrial design (Utterback, 1974; Utterback & Abernathy, 1975). A particularly important strand departed from the role of managing and facilitating design as part of innovation (Cillo & Verona, 2008; Ravasi & Lojacono, 2005), for enhancing a company's performance (Gemser et al., 2011; Landwehr et al., 2013). This strand is focused on incentivizing companies to adapt design strategies on management level (Mortati 2017, Castro and Cardoso 2010, Dos Santos 2009).

The knowledge-based views of the firm stress the role of design capabilities (Castro & Braga, 2010; dos Santos, 2009; Mortati, 2015) in coordinating the complex system of innovation (Borja de Mozota, 2010) and connecting designers and managers (Mortati, 2015; Turner, 2000). Design as a core competency represents the fundamental resource of the firm in its management strategy for sustained competitive advantage (Borja de Mozota, 2011). These design-driven companies are highly knowledgeable in infrastructuring design on all levels of the organization (Celaschi et al., 2009), and active in absorbing and diffusing product signs and meanings from and to society (Dell'Era & Verganti, 2010).

Networks are important in forming strategic design alliances to feed innovation (Jevnaker & Bruce, 1998). The connection between meanings, language and design from a strategic management point of view has been explored within a wave of understanding innovativeness of firms, particularly in the context of the Italian industries (Cillo & Verona, 2008; Dell'Era et

al., 2010; Verganti, 2008). External networks in innovation (e.g. (Battistella et al., 2012) were found to be crucial for creating radical product meanings (Verganti & Öberg, 2013). These investigations were looking beyond of what is assumed to be user-centered design, instead exploring the design process in the context of innovation, and particularly in its networked form.

How to innovate products that would radically stand out, and what are the factors creating a design discourse around technology – are questions framing management considerations. The strategic attitude of applying semantics to product design in a socio-cultural context (Krippendorff & Butter, 1984), and combining immaterial and material qualities (Mauri, 1996) (Mauri 1996) had its early relevance. The framework of „radical design-driven innovation" suggested by Verganti (2008) was making connections between technology management and that of meanings using a variety of iconic examples from the Italian industry. Radical improvements would only come from a combination of technology push and design push on the axis of meaning and technology – that would serve for concept generation and product development. This exploration of strategies for generating meanings was taken up to reveal the connection between technological innovation and product language (Cautela et al., 2022; Simoni et al., 2014); and to connect to sign-level properties behind the design push for innovation (Dell'Era & Bellini, 2009).

Less is known about how the exact linkages between meaning creation and technological improvement are formed into a complex system. Instead of focusing on iconic items of design, and star collaboration projects, this case study looks into the long-term innovation process of an acclaimed manufacturer. It argues that the strategy combining technology and meaning is the DNA of design-driven companies, and produces both incremental and radical product-lines and technologies. For this end, this study adapts Henderson and Clark's (1990) theory of modular and architectural innovation by stretching its frames toward the semantic plane.

Theory of modularity makes its relevance in understanding how companies actually manage the complexity of design and innovation processes. The presented case of Valcucine, a high-end kitchen producer is illustrative of a company of design culture, that places it at the most mature level of the design management staircase (Kootstra, 2009), and that of the design ladder (Ramlau, 2004). As such it is a valuable case for analysis of how core design concepts drive the innovation process. This is illustrated by how sustainability conceptualized through the theory of degrowth by Serge Latouche was converted into core design concepts, across all technological and design innovations that focus on ergonomics and style.

This study adds to design and technology innovation scholarship by demonstrating that modularity enhances both the technological and the semantic value of a high-end product; concluding that semantic core design concepts are strategic in defining the technological ones.

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1. BACKGROUND. ARCHITECTURAL AND MODULAR INNOVATION

The theory of modularity was used early on to understand product design strategy mapping functions and components (Ulrich, 1995). It explains how to organize production (R. N. Langlois & Garzarelli, 2008; Simon, 1962), by breaking complex artefacts into less complex modules (Brusoni, 2005). Although modularity supports mass production benefiting from economies of scale (Baldwin & Clark, 2000), it may increase mass customization capabilities – given the modules are well designed.

Modularized production is a strategy for quick value creation – companies can benefit from product platforms that share components produced by the core technology (Baldwin & Clark, 2000; Meyer & Lehnerd, 1997). Modularity crosses firm boundaries, and spurs innovation (Sanchez & Mahoney, 1996) as manufacturers of the components can independently experiment with new concepts across networks. Modularization creates entry points for third parties to innovate in relation to Just-In-Time (JIT) systems (Frigant & Layan, 2009) or with efficient outsourcing (R. Langlois & Robertson, 1992).

Modularization can reduce costs of production by economies of substitution, by the easy ways of change in design structure, and the minimization of communication costs in organizing production, due to encapsulation of knowledge within the modules (Baldwin & Hippel, 2010; Brusoni et al., 2007; Ethiraj & Levinthal, 2004; Parnas, 1972). It can imply switching costs of organizational re-design, as well as of coordination in case of systemic changes. Design-driven manufacturing firms make a particularly interesting case – given that meanings play an essential role in their innovation strategy. For this end, the study will deploy the framework of technological innovation of Henderson and Clark (1990) assuming that semantics in design-driven industries are nested in technology through the core design concepts. This framework is useful in identifying innovation strategies of companies from radical toward incremental across a given time span.

Radical innovation may overturn a company's production and innovation practices, open new markets, and shift entire industries, thus create difficulties for established firms ((Christensen, 2013; Nelson, 1982; Tushman & Anderson, 1986). It changes the core concepts of product design and may be systemic in changing the whole architecture (Henderson & Clark, 1990). A marker of radical innovation is that the dominant design is copied by competitors, while improvements, as a form of incremental innovation, avoid changing the core concepts but adjust a product, thereby creating a comparative advantage (Abernathy & Clark, 1985). As this strategy exploits the potential of established design, it reinforces the dominance of established firms. Henderson and Clark (1990) suggest further categories such as when architectural innovation recombines modules but does not change the core design concepts. Modular innovation implies that only the elements change, but the core concepts and the architecture remain untouched. Organizational innovation follows shifts in the innovation practices of a company. It aims at efficiency and should be in line with a switch in production practices, that raises the capabilities of a firm. A shift toward a modular production and organizational structure engages changes within the suppliers in the design and innovation of the supplied components. Modularity explains what is observed as fragmentation of production in industries.

Henderson and Clark (1990) suggest that core design concepts are technological characteristics that define technological innovation. Design concepts that define how to deliver the function of a component may vary, while the core design concepts represent the choice over the actual component. Core capabilities constitute the knowledge, technological and managerial systems; and values create competitive advantage that differentiates the company (Henderson & Clark, 1990). This paper argues that in order to develop a system of products ensuring the brand, the core design concepts need to encapsulate the values of the company. These will then define the innovation process aiming at the technology and design of the products. We know that types of innovation do not neatly divide the world into categories, as "a given innovation may be less radical, or more architectural" (Henderson and Clark 1990: 13). Therefore, innovating from the architectural to the modular, and the radical

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to the incremental can take different shades and represents a choice taken by the firm. Moreover, firms leverage the various innovations along their systems of products, and the same technology can be present in different meanings connected to the products.

2. METHOD AND AIM OF RESEARCH

This case study aims at constructing the story of design as an innovation process rather than merely describing "its history as a parade of icons" (Deserti, 2009, p. 65). For this end, it looks beyond the narratives of the products, and adapts the dynamic capabilities view, suggesting that a firm orchestrates its resources in order to enhance its adaptability in the long run; that organizational and technological change is mediated by knowledge evolution (Brusoni & Prencipe, 2006). Some design-driven innovation models were connecting technology and language, the functional and semantic dimensions (Dell'Era & Bellini, 2009; Zurlo et al., 2002). This study follows the assumption of the knowledge-intensiveness of the innovation process in the semantic and technological domains being the core engineering activity, that reproduces the same architecture of meanings. Therefore, the semantic structure of products is analogous to their technological design. We know, that companies are leveraging between different innovation strategies depending on their resources, and the capabilities of their external network of suppliers, designers – the analysis sheds light on how the values of the company are being managed through the process and network of innovation. Value-focused analysis has further relevance, due to the central role of the brand with respect to the company instead of the production-focused organization design (Deserti, 2009; Klein, 2000; Palmisano, 2006).

The analysis takes a timely perspective on design that has undergone modularization for building scale and scope. The transformation helps with understanding the process and semantics of modularized production, making it a case illustrating a phenomenon (Siggelkow, 2007).

Valcucine explicitly incorporated a critical theory of overproduction and excessive consumption into design innovation; thus, represents an atypical case from which lessons can be learned (Stake, 2003), and valuable for observation purposes (Glaser & Strauss, 1999). The company has been in the furniture market for more than four decades, with a long history of design of radical and incremental innovation of products, organization and technology.

2.1. Sampling, and data collection

To construct the case, primary data were collected on-site, in the factory premises and the flagship store. Respondents were in-house designers at the factory and key communication and event management representatives from headquarters. The interviews – with 2 managers, 3 designers, and 1 external partner organization – complemented the secondary sources: reports of the company, catalogues, presentations and documents about the values and design-principles, and the information available on the website of the company (valcucine.com accessed, and data collected between March 2015 and March 2016, complemented with data from documents), specifically the timeline of the story of products launched – as the method of investigation took a dynamic analytical approach (Data sources can be found in detail in the Appendix, Table 1).

The analysis focused on three main issues. First, it explored the process of product development from ideation to production: the first-hand experience of participating in the process, the role and decision-making of different participants in the design phases. The

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second problem was understanding how the core design concepts were being reinforced in the case of in-house and network-based product development. The third theme was finding the locus of innovation to see if it had shifted due to organizational adjustments over the years. A timeline of the design evolution, organizational and production change, and was constructed. This was backed by interpretive analysis and axial coding of both visual and verbal data (the product lines, the design and core design concepts) for revealing how types of innovation unfolded intertwined through time. The coding went through the timeline which consisted of the novelties connected to each product line, as well as the events marked by the company: e.g. 1997. Sponsor of the "Mazzotti literary award". The categories for coding represented two major groups. First, it defined innovation as technological, aesthetic, market (targeting new markets) & communication, organization of production, then it added the axis of architectural, modular, radical and incremental deriving from Henderson and Clark (1990). E.g. 1997. sponsor of the "Mazzotti literary award" fell under the category of "Market & Communication".

2.2. Valcucine, Values and Core Design Concepts

The notion of Made in Italy describes the particularities of Italian manufacturing in the furniture design and electronics industries. The main feature is territoriality, a socio-cultural and economic embeddedness in particular localities, with a complex nexus of relationships, where communication plays an important role, as well as the embeddedness of the design process supported by not just merely the urban milieu but the local territory enhancing the immaterial component of design (Celaschi et al., 2009). Italian manufacturing is based on local clusters and a strongly interacting network of SMEs, that expanded its market in the 80ies (Deserti, 2009; Martignoni, 2010). The main factory of Valcucine is located in an industrial district near Pordenone, Italy, within the Treviso-Venezia axis (Bonomi, 2006) and has local suppliers from the furniture industry, and mechanics from Germany. This district features a concentration of manufacturers in the furniture industry, with several local brands selling internationally and to the domestic market. The factory of Valcucine serves as a point for assembling the components at the pre-distribution phase. After an investigation of how other firms innovate in different sectors, Valcucine's own vision was defined by 1980, when Gabriele Centazzo, combining his knowledge as a chemist with the role of entrepreneur-manager, became the designer for the company for the forthcoming decades, defining the line of innovation. Since, the company has been challenged by reorganization due to the withdrawal of Centazzo and acquisition by the Italian Creation Group.

Furniture production is typically relied on a supplier network, as well as stocking of components rather than end-products – based on the principle of mass customization since the seventies (De Fusco, 1985; Deserti, 2009; Martignoni, 2010). Since the vast urbanization processes of the early 20th century, the dominant kitchen design became modular with furniture units and standardized measures, and fixed to the wall. A kitchen is a low-complexity system having the main parts of a core carcass, shelve cases, and a worktop. Further accessories, such as appliances are substructures within the hierarchy of the arrangement. Complex systems even of the most basic furniture production can be embedded into the local economy of suppliers (dos Santos, 2009). Kitchen and furniture manufacturers are nested within industrial districts, a nexus of selected specialized suppliers producing and supplying: materials (wood, plywood, glass, plastic, aluminum); household appliances; electronic devices and equipment: fridges, cooking panels, stoves, etc.; dining assets and furniture; technology

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for sound reduction and ergonomics (closure/opening of doors, etc.). This implies that the values defined by the company shall be engrained in the supplier system as being represented in products, product lines, and subsystems of products¬. The values are operationalized into the core design concepts that define the basic principles of design innovation and production over time (Figure 1).

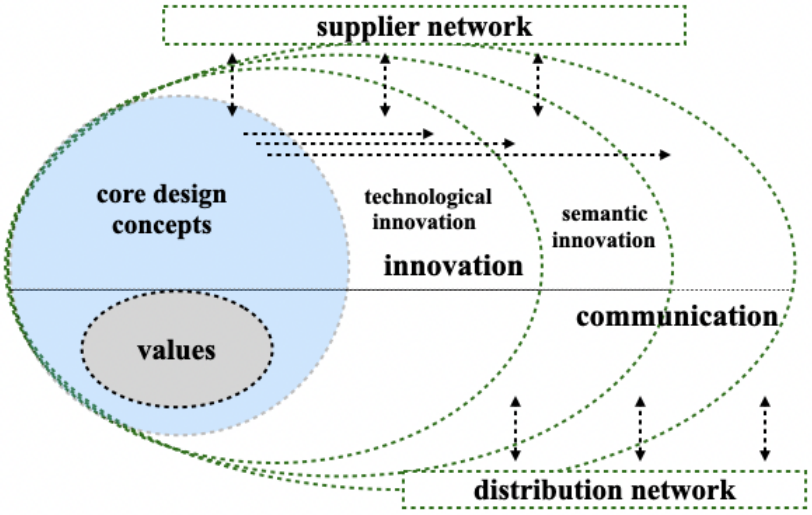

Figure 1. From Values to Innovation

3. DISCUSSION AND FINDINGS

3.1. Finding the Dominant Design: Evolution

The first phase of Valcucine's design story was an introductory one, the company was known in the area, but focused on widening its customers, and had to find its own language of design. The contemporary kitchen can be conceptualized as a system of functional and aesthetic blocks. Refreshing a kitchen design means changing either the aesthetics or adding/subtracting functions, materials, or adopting incremental and modular innovation to doors.

The first step towards finding the design language of the company, came from an experimentation with the doors – the most spectacular part of the kitchen. The first model Ghianda (1981) softened the edge of the door, and recessed the handle into the panel. A change in the attributes of the door (texture, quality, materials, color, functions) can bring visible changes quickly, leaving the architecture of the whole product untouched. 5 stagioni was the product that transmitted the aesthetic meaning of modularity, featuring modular doors of possible combinations of color, frame, and glass. The components of blocks of color were added into the frame with a silicone trim – a new technology allowing for mixing and matching the product attributes. This shift toward modular doors adopting new technology implied the switch to a just-in-time system (1983) that favored the modular construction of the subsystem of the product, whereby elements were manufactured by a net of suppliers and assembled in the factory according to the customized product description. How a door is constructed, joined to the carcass or can be opened defines the parts it is made of (if it has a catch attached to it, if it includes touch or gravity sensors, and how the sound of closure is muted); these components require sourced technology. A further improvement was featured by Mela, with customizable

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surface, the first to use PVC coating. The imitations of these models were re-produced by competitors, indicating how radical the innovation was, causing the industry to switch to the modular door design (similar door was a top-seller at Ikea).

The second stage of the design story of Valcucine is marked by the dominant design that defined the next decades. The values of Valcucine were established at the outset, and explored during the second stage manifesting in the three dimensions of technology, style, and communication that define the brand (Figure 2).

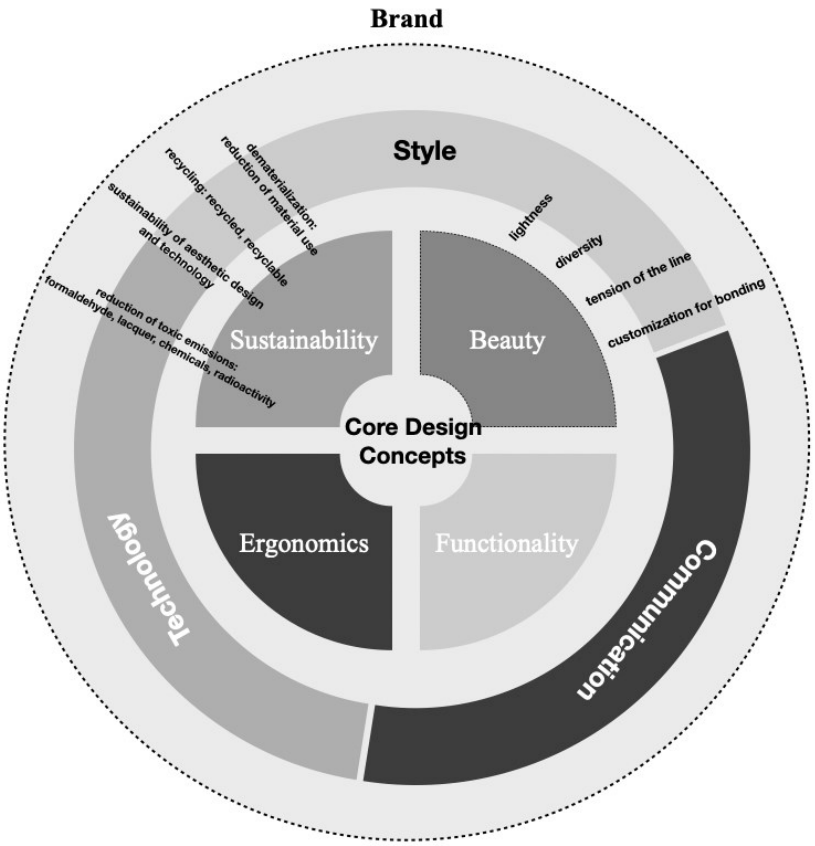

Figure 2. Core Design Concepts

The next phase evolved around the two major core design concepts – sustainability and ergonomics. The cornerstone was Artematica (1988), which swiftly became the new dominant design. Artematica featured a single-block door, an aluminum frame as a core structure to which a range of materials and panels can be attached on top: MDF, glass, layered laminate, or HPL. The frame itself was invisible on the outside of the panel, streamlining the aesthetics of the product, and creating a radically new design language. Aluminum production is considered to cause less environmental emissions than other materials, and stretches ergonomic solutions. This created the advantages of versatility, a single system, easy decomposability, and dematerialization (as less material was used due to the strength of the frame). Incremental adjustments that reinforced the core concept shrunk Artematica into Ricicla and Riciclantica, with the final achievement of a 2mm thick door panel. The radical technology was adapted from the car industry, and won the ADI design index award (1996). The concept of recycling headed in two directions: the creation of a recyclable product, and one manufactured of recycled material. Experimentation led to the almost totally recyclable Invitrum (2007) model. Innovation was triggered by a change in one component, with the aim of reducing the doors, according to the reinforced core concept of dematerialization, thereby changing the

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relation to the core carcass, while on the semantic plane the concept of the reduction of toxic emissions gained increasing focus and transformed from "recycled" to "recyclable". Modular innovation within the kitchen system featured the radical adaptation and improvement of technology triggered by semantic innovation and coordinated by the core design concept. Decomposability is an important feature of recyclability of a product. Invitrum can be disassembled by the user and re-assembled, thereby increasing the lifetime of the kitchen – long duration –, and being 100% recycled and reusable, thereby eliminating the toxic and carcinogen emissions from glue. There is only one side between the shelving cases, and Invitrum is made of glass (including doors, sides, and worktops) which lessens production-related emissions. Finally, Meccanica has been elaborated under the 8Rs (redistribute, reuse, recycle, reduce, relocate, renovate, re-contextualize, re-evaluate) label inspired by Serge Latouche – an unprecedented example to operationalization of the concepts of degrowth into industrial design.

After the radical turn of Artematica in 1988, innovation in the stream of ergonomics led to the development of Logica as a new guideline. Technological solutions in ergonomics featured Ala, a wall-unit door that exploits gravity for its closing and opening, and Libera, a hood that rendered head movements free. The New Logica System featured a further exploration of these improvements (along with Aerius), which took into consideration the rules of universal design (thus accessibility for all needs). The aesthetics of product design was defined by a contemporary look referencing sustainability. For the "eternity" of a natural and elegant look, the glass-surfaced Invitrum allowed for personalized pictures and coloration.

Along with the explorations in high-tech defined by ergonomics and sustainability some products referenced the territoriality, and longevity of local design. Fabula (1993) representing the "Mediterranian dream" featured colored wood and inlaid pictograms, or Sinetempore (2012) referenced handicraft techniques featuring traditional intarsia, mosaics, inlays, craftwork from local Italian artisans who decorated and customized the wooden doors and panels. Hand-crafted solutions are taken over by the Genius Loci model.

The kitchen systems today are fully customizable, due to the "special elements", such as the Aerius wall unit, or New Logica doors, back panels. The signature language of Valcucine is spoken by the aluminium and glass kitchen of total recyclability.

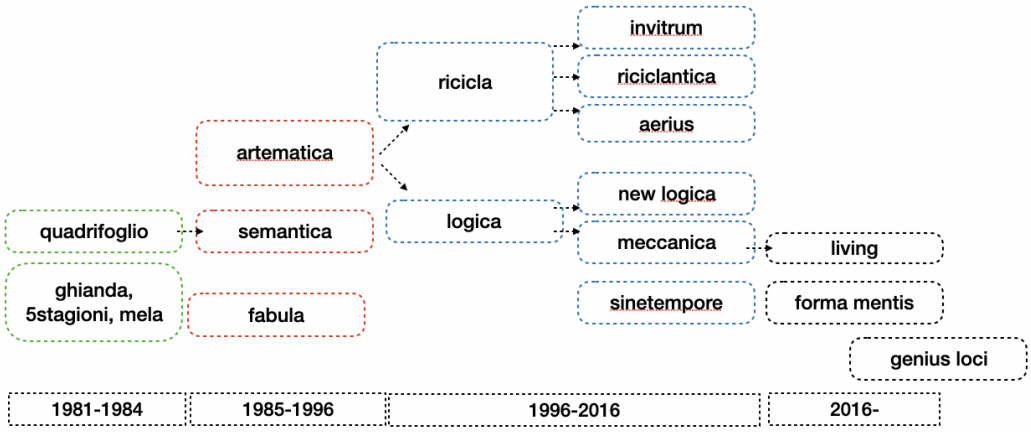

Figure 3. Evolution of Design

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3.2. Component and architectural knowledge and innovation

A component embodies a core design concept, and a physically distinct portion of the product. If becoming embedded in the structure, firms may fail to recognize that architectural innovations destroy the usefulness of architectural knowledge (Henderson & Clark, 1990). The case study demonstrates, that in design-driven innovation, the knowledge of the semantic architecture and core design concepts keeps the firm from outsourcing the entire component knowledge. The interaction of technological and semantic concepts of the component become the focus of design innovation. As an example, the core design concept of the door was adapted from the car industry technology and produced by the suppliers: but the knowledge of the semantic core design concept encapsulating the reduction of emissions and recyclability remained within the firm, and was explored in other product architectures such as in the Artematica/ Ricicla/ Riciclantica. The radical door became the dominant design, followed by incremental innovation thinning it. Designers, have been reportedly challenged to become informed about opportunities for recycling, thus indoor architectural knowledge backing outsourced component knowledge was enhanced, and managed inside the firm. The switch from the production of wooden doors and panels to aluminum and glass surfaces involved the restructuring of technology. Ricicla and Aerius represented radical technological and semantic innovations establishing a new dominant design compared to the wooden or laminated kitchen doors. One line of innovation activity may focus on different subsystems of kitchen design triggering architectural innovation of the product system.

The just-in-time production rendered the company to handle external information effectively, and enhance its absorptive capacity by reorganizing its innovation management processes (Cohen & Levinthal, 1990). As the technology of suppliers is constantly updated, new entrants are contributing to lowering the costs of adjusting, acquiring, and maintaining technology. Suppliers approach the company with new technologies, while being addressed directly by the design needs of the company, improving quality, and enhancing the capacity of the materials that are used. In these collaborations, technological characteristics, functions, and the quality of the materials are identified by the company. It is crucial that the language surrounding the artifacts is spoken and understood by all participants, inviting further knowledge-building. As an example, the collaboration with Electrolux targeted a single worktop, incorporating a cooking panel with no integrated pieces, thus finding a unified material for large surfaces that combined the required characteristics. The solution represented both technological and stylistic innovation, integrating different functions (preparation and cooking), and serving as an interface for kitchen modules. In-house product development involved a collaborating team of contributors recruited internally from the technical, marketing, and communication offices, and external partners.

Collaborating designers have general knowledge that interacts with the specialized knowledge of the company team about the core design concepts and the accumulated internal knowledge about products and technical solutions. For assimilating the outside knowledge, the key figure was responsible, the designer-entrepreneur and manager who took care of the core design concepts, expanding partnerships, and taking managerial and financial decisions – along with decision-making related to design management.

The product-development phase was located at the supplier. Quality tests were used to appraise the needed characteristics, covering quality of technology and materials. The phase of prototype-improvement was taken over by the technical staff of the company.

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Improvements were made after launching the product, and long years in a product lifecycle: Artematica (launched in 1988) has seen 25 years of improvement. When launching the product to market, the company is backed by a net of specialized retailers who maintain a portfolio of brands and are in charge of the distribution. Valcucine is a design enabler and advocate (Mortati, 2015), it raises the capacities of retailers through offering training in interior kitchen design. Customers are being educated in sustainable design when they are purchasing the product: as many show less sustainability awareness in their purchasing decisions.

4. CONCLUSIONS

This paper sheds light on how innovation unfolds around the core design concepts design in temporality. Innovations that are started in one model are explored in a later one, while other improvements target differentiated needs that are shaped by constant changes in lifestyles. Counter-intuitively to the suggestions on alienating the user perspective from the design innovation for achieving radical product meanings (Verganti, 2008), it can be argued that user-insight might be relevant in developing radical innovations. Ergonomics is one of those fields, where early kitchen design was deploying ethnographic techniques for adopting efficiency and usability of the furniture. Valcucine's explorations in ergonomics produced cutting-edge solutions based on user-centred research, that favored accessibility for all, along rationalization and optimization. Constant improvement suggests that innovation is based on experiential learning and the imperfection of the learning process, rather than calculative rationality (Levinthal & March, 1993). Inventions in kitchen design as spillovers have broadened the product line, such as the living room and laundry (Valcucine Living and Laundry of Valcucine). These were based on an easily decomposable, transportable, and adjustable kitchen, the Meccanica (branded DeMoDe, Democratic Modern Design), that represented a philosophy of "easy" design of the conceptual framework of degrowth. Modular design contributed to easy adaptability for newer functions and entry into the living room market.

It can be concluded that a company may leverage the space between innovation modes if the architecture and a modularized system coordinate efforts in a dynamic approach. Innovation efforts are intertwined; however, the focus for each yearly product development may shift. Efficient innovation management and the development of the core design concepts was backed by centralized decision-making concentrated in the hands of the founder and manager of the company, Centazzo. The visionary role of the designer-entrepreneur, combined with his decision-making competencies over investments created an opportunity to explore values in-depth.

By taking the values of the company as core design concepts, this study found that design-driven innovation is a process in the semantic and technological domain, creating a space for adaptability of the firm by strategically using innovation strategies. If a company has a set of well-defined core concepts that are being explored and recombined at each stage of product-development, a clearly defined system of products may be created.

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APPENDIX

Table 1: Data sources

Primary data **Interviews with actors involved in the design process**		**source**
General knowledge: design principles, leveraging the innovation-design process, decision-making	Design Office and Technical office: designers team (Ufficio di progettazione, ufficio tecnico) Factory	3 interviews
Contact with customers, implementing communication strategy	Marketing and communication manager Flagship showroom	1 interview
Managing the design process and communication strategy	Marketing and communication Factory	1 interview
Managing the design process and communication strategy	Collaborative Design Project – external partner organization	1 interview
Secondary data		
Story of the company	Timeline and milestones in innovation	website
Products and brands	Product lines, and features	catalogues
Evolution of company values	Company values	Reports, presentations
Evolution of company values and innovation	Design principles	Guidelines, presentations

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