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Discovering quiescent meanings in technologies: exploring the design management practices that support the development of Technology Epiphanies

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Keywords

Value of design; Design-Driven Innovation; Technology Future Analysis; Technology Epiphanies

Research highlights

- The empirical results show how there are three design management practices that can guide managers in developing Technology Epiphanies. These are: interpreting technology as enabling platform, building double-sided network and accessing new knowledge domains.

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Discovering quiescent meanings in technologies: exploring the design management practices that support the development of Technology Epiphanies

Abstract

In contemporary business and academia, design is increasingly viewed as an important strategic asset such that several scholars and executives have recently investigated the links among design, innovation and competitive advantage. Indeed, recent and emerging literature streams are exploring the potential contribution design can provide in valorizing and differently adopting new or existing technologies (Dell'Era, Marchesi, and Verganti 2010; Buganza et al. 2015). This paper aims to investigate the design managerial practices able to support Technology Epiphany, which are defined as the discovery of quiescent meanings in new or existing technologies (Verganti 2009). The paper relies on four in-depth case studies developed by both primary and secondary sources: Nintendo, Kartell, Technogym and KUKA Robotics. The paper identifies three design management practices that can guide managers in the development of Technology Epiphanies: interpreting technology as an enabling platform, building double-sided network and accessing new knowledge domains.

1. Introduction

Design has recently attracted substantial attention among practitioners and scholars as a source of innovation. This growing attention to design has led scholars and executives to investigate the links among design, innovation and technologies. Moreover, increasing attention has been paid to design as a way to create innovation and to develop and steer technologies. Case studies, including those of Alessi, Apple, and Swatch, demonstrate how designers are becoming key actors in terms of product innovation and strategic renewal (Ravasi and Lojacono 2005). As demonstrated by several studies (Schmitt and Simonson 1997; Bloch, Frederic, and Todd 2003; Postrel 2003), consumers increasingly make choices based on the aesthetic and symbolic values of products and services. Consequently, several companies have invested increasing amounts of resources to make their products more meaningful rather than more functional (Pesendorfer 1995; Cappetta, Cillo, and Ponti 2006). R&D departments are exploring the potential contribution design can provide in valorizing existing or new technologies. Technology Future Analysis (TFA) can be defined as a set of approaches and methodologies aimed at defining the future opportunities provided by technologies. Technology Epiphany (TE), defined by Verganti (2009) as “a particularly effective type of innovation strategy able to merge technological breakthroughs with radical innovation of meanings”, enriches the set of approaches aimed at valorizing the opportunities provided by new or existing technologies. According to Verganti only farsighted industries are able to discover and exploit these opportunities. Considering that existing studies have outlined the key role of technology in developing new meanings and the importance of new meanings in the competitive market, trying to better understand the potential of different technologies in the early stages of development is fundamental to gaining competitive advantage.

Although several scholars agree about the relevance of design as a strategic tool able to generate competitive advantage, studies that analyze technology and, furthermore, the relationship between the latter and design are confronted with two main limitations: first, TFA studies, as few others, mainly demonstrate techniques for assessing the future development of technology, but they do not investigate how to realize more meaningful applications of the latter (Perez-Freije and Enkel 2007; Ravasi and Stigliani 2012); second, such studies adopt different definitions of "design", making it difficult to compare the empirical results or limit the interpretation of design to the capability of improving the aesthetic quality of products and services (Swan and Luchs 2011).

To overcome the first limitation, this paper aims at exploring the role played by designers, interpreters and R&D departments in relation to design and TE. Although the literature pertaining to innovation and design provides several contributions that investigate the relationship between design and technology, few studies have tried to outline managerial practices that could help companies in developing TE. Moreover, few studies consider the influence of context variables such as the nature of the industry in which the company operates. To cope with the second limitation, we refer to Klaus Krippendorf and John Heskett, two major theorists of design, to capture its peculiarity, to clarify the interpretation of design adopted in this paper:

> *"The etymology of design goes back to the Latin de + signare and means making something, distinguishing it by a sign … Based on this original meaning, one could say: design is making sense (of things)."* (Krippendorff 1989).
> *"Design, can be defined as the human capacity to shape and make our environment in ways without precedent in nature, to serve our needs and give meaning to our lives."* (Heskett 2002)

Both scholars clearly point to a peculiar characteristic of design: It is concerned with making things more meaningful. Design is the activity through which we innovate the meaning of things. Using design as a driver of innovation implies moving from the "what" of a product (its features) to the "why"; in other words shifting the reason why people buy and use things (Verganti 2009). Consequently, this type of innovation acts not only on the utilitarian dimension of use but also on emotional/symbolic meaning.
The article is structured as follows. The next section discusses the primary contributions of this study to the literature. Next, the conceptual framework and the methodology used in the analysis are presented. The ensuing sections describe and discuss the empirical results. Finally, conclusions and avenues for future research are outlined.

2. Literature review

The literature review is organized into two sections. First, we summarize the principal contributions of the literature on technology development. Then, we briefly review the literature on the innovation of meanings, which represents the main research domain of this paper; more specifically, we focus on TE.

2.1 Technology Development

In addressing technological studies we must consider the state of maturity of the technology. As previously mentioned, new technologies and old ones must be considered differently because of their peculiar aspects that affect their analysis (Bourreau, Cambini, and Doğan 2012). Moreover, practitioners have indicated that when a new technology arises, companies, typically behaving myopically, replace the existing solution with a new one without considering the large number of opportunities and meanings that are embedded in the technology (Verganti 2009).

Sometimes this approach is due to the fact that companies do not know all the potentiality of the technology that they are managing. Considering this a focus on the literature of TFA is mandatory, considering its strong connection with the technology development and ultimately to its usefulness in learning more about the technology in itself. This literature review becomes even more important considering the emphasis recently placed by scholars on the impact that technologies have, or will have, in today's and future economies (Porter et al. 2004). This field of study is consolidated, and several methods and technologies are grouped within it. Porter's work is a reference point in this literature because it collects all the existing practices and processes that are useful for making suggestions about the possible future evolution of technologies. As an outcome of that study, TFA could be defined as any systematic process for making judgments about emerging technology characteristics, development pathways, and possible future evolution of a new/old technology. These are elements that are not in themselves useful to scout new meanings but that can help in better understanding the technology. To summarize the variety of methods and practices useful for conducting a TFA, Porter (2004) proposes a structured framework of the major forces and elements affecting the process (Figure 1).

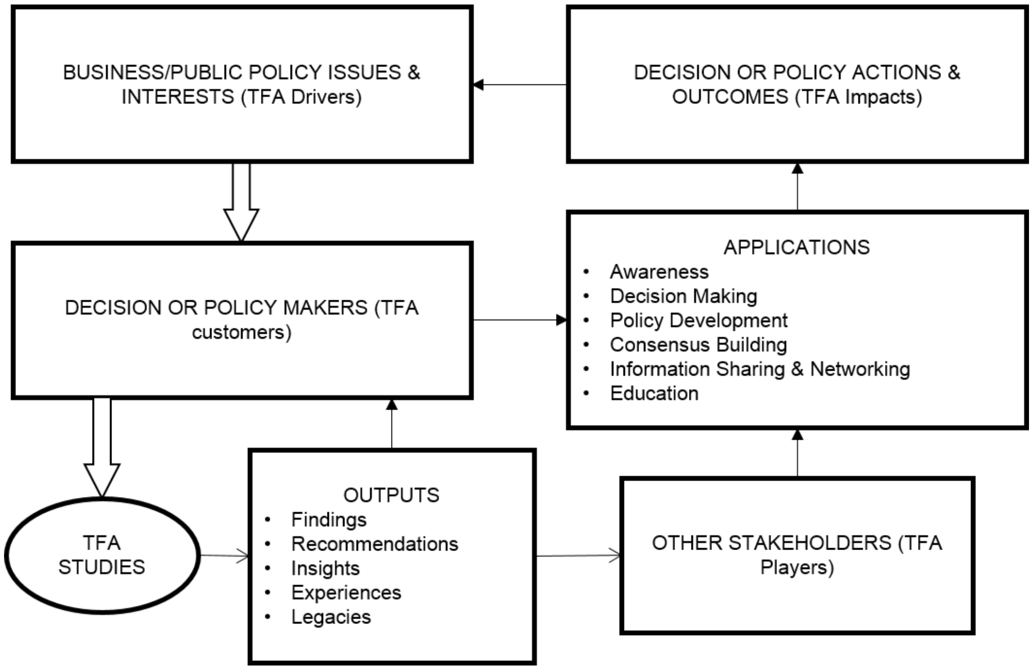

Figure 1. Framework for Technology Future Analysis (Source: Porter 2004).

Furthermore there are other few research streams that are somehow related to the analysis conducted. Indeed, they can be considered approaches that can help companies in enlarging their knowledge on the technology. The first one is the Social Construction of Technology (SCOT) and for it we refer to the seminal work of Pinch and Bijker (1987) where they state that the social structure of groups can influence the technology development. In particular SCOT is composed by four different concepts: interpretative flexibility, relevant social group, closure and stabilization and wider context (Klein, and Kleinman 2002). The second one is the Actor Network Theory (ANT) that is an approach that allow researchers to comprehend the interactions between humans and artefacts through out a given network (Cressman 2009). In particular, an actor of the network was defined by Latour as actant which could be both an individual or a non-human actor of the network. This field of research is interesting because helps researchers in understanding the relationship among different entities inside the innovation process. The last one is the Social Shaping of Technology (MacKenzie and Wajcman 1985) that was defined as a way to assess how technology is shaped by the society in which it is developed. This approach left the idea of a deterministic output of a process and focuses on organizational and social changes (Williams 1996). On one hand all the previous studies are relevant if the ultimate goal is to better understand the technology. On the other hand, they are less relevant to create new meanings, but despite this they are for sure an interesting starting point to discover TE by leveraging on the technology aspects.

2.2 Technology Epiphany

As previously mentioned, according to Krippendorff (1989) and Heskett (2002), we interpret DDI as the innovation of the reason why people buy and use things. The meaningful dimension of design has been recognized and underscored by several design scholars (Cooper and Press 1995; Petrowski 1996; Karjalainen 2003; Bayazit 2004; Norman 2004; Redström 2005; Dell'Era and Verganti 2007). Research in marketing, consumer behavior and the anthropology of consumption has also demonstrated that the affective/emotional and symbolic/socio-cultural dimensions of consumption are as important as the utilitarian perspective of classical economic models, even for industrial clients (Du Gay 1997; Holt 1997, 2003; Bhat and Reddy 1998; Schmitt 1999; Pham et al. 2001; Oppenheimer 2005; Shu-pei 2005).

There are two strategies for innovating the meaning of things: User-Driven and Design-Driven. User-Driven has been popular in the last decade. It has been in the spotlight thanks to the successes of major design firms such as IDEO (Kelley 2001) or Continuum (Lojacono and Zaccai 2004). This approach implies that product development should begin with a deep analysis of user needs (Stein and Iansiti 1995; Leonard and Rayport 1997; Thomke and Von Hippel 2002; Chayutsahakij and Poggenpohl 2002). By using ethnographic methods and observation firms may better understand those meanings, and therefore, through creative problem-solving sessions, they may address this mismatch between existing meanings and existing products (Verganti and Dell'Era 2014). Radical innovation of meaning, however, clearly requires a different process. Indeed, customers hardly help in anticipating possible radical changes in product meanings. The socio-cultural context in which they are currently immersed makes them inclined to interpretations that are in line with what is happening today. Radical changes in meanings instead ask for radically new interpretations of what a product is meant for, a which might be understood only by looking at things from a broader perspective (Dell’Era, Marchesi, and Verganti 2008; Verganti and Oberg 2013; Verganti and Dell'Era 2014). In some occasions, a particular type of DDI could be generated by deeply analysing possibilities offered by new or old technologies. Indeed, when the innovation comes from the revelation of quiescent meanings hidden in technologies, a TE occurs (Verganti 2009). Indeed, as claimed by semiologist Giampaolo Proni, “Technologies offer opportunities which are of course not infinite, but are greater in number than those imagined by early developers” (Proni 2007). In particular, in Verganti’s view, TE arise from the interplay of two different radical innovation approaches: technology-push on one hand and design-push on the other. Technology-push is an innovation attitude based on the discovery of a new technology that fosters the emergence of revolutionary products on the market (Norman and Verganti 2014). The new technology is usually embedded in the new objects and gives rise to new usage of the latter. On the other hand, the design-push approach focuses on radical changes in meanings. The recent stream of literature concerning TE provides additional insights into strategies that companies can adopt to gain value from applications based on new technologies (Verganti 2009; Dell'Era, Marchesi, and Verganti 2010; Buganza et al. 2015). In this vein, Swatch represents an exemplary radical innovation based on technological discontinuity (Verganti 2008). In the mid-1980s, Swatch, leveraging on the quartz technology, completely changed what people meant by a "watch" to the extent that Swatch was no longer about timekeeping—although, from a functional perspective, it still provided this feature—but about fashion.

3. Research methodology

As previously mentioned, this paper aims at exploring the design management practices that can support the development of TE. Considering the exploratory nature of our research and the importance of ensuring an in-depth analysis of the phenomenon from different perspectives, both internal and external to the firm, the most appropriate methodology appears to be case study research. Indeed, case studies allow for the study of complex phenomena embedded in their context and the collection of detailed and rich data and are longitudinal by default (Easton 2010; Eisenhardt 1989; Eisenhardt and Graebner 2007). The intent of the paper is to enrich the literature about design management, providing new design managerial practices able to support the discovering of quiescent meanings in new or existing technologies. According to Voss et al. (2002), we use a Theory Building approach to identify patterns and linkages between several variables. Consequently, the case studies conducted herein have an exploratory character, are retrospective and are multiple in nature (Yin 1984). They have successfully proposed on the market TE becoming leaders in different industries. The selection of the cases was based on the combination of ongoing research activities and theoretical interest (Siggelkow 2007).

This paper is based on four in-depth case studies, developed mainly by secondary sources, concerning companies that operate in different industries in which design orientation is differently diffused: Nintendo in the video game industry, Kartell in the furniture industry, Technogym in the fitness equipment industry and KUKA Robotics in the industrial equipment industry (Table 1). More specifically, each case study focuses on TE that is mapped in the following matrix proposed by Verganti (2009).

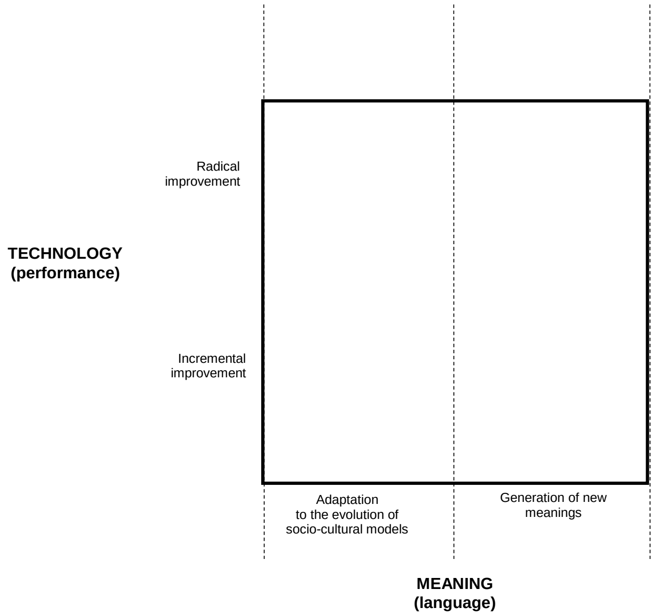

Figure 2. Technologies and meanings as dimensions of innovation (Source: Verganti 2009).

According to Verganti (2009), innovation may be driven by technology, by meaning or by both, and similarly to how technological innovation may imply an incremental or radical change, innovation of meaning may be more or less radical.

Case studies are based on rich secondary sources such as reports, books and archival data, although we directly interviewed key informants about two case studies: Kartell and Technogym. Content analysis was performed by each author, who coded the principal phases of the innovation process (Eisenhardt 1989). Each case was analyzed by at least two researchers. The next step was the construction of a data matrix (cases / dimensions) as recommended by Miles and Huberman (1994). The authors analyzed the transcripts and the matrix (across cases) iteratively and separately. Across cases, we found regularities and patterns. Both innovation dimensions (technologies and meanings) were qualitatively evaluated to highlight the new technologies adopted by the pivot company and its main competitors and the new meaning proposed by the pivot company compared with that of its main competitors. According to the definition of TE introduced in the previous section, we capture the ability of a company to propose innovations of meanings on the market. Investments in design are related to the amount of financial resources a company dedicates to the management of design activities; thus, we measure the percentage of annual revenues invested in design activities (i.e., economic investments) and the ratio of the number of employees dedicated to design activities to the total number of employees (i.e., organizational investments). Competitive performances focus on market results obtained by a company relative to its competitors; more precisely, we consider revenue growth (over the 5 years following the TE considered).

Table 1. Description of the companies.

	Industry	Year of foundation	Description
Nintendo	Video games	1889	Nintendo Co., Ltd. of Kyoto, Japan manufactures and markets hardware and software for its Wii™ home console and the Nintendo 3DS™ and Nintendo DS™ family of portable systems. Since 1983 Nintendo has sold more than 3.5 billion video games and more than 577 million hardware units globally. Nintendo of America has engaged in several high-profile marketing campaigns to define and position its brand. One of its earliest and most enduring slogans was "Now you're playing with power!" to promote its Nintendo Entertainment System. For the Wii, they used the "Wii would like to play" slogan to promote the console to people who tried games such as Super Mario Galaxy and Super Smash Bros. Brawl.
Kartell	Furniture	1949	Kartell SpA was founded in 1949 by Giulio Castelli, a chemical engineer who studied at Politecnico di Milano under Giulio Natta, winner of the Nobel Prize for chemistry. Castelli sought to create something new with the new materials that the market was beginning to offer, "attempting to generate, through [his] products, beauty, innovation, and most of all astonishment." Through a process of continuous technological research, the company worked on plastics, exploring new production techniques and pushing the boundaries of what could be made with this radical new material.
Technogym	Training equipment	1983	Technogym was founded in 1983 by Nerio Alessandri, a 22-year-old industrial designer who began building exercise equipment in the garage of his home in Cesena, Italy. Technogym's goal was to create products for everyone, not just for gym enthusiasts and bodybuilders, and hence the company aimed to reach a much wider market. Technogym's most important achievement during the 1990s was the development of the Wellness concept. The company embraced this concept in 1992 by changing its slogan to "The Wellness Company".
KUKA Robotics	Industrial equipment	1995	KUKA Robotics was founded in 1898 in Augsburg, Germany by Johann Josef Keller and Jacob Knappich. Initially, the company focused on house and street lights, but soon KUKA concentrated on other products (welding equipment and solutions, large containers) and became the market leader in communal vehicles in Europe in 1966. In 1973, KUKA created the world's first industrial robot. Today, KUKA concentrates on progressive solutions for the automation of industrial manufacturing processes.

4. Empirical results

The aim of the following case studies is to examine the managerial practices adopted by companies during the development of TE.

4.1 Nintendo - Wii (2006)

In 2000, when Sony, Microsoft and Nintendo released their latest products, Sony's PlayStation 2 ("PS2") emerged as the clear winner, outselling Microsoft's Xbox and Nintendo's GameCube. The focus of the industry had turned to an even greater extent to the technological development of the console hardware, particularly in terms of faster processing speed, higher-definition video quality and increased game complexity. The relentless pursuit of superior technologies became the convention that drove the industry's dynamics. The market did not provide a warm welcome to Nintendo's new consoles: the Nintendo 64, released in 1996, and the GameCube, released in 2001. The company sold 21.6 million units of the GameCube, compared with 24 million Xboxes and 120 million PlayStation 2s. In 2006, these players released a new generation of video game consoles, precipitating a new competitive battle in the industry. Microsoft and Sony continued with their previous strategies of increasing the computing power of their newest products and adding more impressive graphic interfaces. The Nintendo Wii was a nifty machine that used a wand-like remote controller to detect players' hand movements, allowing them to emulate the real-life game play of such games as tennis, bowling and boxing. The Wii transformed what a console meant: from immersion in a virtual world approachable only by niche experts to an active workout, in the real world, for everyone (Verganti 2009). The Wii, released in November 2006, offered a radical change in meaning relative to its competitors (Figure 3). It was a physical experience to be played not with the thumbs but with the entire body, using natural movements.

> *"Our goal was to come up with a machine that moms would want—easy to use, quick to start up, not a huge energy drain, and quiet while it was running. Rather than just picking new technology, we thought seriously about what a game console should be."*
> Shigeru Miyamoto, Member of the Wii Development Team[1]

The Wii effectively combines a radical innovation of meaning with a radical innovation of technology. On one hand, it has redefined what playing a game console means—not passive immersion in a virtual world, but active entertainment in the real world; on the other hand, the company has achieved this result thanks to the use of a breakthrough technology called MEMS (microelectromechanical systems) accelerometers, which allow the console to sense the speed and orientation of the controller.

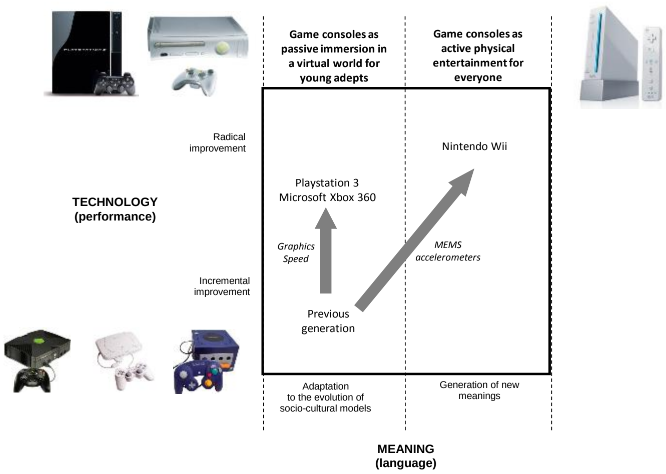

Figure 3. Nintendo (Wii) - Technology Epiphany.

The Nintendo Wii was not conceptualized as interacting with users and adopting a user-driven approach. The development of the Nintendo Wii was championed by the designer Shigeru Miyamoto, who collaborated with game designers and technology suppliers. The Wii concept was enabled by the accelerometers developed by STMicrolectronics. These semiconductor components sense movement and inclination along three physical dimensions (x, y, and z). MEMS were not even new at Nintendo. The company had used a previous generation of these components, in its Game Boy portable console, allowing the user to move a ball-shaped character around a maze. However, the market reacted coldly to this product because the

[1] http://www.engadget.com/2006/11/16/businessweek-interviews-miyamoto-and-ashida-about-the-wii/

meaning of the game remained the same: movement was virtual, occurring inside the game and not in the player.

> *"If a client asks for a specific feature or component, it means that someone else has already created it."*
> Bruno Murari, Scientific Advisor for MEMS, STMicroelectronics

The number of Nintendo employees increased during the 2000s from 2,900 to 4,700[2]; on average, 30% of the employees were involved in R&D activities. In the same period, Nintendo invested approximately 4% of its annual revenues in R&D activities each year (excluding salary costs for employees involved in R&D activities). From 2006 to 2010, the competitive performance achieved by Nintendo demonstrated incredible growth: revenues (+219%), EBIT (+342%), EBITDA (+334%)[3]. In the first two months after its release, the Wii sold 1 million units; in April 2007, six months after its release, the Wii's sales in the U.S. market were twice those of the Xbox 360 and four times those of the PlayStation 3. In the summer of 2007, cumulative worldwide sales of the Wii surpassed those of the Xbox, which was released a year and a half earlier—10.57 million units to 10.51—with the PlayStation 3 lagging behind by 4.3 million units.

4.1 Kartell - Bookworm (1994)

During its period of decline in the 1980s, Kartell realized that because a shift in core competencies or markets would be unfeasible, it would need to reinvent its current product offerings to begin growing again. The company had to dissociate itself from the widespread understanding of plastic as a cheap material for low-quality furniture (Dell'Era, Marchesi, and Verganti 2010). New meanings had to be injected into the material, and a new product language had to be developed (Figure 4). One of the products that best represented Kartell's new direction was Bookworm, the bookshelf designed in 1994 by Ron Arad. While moving out of his home, he was inspired by a coil of steel to create a continuous shelf that could unwind along a wall, held in place by faux metal books. The bookshelf could stand as long as the customer wished and shaped however the customer liked. However, it was not yet a product: It was a one-off piece of art that Arad had created for his personal use. The steel made it expensive, heavy, and impossible to install without specialized equipment. To Mr. Luti, however, it was precisely what the company needed. The company's skill with plastic allowed them to turn that idea into a a work of art going well beyond its basic functional value.

> *"Making Bookworm was very complex because the blend, the mixture of polymers had never been produced by anyone before. Firstly, we went to the large chemical companies like Bayern to see how they produced the materials in order to understand their characteristics."*
> Giulio Castelli, Honorary President and founder of Kartell

[2] Source: ORBIS and WORLDSCOPE.
[3] Source: ORBIS and WORLDSCOPE.

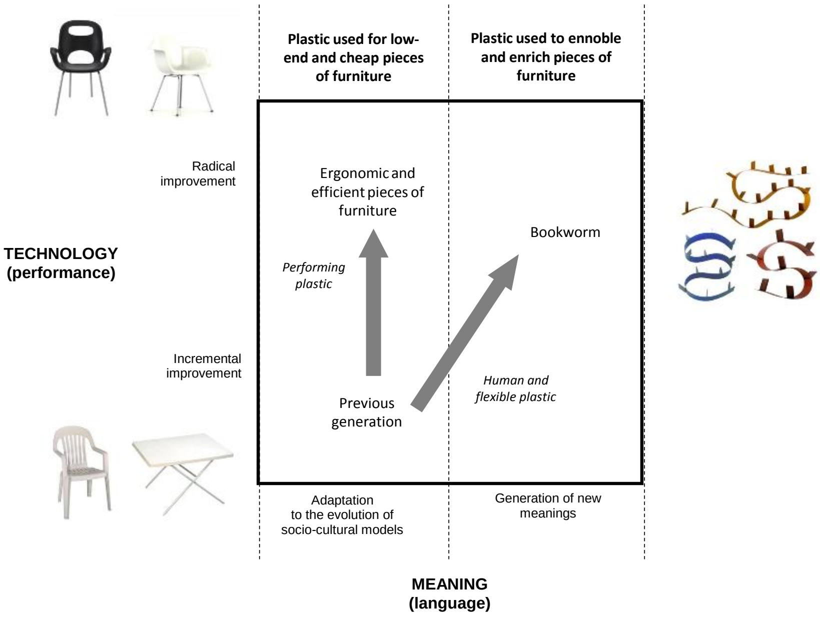

Figure 4. Kartell (Bookworm) - Technology Epiphany.

The efforts of the R&D department during the development of Bookworm aimed to provide a technological solution that could convey the meanings conceptualized by the designer, ensuring the innovativeness of the initial idea. The final version of Bookworm took approximately one year to develop because of a complex process of technology steering needed. Bookworm gave the customer freedom of expression by allowing him to shape it. The fascination that people have with the product originates from their opportunity to interpret a wall themselves by designing a free-form shape. The collaboration with a supply network with varied technical capabilities was one of the key factors to the success of Kartell; this collaboration provided several technological solutions to free the creativity of designers from as many constraints as possible. Kartell can focus only on a few technologies, and it must steer several technologies to enlarge its portfolio. Giulio Castelli described the technological innovation introduced by Kartell during the Bookworm project as an enabler of the meanings conceptualized by Ron Arad:

> *"The research carried out by our R&D department to develop Bookworm was enormous and very difficult. To find the material with the right technical characteristics and the right mould able to embed the concept proposed by Arad was an incredible challenge. Not even Bayer guaranteed the result."*
> Giulio Castelli, Honorary President and founder of Kartell

The number of Kartell employees during the 1990s increased from 60 to 80[4]; only 3-4 employees were exclusively dedicated to design activities (although the CEO was significantly involved), but Kartell

[4] Source: AIDA (https://aida.bvdep.com).

collaborated with approximately 40 external designers. In the 1990s, the average number of external designers equaled approximately half of the employees. In the same period, Kartell invested approximately 5.0% of its annual revenues in design activities annually (considering only the salaries for employees partially or fully dedicated to design activities and the royalties for external designers). In 1994, Bookworm was selected for the Compasso d'Oro Award and was exhibited in the Museum of Modern Art (New York) and Die Neue Sammlung (Munich). From 1995 to 1999, the competitive performance of Kartell demonstrated incredible growth: revenues (+75%), EBIT (+300%) and EBITDA (+107%)[5].

4.3 Technogym - Kinesis (2005)

Following its vision of Wellness, Technogym worked intensely on its home training business. In 2005, the company introduced an entirely new training method called Kinesis, a multipurpose training machine based on cables and spring resistance that allowed the user to perform more than 200 different exercises. A pivoting pulley and cable system provided smooth movement in all dimensions, allowing for total freedom of movement. The workload could be selected with one touch on a display with a single rotating dial by choosing a value from 1 to 20. Kinesis liberated the user from complicated setups and machinery by hiding the main mechanisms. When not in use, the machine almost completely disappeared into a wall, becoming a piece of furniture that could adapt to its surroundings naturally. Technogym not only sold machines; it provided its clients with access to Wellness, a new way of life that. Kinesis combined a radical innovation of meaning with a radical innovation of technology: on one hand redefining what training is about (Figure 5), from Fitness to Wellness, and on the other hand introducing the innovative new "Full Gravity System" to fulfill the Wellness vision by allowing freedom of movement and mind, with synergic exercises and no setup.

> *"Wellness, the philosophy of living well, is expanding at every level: young people, women, seniors, in gyms or at home, during leisure time or during a short break at work. There has been a change in culture: today people who train at home demand the same quality and technological standards of a gym."*
> Nerio Alessandri, President of Technogym SpA

[5] Source: AIDA (https://aida.bvdep.com).

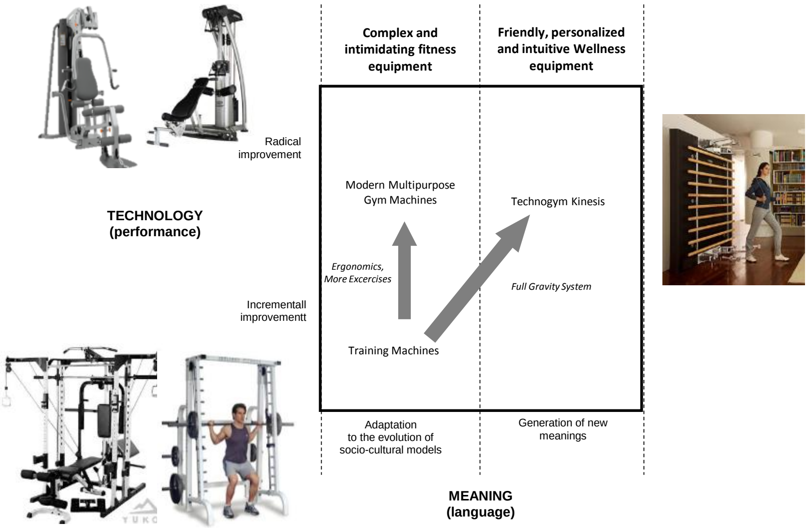

Figure 5. Technogym (Kinesis) - Technology Epiphany.

The real force behind Technogym growth has always been innovation across 360 degrees. When bodybuilding became a trend in the 1980s, Technogym was already oriented towards fitness; when fitness exploded on the market, the company became "The Wellness Company," the only firm in the world capable of offering global solutions for well-being equipment.

> *"Our philosophy dictates that when a product works, it's already obsolete. You must always look forward. You compete by always innovating faster and betting on additional services, like technical and design consultancy. Innovation is company culture. Because, contrary to technology, it's something you can't buy or improvise."*
>
> Nerio Alessandri, President of Technogym SpA

Every product is born from in-depth medical research and is executed by a multidisciplinary team from the Research Centre that is composed of engineers, designers, sports medicine experts and orthopedists, comprising 15% of the company's employees. A portion of the R&D activity is dedicated to the identification of medium- and long-term opportunities, concentrating on the analysis of possible future evolutions of the market and highly innovative products. Technogym has created a tight network of collaborations with various partners, suppliers and external entities, generating new research opportunities (for example, in partnership with the IHRSA, it created a center entirely dedicated to studying the relationship between exercise and health) and new products (in partnership with Sony, it created an entertainment system for its machines).

The number of Technogym employees during the 2000s increased from 600 to 1700[6]; on average, 15% of the employees were involved in research and development activities, and Technogym developed a few collaborations with furniture designers and architects (e.g., Antonio Citterio) based on royalties (3%). In the same period, Technogym invested approximately 15% of its annual revenues in research and development activities annually. From 2006 to 2010, the competitive performance achieved by Technogym demonstrated significant growth: revenue increased by 19%[7].

4.4 KUKA - Robocoaster (2003)

In 2003, KUKA developed the Robocoaster, which was the world's first passenger-carrying industrial robot. The ride used roller-coaster-style seats attached to robotic arms and provided a roller-coaster-like motion sequence to its two passengers through a series of programmable maneuvers. Robocoaster was a product for the amusement industry, and its success led to the creation of an entirely new entertainment division within KUKA (Figure 6). The idea came from Gino De-Gol, a worker in one of KUKA's factories, who combined his interest in amusement rides with his knowledge of robotics to develop the concept of an interactive passenger-carrying robot. After founding his own company, Robocoaster Ltd., he approached KUKA with a detailed plan to establish a partnership to accomplish his dreams. The proposed "Robocoaster" was considered a joke by all the other industry players whom De-Gol had approached. One of KUKA's major competitors preferred not to develop a similar robot, arguing that such a product was too dangerous for humans. However, KUKA recognized the opportunity presented by this new project thanks to their new strategy, which was to be open to new opportunities. After introducing the concept in 2003, the Robocoaster became the world's first and only passenger-carrying industrial robot. Most of the technology was already available, and the company only needed to modify one of its industrial robots by adding some precautionary safety features to have it certified to carry humans by TÜV (technical inspectorate). The first version of the new concept was a stationary ride in which passengers boarded roller-coaster-like seats and were put through a variety of highly programmable maneuvers. In 2007, the company explored new applications of the original concept at Walt Disney World's EPCOT, in which it created a motion-simulator ride that enclosed guests in small capsules and put them through motions synchronized to video, performing maneuvers and motions no normal simulator could even begin to attempt. In 2010, the company introduced one of the largest installations of Robocoaster technology, providing its robots for the centerpiece ride of the Wizarding World of Harry Potter section of Universal's Islands of Adventure in Florida. With this ride, KUKA placed massive robotic arms on a track, a concept it first introduced in 2004, increased seating from two to four, and with Universal's help, KUKA immersed guests entirely in the world of Harry Potter. Currently, Robocoaster has expanded into an entire product line, ranging from basic two-seat variants to advanced 4D

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[6] Source: ORBIS.
[7] Source: ORBIS.

simulation models, while also offering custom versions for dedicated uses in parks and research centers. Even 10 years after its introduction, the Robocoaster remains the only passenger-carrying robot on the market (Verganti and Oberg 2013).

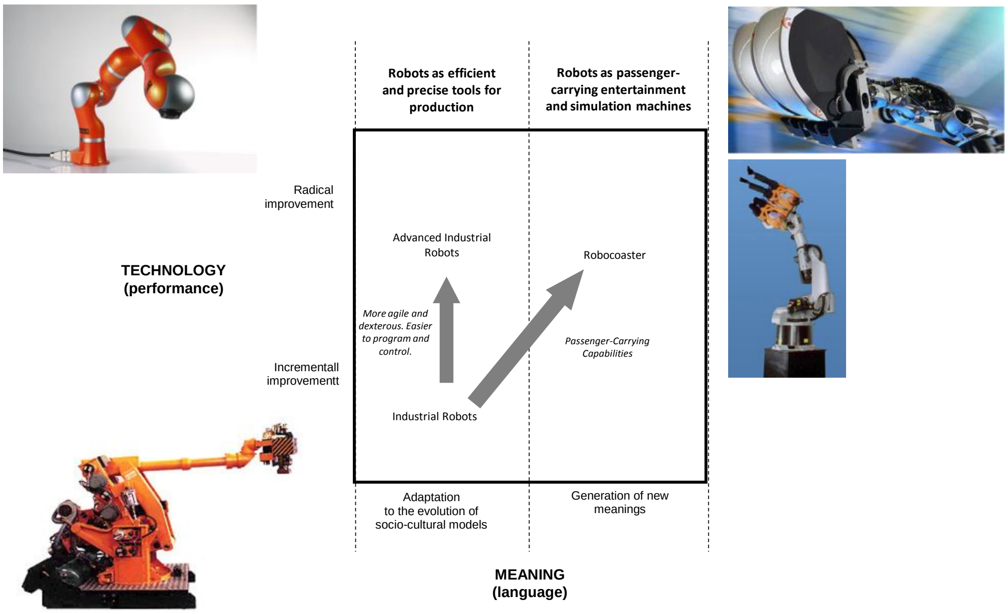

Figure 6. KUKA (Robocoaster) - Technology Epiphany.

The success of the Robocoaster has driven KUKA to open its vision to the possibility of considering robots as entertainment machines. The company created a division dedicated to the entertainment and simulation sector, exploring other applications as tools for movie and theater productions, for public events and fairs, or even for museums and research environments.

The number of KUKA employees during the mid-2000s increased from 12,800 to 13,200[8], whereas the Robotics division increased from 1,800 to 2,000; the Robotics division had more than 200 employees working in the R&D department, representing approximately 10% of the total workforce. In the same period, the Robotics Division invested approximately 7% of its annual revenues in R&D activities each year. From 2004 to 2008, the competitive performance achieved by KUKA Robotics demonstrated incredible growth: Revenues increased 47%, and EBIT increased 284%[9].

5. Discussion

All the investigated case studies demonstrate significant investments in design: The economic investment defined as the percentage of annual revenues invested in design activities is >= 4.0%. However, investments

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[8] Source: www.kuka.com.
[9] Source: www.kuka.com.

in design and competitive performance do not show a clear correlation: Kartell and Nintendo show similar economic investments (5.0% and 4.0%), but their competitive performances, defined as the revenue growth over the 5 years following the radical innovation of meanings, are significantly different (+75% and +219%). Similar conclusions can be made about organizational investment. One possible explanation is that above a critical mass, what makes a difference is not the quantity but the quality of the investments. The empirical results (see Table 2) present some managerial practices that influence investments in design and firms' competitive performance (Gemser and Leenders 2001; Chiva and Alegre 2009). Investments in design are significantly correlated with competitive performance if mediated by appropriate design management practices such as the ability to manage design process and capabilities and involve valuable partners (Chiva and Alegre 2009). Companies differ in the practices that transform investments in design into innovation of meanings enabled by new technologies. However, a few common traits can be identified (Table 2).

Table 2. Investments in design, design management practices and competitive performance.

Case Study	**Investments in Design**		**Design Management Practices**	**Competitive Performance**
	Economic Investment [Percentage of annual revenues invested in design activities]	Organizational Investment [Ratio of people involved in design activities and total number of employees]	Design Process and Capabilities and Design Network	Revenue growth [5 years following the radical innovation of meanings]
Nintendo (Wii, 2006)	4.0%	0.30*	Interpreting Technology as Enabling Platform and Building Double-Sided Network	+ 219%
Kartell (Bookworm, 1994)	5.0%	0.50	Interpreting Technology as Enabling Platform and Building Double-Sided Network	+ 75%
Technogym (Kinesis, 2005)	n.a.	0.15*	Accessing new Knowledge Domains	+ 19%
KUKA Robotics (Robocoaster, 2003)	7.0%	0.10*	Interpreting Technology as Enabling Platform	+ 47%

(*) Data referring to R&D activities

5.1 Interpreting Technology as Enabling Platform

If designers can support companies in capturing emerging trends in society, this activity has to be integrated with studies of technologies that allow products to embed appropriate languages and consequently to convey coherent meanings. Constant research into new materials and innovative engineering methods has allowed Kartell to express its ideas on design and radically innovate product meanings; the research undertaken by Kartell aims to enrich the meanings of artificial materials with new and more expressive surfaces and functions (Dell'Era, Marchesi, and Verganti 2010).

> *"The band of Bookworm shows a surface that is not smooth but is [instead] characterized by little bubbles. This is no defect but a technological solution to give an impression of softness both to the eye and to the*

touch. It was not easy to achieve this aspect because it was necessary to convince the extruder to introduce a sort of imperfection."

[Simona Romano, Curator of the Kartell Museum]

The identification of innovative meanings can be combined with research on new materials, surface treatments, manufacturing processes, etc., that can be embedded into new products. In this sense, technological research and design research work together, exploring new languages embedded in artefacts and, consequently, playing with new technologies and new materials. Similarly to radical technological innovations, which also call for profound changes in technological regimes (Geels 2004), radical innovations of meaning call for profound changes in socio-cultural regimes. In other words, innovation of meanings derive from an interaction between consumers and firms. TE are not an answer to but a dialogue with and a modification of the market (Verganti and Dell'Era 2014).

The concept behind the TE, studied by Verganti (2009), is that each technology is considered to embed a set of disruptive new meanings that are waiting to be uncovered. If a company reveals those quiescent meanings, it will seize the technology's full value, celebrating a TE. Unfortunately, short-sighted companies often focus on the search for new markets for a technology without considering its meanings. In this manner, when companies look for potential applications, they simply focus on technological substitutions. The myopic part of the industry embraces the new technology for utilitarian reasons—until a firm invests in DDI, discovers the disruptive quiet meaning and realizes its full potential. The Wii does not merely add a new functionality to a traditional game console but creates a radically different meaning that is conveyed by all aspects of the product, including the brand, the product name, and the commercials. Nintendo represents a radical innovation in both technology and meaning, distinguishing it from Microsoft and Sony, as expressed above.

5.2 Building Double-Sided Network

The development of TE requires an intense dialogue between technology partners and designers. Collaboration with a supply network with varied technical capabilities is one of the key factors in the development of TE. They provide several technological solutions to free the creativity of designers from as many constraints as possible. To attract the most valuable designers and new talents, companies cannot focus only on few technologies; rather, they must enlarge their portfolio by rotating several technologies (Dell'Era, Marchesi, and Verganti 2010).

"I believe that Italy, or more specifically Northern Italy, is still the centre of the design world, and I must say that it is not just because of the design that comes from Italy, but, above all, it is because of the manufacturing culture; there is no other place in the world where you can find such a vast array of craftsmen and manufacturers for all intents and purposes who know the value of design ..."

[Ron Arad]

As previously mentioned, the development of the Nintendo Wii was championed by the designer Shigeru Miyamoto. According to his view, the radicalness of this innovation was achieved thanks to the collaboration with game designers and technology suppliers. In particular, the contribution provided by STMicroelectronics in envisioning a different application of an old technology such as the accelerometers was crucial.

5.3 Accessing New Knowledge Domains

A critical factor in generating competitive advantage through design is dynamically innovating design capabilities, specifically those competences that allow for a fresh look at the opportunities provided by technologies. Most case and quantitative studies reveal a positive correlation between collaboration with outside designers/players and performance. The most important factor is to continuously renew this network of collaborators to access new insights. The success of leading Design-Driven companies does not appear to be necessarily related to the choice of a specific designer but rather to the capability to identify and manage an articulated portfolio of designers (Dell'Era and Verganti 2010). Similarly, single designers do not provide an analogous value when working with other firms (Heimeriks, Klijn, and Reuer 2009; Holmberg and Cummings 2009). A company's innovation is significantly affected by the diversity of its direct contacts, whose number is relevant only to the extent that it increases the probability of network diversity. Several studies on networks suggest that a firm's portfolio of partners may be as influential as the dyadic characteristics of those alliances (Gulati 1998). A lack of redundancy in a network allows the firm to acquire new capabilities (interpreted as a proxy for innovation) (McEvily and Zaheer 1999). Firms' innovation often relies on the ability to identify and access valuable knowledge outside their own boundaries (Morillo, Dell'Era, and Verganti 2015). As argued by Verganti (2009), leading Design-Driven companies carefully select dozens of designers after years of cumulative investment in building relational assets. Moreover, to pursue radical innovation of meaning, these firms tap this familiar resource or further invest in searching for new talents and attracting them before and better than their competitors do. Identifying key designers and technology partners in the global arena before competitors do requires investment and support. Technogym often organizes research projects involving new potential designers to both explore emerging product meanings and verify the capabilities of new potential collaborators. Technogym was able to move fitness equipment from gyms to houses also because of the collaboration with Antonio Citterio, an architect with special expertise regarding the home context.

6. Conclusions

The paper has identified three design management practices that can guide managers in the development of TE. Re-interpreting new or existing technologies as platforms that enable the discovery of quiescent meanings can allow companies to significantly valorize their potentialities and consequently capture additional value (*Interpreting Technology as Enabling Platform*). The development of TE requires an intense dialogue between technology partners and designers. On the one hand, technology partners provide several technological solutions to free the creativity of designers from as many constraints as possible; on the other hand, designers allow technology partners to steer technology development differently, envisioning new potential applications in completely different fields (*Building Double-Sided Network*). Competences that allow for a fresh look at the opportunities provided by new and existing technologies are crucial to the development of TE. Consequently, it is fundamental to continuously renew the network of collaborators to access new insights (*Accessing New Knowledge Domains*). Furthermore, the empirical results highlight that there is little or no correlation between investments in design and competitive performance (Gemser and Leenders 2001; Chiva and Alegre 2009): Although all case studies show similar investments in design, they obtained significantly different competitive results. The relationship between innovation in design and competitive performance is independent of the industry but is dependent on the diffusion of design orientation (Gemser and Leenders 2001). Design can renew industries and product categories that appear to be mature and static. Considering this, there is no truly mature industry because design has the capability to radically reinvent and revitalize even the most static environment, helping to unveil the quiescent meaning of technologies present within it, as shown by Kartell's case study. Design management practices can also provide added value, facilitating the development of new technologies. Often when a novel technology emerges, companies simply substitute it for an old technology, leaving existing meanings untouched. However, a new technology often obscures a more valuable meaning (see the Nintendo case study). This strategy is especially interesting in the early stages of technological development. Therefore, whereas high-tech companies often regard design as marginal in their context or relevant only when technologies become mature, design can also provide substantial value in the early stages of technology creation.

Because it is exploratory in nature, this research is unable to measure the mediating impact that different design management practices can have on the relationship between investments in design and competitive performance. Similar reflections can be developed concerning the role played by context variables such as the design maturity of the industry. Furthermore, it could be intriguing to operationalize competitive performance according to different measures (e.g., revenues, EBIT, market share) to investigate how the relationships between investments in design and competitive performance can change. This paper also establishes a foundation for further investigation that can focus on the entire model or exclusively on specific relationships. Future research could adopt more refined and quantitative variables. Finally, extensive analyses in different industries could provide additional details based on industry-specific phenomena.

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