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RESEARCH PERSPECTIVES ON CREATIVE INTERSECTIONS

Managing technology development: A two-steps process to discover new meanings

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In the past few decades, several researchers have tried to understand how technology development can be influenced to reduce development expenditures. Moreover, the growing attention to idea generation from both practitioners and academics has given rise to several different veins of inquiry. Considering this, in the literature several studies have attempted to cluster the existing methods to select the technology to be developed (i.e. technology future analysis), but few have tried to medialize how technology development can be influenced in the following stages of evolution. In addition, the increasing attention that enterprises pay to design can be of help in understanding the role that a design mindset can play in technology development. Therefore, this article aims to investigate those managerial practices that can enhance the development of technologies. The methodology used is the single-case study, and the company analysed is Fullpower. Through the investigation, the article identifies a process that can enrich managers' knowledge regarding technology development by proposing a two-step process.

Keywords: Technology Management; Technology Epiphany; Technology Development; Technology Steering

Introduction

In recent years increasing attention has been paid to analysing the effectiveness of R&D expenditures (Baghana & Mohnen, 2009; Bianchi, Croce, Dell'Era, Benedetto, & Frattini, 2016; Lee, Son, & Lee, 1996; Schwartz, Miller, Plummer, & Fusfeld, 2011). Indeed, investing in several new technologies is not easy for today's companies, but they do so to

select the most promising one among all the possibilities. To overcome this limitation, several companies have recently adopted different strategies to select and to develop technology. Under one approach some companies have involved other investors (foreigners or externals) in their research and development processes as co-financing entities. Alternatively, other companies have acquired technology and know-how from outside their company. The first approach is clearly described in the open innovation literature (Chesbrough, 2006), whereas the second refers to the growing phenomenon of the acquisition of innovative start-ups by large companies (Cassiman, Colombo, Garrone, & Veugelers, 2005). This is a largely diffused trend in the digital environment, but is also manifest in other sectors. Thus, Facebook's 2014 acquisition of Oculus is a typical acquisition made by a large firm to enhance its knowledge of other potential and interesting technology and to explore the opportunities offered by the virtual reality technology. The acquisition of a company is a way to explore the technology, but not all companies are willing to risk the acquisition failing, so other approaches can be evaluated by managers. Indeed, the process of exploring new opportunities is a risky one in which the potential spillovers are greater than in other processes. This is one of the main reasons why several developers have decided to develop the technology internally (Mu, Peng, & MacLachlan, 2009). When a technology is developed internally, new perspectives and insights are needed; moreover, if the development purpose is guided by a desire of the company to create an innovation in the reason why people should buy the new product (Verganti, 2009), this necessity is even stronger. In this case a new perspective on how to develop a technology effectively and profitably is needed. Indeed, it is unclear to these companies how they can find more meaningful (i.e., more profitable and more valuable) applications for the technologies that they develop. This question appears to be even more relevant if we consider the words of the semiologist Giampaolo Proni, who in 2007 stressed the concept according to which each technology has a greater number of opportunities than are really exploited by companies. Therefore, the aim of this study is to understand how companies can steer technology development to identify the more meaningful opportunities within it. In other words, through this investigation we try to understand the process and the guidelines that companies can follow to unveil quiescent meanings.

To achieve this aim, the paper is grounded in the concept of a technology epiphany, which was defined by Verganti (2009, 2011) as the discovery of a hidden and often more powerful meaning inside a particular technology. Considering this approach makes it clear that it is not a matter of being the first but of being the first to identify the real market potential of an analysed technology (Verganti, 2011), which is what has occurred in several companies, such as Kuka with the Robocoster (Verganti & Öberg, 2013). Thus, as previously expressed, the real challenge that we want to investigate is how companies can identify the most potential applications and envision new meanings within technologies. Consequently, the focus is more on the technology business unit inside firms than on the companies that deliver the final products. The paper aims to provide a structured process that can help R&D departments and innovation business units in influencing technology development. Considering the scope of the research, the main literature streams on which the reasoning is built include marginally technology management but in more detail the technology epiphany stream.

To cope with the scope of the research, a brief review of the most important literature is reported and then the methodology adopted is presented. The empirical result follows, and the link between it and the theoretical underpinning is reported. The final section contains the managerial practices, limitations, and potential follow-ups.

Literature review

To achieve the aim of the research, as previously reported, a structured methodology was adopted to survey the existing literature. In particular, the first step was the identification of articles relevant to the technology management topic. Then a deeper focus was directed to a peculiar moment of technology development.

Technology management

What emerges from the literature search is that technology management research is mainly divided into three streams: technology selection, technology development, and technology integration (Brode-Jepsen, Dell'Era, & Verganti, 2014; Cassiman & Veugelers, 2006; Iansiti, 2000; Soukhoroukova, Spann, & Skiera, 2012). In particular, the three streams of research mirror the crucial phases of technology management itself. Indeed, the first phase of the evolution of the technology is the period of selection, during which the technology is chosen among different alternatives developed within the R&D department. The most important work in this area is that of Porter et al. (2004), which proposes a framework, under the name of technology future analysis (TFA), that embraces different techniques and methodologies that help companies in selecting technology. After the selection, there is the technology development stream and phase, which match the phases in which the technology opportunities are explored. Part of this field of study is the social construction of technology (SCOT) (Pinch & Bijker, 1987) or the research undertaken by Verganti (2009) regarding how to develop a new vision inside companies leveraging both on technologies and on strategies. The last phase of technology management refers to technology integration (Iansiti, 2000). In other words, it refers to all the studies conducted around the idea that, at the end of the process, the main goal of every company is to launch onto the market a new product that exploits the selected and developed technology.

Given the aim of the research, the most important stream is technology development. Indeed, to identify more meaningful application fields starting from the technology, the way in which decisions are taken during the phase of technology development is quite important. It is clear that, among the three phases of selection, development, and integration, development is the most exploratory one. Indeed, as Porter framed the TFA, in that period the decision is based more on the forecasting that researchers can carry out than on the exploration of opportunities in the application fields. Considering integration, the focus is vice versa on the exploitation and the implementation in a particular application field and not in a complementary or adjacent application field. Thus, the relevance of technology development is demonstrated in this study. Indeed, in this phase of technology management, the more exploratory search around the potential applications of the technology in the market is managed. In addition to that and in line with the aim of the research, a focus on the technology epiphany phenomenon seems to

be relevant. The study aims to identify a process to find meaningful application fields; therefore, clarification of what meaningful means in a technology context is needed.

Technology epiphany

Addressing the innovation of meaning, it emerges that there are two types of strategies, user-driven and design-driven strategies. User-driven design has been popular over the last decade and has been in the spotlight thanks to the successes of major design firms such as IDEO (Kelley, 2001) and Continuum (Lojacono & Zaccai, 2004). This approach implies that product development should begin with a deep analysis of user needs (Chayutsahakij & Poggenpohl, 2002; Dell'Era & Landoni, 2014; Leonard & Rayport, 1997; Stein & Iansiti, 1995; Thomke & Von Hippel, 2002). By using ethnographic methods and observation—and therefore becoming closer to users—firms may understand those meanings better and, through creative problem-solving sessions, may be able to address any mismatch between the existing meanings and the existing products (Dell'Era & Bellini, 2009; Dell'Era & Verganti, 2007; Dell'Era et al., 2008a; Verganti and Dell'Era, 2014). Importantly, radical innovation of meaning clearly requires a different process. Indeed, customers can barely help but anticipate possible radical changes in product meanings. The contemporary socio-cultural context in which customers are immersed makes them inclined to make interpretations that are consistent with what is occurring today. However, radical changes in meanings instead ask for wholly new interpretations of what a product is meant for, which might be understood (and affected) only by looking at things from a broader perspective (Dell'Era & Verganti, 2009; Dell'Era et al., 2008b; Verganti & Dell'Era, 2014; Verganti & Öberg, 2013). On some occasions a particular type of design-driven innovation might be generated by deeply analysing the possibilities offered by technologies. Indeed, when the innovation comes from the revelation of quiescent meanings hidden in technologies, a technology epiphany occurs (Verganti, 2009). In particular, in Verganti's view technology epiphanies emerge from the interplay of two different radical innovation approaches: technology-push, on one hand, and design-push, on the other; see figure 1 for more details. Technology-push is an innovation attitude based on the discovery of new technologies that foster the emergence of revolutionary products on the market (Norman & Verganti, 2014). The technology is typically embedded in new objects and gives rise to new usage of the latter. However, the design-push approach focuses on radical changes in meanings. The recent stream of technology epiphany literature provides additional insights into the strategies that companies can adopt to extract value from applications based on new technologies (Buganza, Dell'Era, Pellizzoni, Trabucchi, & Verganti, 2015; Dell'Era et al., 2009 Verganti, 2009). In this vein both KUKA and Swatch are examples of radical innovation based on technological development that was guided by the idea of proposing new meanings to the market (Verganti, 2008). Especially if we consider Swatch, we can understand that the same quartz technology was explored in greater depth by researchers to identify new opportunities, and in doing so they were able to produce an innovation and the reason for its influence on the market. Indeed, the company sold 1.1 million Swatches in 1983, 4 million in 1984, and 8 million in 1985; it has sold an increasing number of watches ever since. Considering that no clear guidelines on how to foster this type of innovation have already been shared and that the vast majority of the studies in this field are more

focused on identifying cases of technology epiphanies, a study that investigates the decisions that lead companies to develop such innovations is particularly interesting and powerful.

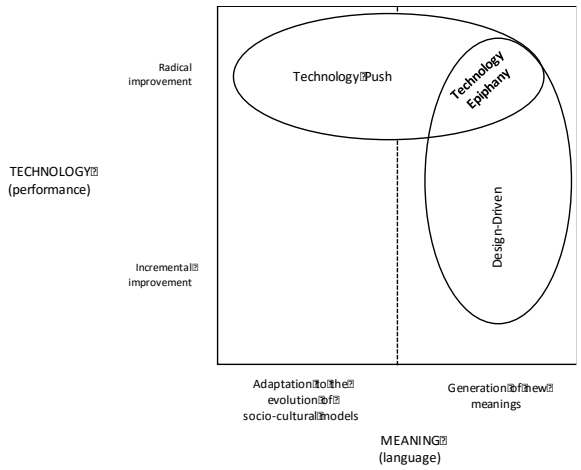

Figure 1 Technologies and Meanings as Dimensions of Innovation (Source: Verganti, 2009)

Considering the streams of literature and the previously discussed objective of the paper, our investigation aims to enhance the knowledge regarding both managers' and practitioners' perspectives. Indeed, the main goal is, on one hand, to identify a few practices that can help R&D departments in identifying meaningful application fields to steer their technology development and, on the other hand, to enrich the theoretical knowledge regarding the technology development field of research.

Research design

To fulfil the objectives, the company selected for this study is a high-tech firm in which the technology development is undertaken in the R&D department. In fact, the objective of this investigation is to enhance the existing theory on technology development and especially on the technology epiphany phenomenon. Thus, as opposed to previous research (i.e. Dell'Era, Altuna, Magistretti, & Verganti, 2017), the perspective adopted by the present study is that of upstream firms in technology development and not that of the companies that market products. For this reason this study investigates Fullpower,[1] a leading American company in the production and development of smart technologies. In particular, we refer to a specific technology developed by Fullpower for a product that is known all over the world, that is, Jawbone. The selection of a single-case study analysis is both empirical and theoretical to try to enrich the knowledge around the technology

[1] Fullpower was founded in 2003 by Philippe Kahn. Thanks to his passion, the company has been a leader in the sensor manufacturing industry since its foundation. The company's particular mission is to integrate motion sensors into mobile devices. To achieve that, Fullpower developed a peculiar accelerometer and an IT platform called MotionX.

development phenomenon (Dubois & Gadde, 2002; Easton, 1995; Eisenhardt, 1989; Halinen & Törnroos, 2005; Siggelkow, 2007). In particular, the selection of the case followed a particular process. Having identified an innovation of meaning that is rooted in the Jawbone technology, a qualitative research methodology to investigate it was defined (Yin, 2003). Thus, we built an explorative case study. In doing so we utilized both primary and secondary resources, collecting reports available online, institutional web pages, articles, and insights gathered during direct contact with the managers of the company. All this information was collected to create the genealogy of the technology. In particular, having identified the epiphany, this study focused on the different application fields in which the technology was applied before the unveiling of the quiescent meaning in the Jawbone bracelet to define the path followed during the technology development with the intention of understanding the development and the decisions undertaken by the company. After the mapping phase, the interpretation of the results took place with the aim of highlighting a few managerial practices that can help R&D-centric companies in unveiling the potentiality offered by technology.

Empirical results

This section will describe longitudinally the process through which the company under investigation generated an epiphany. In particular, the description will start by explaining why we consider this technology to be an enabler of an epiphany and then try to express the decisions taken by the company to develop it.

Fullpower

To cope with the aim of the research, a technology-based company was needed, especially a company that was able, through different developments of the technology, to identify different application fields. Consequently, by screening the digital market, a few tech suppliers were identified. In particular, the focus was on the supplier, because in that field are the real companies that develop and bring the technology to the market. In addition, to be consistent with the investigation, it was not enough for the company to develop a technology internally; it should have developed technology epiphanies through that technology. This limited the available companies considerably, so our final decision was to study Fullpower.

Fullpower is a US company founded in 2003 that deals with several digital technologies, but it is famous worldwide for the sensors that it develops and in particular for a technology called MotionX. MotionX is basically a platform on which an accelerometer, especially a three-axis one, interacts with a very sophisticated and accurate algorithm. In today's world accelerometers are widely used for several different purposes, from entertainment, such as the Nintendo Wii control system, to safety features, for example air bag activation. They are sensors that recognize the acceleration experienced by an object. In particular, by studying this technology longitudinally, we were able to understand that the company was capable of launching onto the market several different products that were introduced into different application fields. In detail, it first launched a mobile application to test the software part of the solution, which was a dice game, then, relying on its data analysis expertise, it started to identify potential markets in which the

combination of it and the sensor could create a more meaningful application, unveiling a quiescent meaning of the technology. Thus, the company came up with the Jawbone bracelet. This can be considered as an epiphany, because, exploiting the same technology as several different fitness bracelets, it was able to monitor in detail the sleeping action and change the meaning of tracking. Indeed, it moves from pure fitness tracking, the number of steps taken, kilometres run, and so on, to 360° fitness in which sleeping is also crucial for the recovery of the body. The wake-up feature is one of the most important features added, and it was first introduced by the company. Analysing the movements and data from the sensor, the algorithm is able to understand whether the person who is wearing the bracelet is in REM or non-REM sleep, allowing it to wake up the person in the smoothest and most appropriate way by considering the sleep moment. This allows the company to change the reason why people should buy the product, moving from the concept of feeling good is fitness to that of feeling good is living well. Thus, we can conclude that the MotionX technology is a technology epiphany and that studying the history of the development further can give us insights into how the company moved from a mobile application to a well-being bracelet.

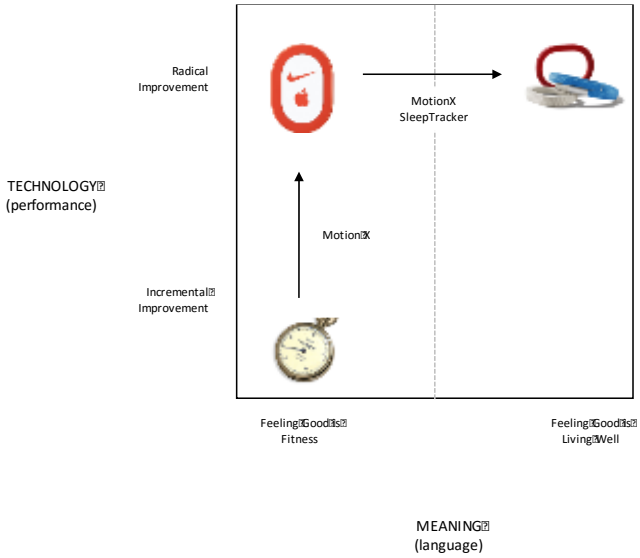

Figure 2 Technology Epiphany in an Activity Tracking Industry

Looking at the history of the development of the technology and ultimately the technology epiphany, the first application field identified was the mobile application one. Launching the MotionX-Poker application, based on a 3-D rendered die, the company was able to develop the software and the technology of interaction more between the sensor, the accelerometer present inside the smartphones, and the algorithm.

The second step of development was the identification of an opportunity to develop its own sensor to exploit the potentiality of the technology better, so the accelerometer was developed by Fullpower. This decision gave birth to the Nike+ activity tracker in 2010. This tracker allows users to monitor the distance walked and run.

The third application of this technology, which required further development, was the Jawbone ERA. This product is a headset that recognizes the movements of the headset that the user can make to enable different actions, such as call answering or rejection. This

product was the first to come from Fullpower with the aim of integrating both the sensor and the software.

The final application and the one that enabled the epiphany is the Jawbone UP. This product emerged at the end of the development of the technology, and it was mainly driven by the willingness of the company to address a new application field. Indeed, the technology development was boosted in the motion recognition not only when people are in real movement, such as running, but also when they are resting in bed. This further development of the accelerometer was guided by the foresight of the owner of the company in identifying new application fields.

Discussion

This section is mainly dedicated to the critical analysis of the case to understand the decisions taken by the company to identify different application fields.

Analysing the case, we understood that a little information about why and how the technology was developed emerged. Indeed, what emerged immediately from the empirical results reported previously is that, to identify a meaningful application field and give rise to an epiphany, a company should explore the technology through different application fields. This is mainly due to the necessity of understanding the opportunity offered by the technology, because this enables the company to steer the development to gain a competitive advantage from the implementation of the technology in products. Thus, it is clear that the first phase of the technology development followed by Fullpower is the *exploration* one. Indeed, in this phase, through the identification of several application fields, like the mobile application, the activity tracker, and the headset, Fullpower was able to understand the MotionX technology a little more. The outcomes gathered during the explorative phase turn into inputs for the second phase of the innovation process, which can allow the company to identify a more meaningful application field. In particular, the explorative phase concerns a creative and divergent process to generate solutions that is shared among practitioners; during this phase a heterogeneous team of experts and the presence of both designers and material scientists can bring useful and valuable insights to the technology development.

The second phase is the *selection* phase and aims to transform the opportunities identified into the identification of the new application field in which the technology can embrace potential new meanings, allowing an epiphany to occur. The application in which so-called quiescent meaning can be unveiled can allow the company to achieve a significant competitive advantage in the market or to create a new market.

Explorative phase

From the case study conducted, certain insights emerge regarding how to explore the opportunities offered by a technology. In particular, the figure reported below shows different approaches to the exploration phase.

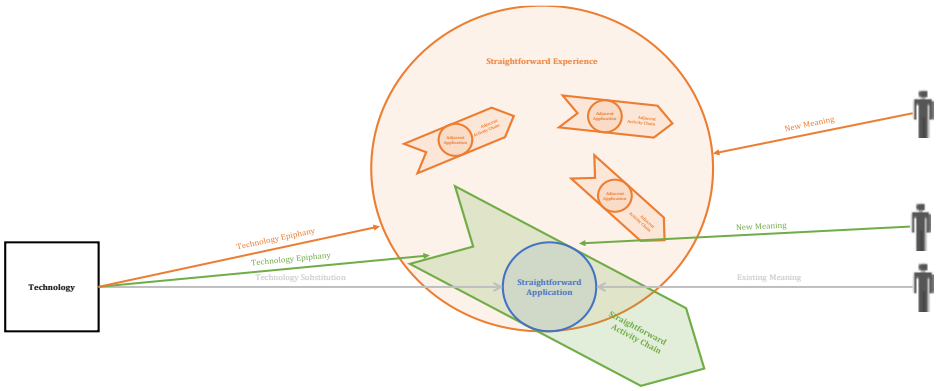

Figure 3 Framework Highlighting Technology Epiphany Approaches

Looking at Figure 3, we can see that three different approaches are envisaged. The first, most common, way to exploit the technology appears to be the *technology substitution* approach, in which the new invention is used in a straightforward application. In other words, an older technology is replaced by a new technology that typically performs better. With this approach no new meanings are brought to end users. This approach does not lead to an epiphany, because no quiescent meaning is unveiled. An example of this methodology is the first usage of MotionX in the Nike+ product. In this case the technology was used to substitute the previous pedometer technology, but the meanings remained untouched.

The second approach involves the exploration of the *straightforward activity chain*. By this denomination, we refer to all the types of activities that are strictly related to the previously addressed application field. Indeed, identifying closer activities to the one currently addressed by the solutions allows managers and researchers to understand the need and the information that they can leverage to offer a new product that can be based on the same technology slightly developed. With respect to MotionX, this approach allowed the company to move from an application that was made to play poker to the creation of an external sensor for fitness tracking. Indeed, the activity chain is the same—smartphone infotainment—but the service provided is quite different. In addition, if we consider the exact point in the activity chain, we can outline the difference, because it is in the end product, the mobile app, whereas the other exact point is in the sensor that populates the mobile app.

The third approach is referred to as *experience exploration*. In this case the exploration is even enlarged; indeed, this approach suggests that the company should focus on the overall experience in which the current technology is used. If we consider Fullpower and MotionX, this approach can be seen in the development of the Jawbone UP starting from the Nike+ product. Both of the solutions are in the overall experience of motion tracking, but the experiences to which they refer are completely different. In a sense the company was able to jump to another activity chain that involved the tracking experience but was different from fitness and running monitoring, which was sleeping recognition and analysis. Thus, what emerges from the case is that the probability of creating a technology epiphany in this case was larger, because the company opened up the technology's boundaries and tried to identify several different application fields in which the value and

the meanings were greater. Table 1 summarizes the findings in term of the probability of realizing a technology epiphany.

Table 1 Different Technology Epiphany Approaches

Technology epiphany approach	**What should I study?**	**When is the adoption of each approach preferable?**
Activity chain exploration	The output of the technology application	When the applications are well known
Experience exploration	The overall experience provided by the technology application	When many applications have previously been disclosed

Selection phase

Having described how the explorative phase works by digging into the case, we were able to understand that a second moment took place after it. In particular, the output of the exploratory phase is the input of the selection phase, and what emerges from the analysis is that these two phases are iterative and not subsequent. The deep study of the case outlines that there are some drivers that can lead to the selection phase. In particular, having created a heterogeneous long list of possible new applications, the selection of the more promising studies is based on the following four criteria.

1. *Value for users* (will people love it?): This criterion is based on the appeal that the product has to final users;
2. *Differentiation* (will it make a difference in the competition/current path?): This criterion represents the capability of generating a competitive advantage;
3. *Appropriability* (can we 'own' the meaning? Branding, technology, distribution): This criterion represents the ability of the company to retain the profits generated by its research activities and limit imitation by competitors;
4. *Feasibility* (is there any interesting product/service idea already?): This criterion represents the investigation of whether there are previous ideas and/or prototypes of the technology that have been studied in the market.

These four criteria emerge from the analysis conducted on the shift between different application fields explored by Fullpower during the development of the MotionX technology. Indeed, choosing to steer the MotionX technology to foster the realization of the Jawbone UP forced Fullpower to take into account different aspects of the technology. After evaluating the potential value for the user, the company decided to add a new feature to the fitness tracker, sleep monitoring, following the insights of the founder, Philippe Kahn, because every design-driven innovation employed these emotional aspects of the purchasing process. Moreover, it was a differentiation choice, because it opened the market of tracking bracelets to a new and different segment of users. Indeed, it allowed the company to focus also on people who want to feel good and not only people who are addicted to running. In addition, in terms of appropriability, this choice is

interesting thanks to the brand awareness created through the communications of the sleeping recognition and the wake-up modality. There were no other solutions on the market for the feasibility concerns at the time of development.

Conclusion

Considering that competitiveness is increasing and the costs of technology development and investments are rising in today's market, a deeper knowledge about how to foster radical innovation is relevant to both practitioners and scholars. In line with the foregoing conclusion, this paper has enhanced the knowledge around the concept of technology epiphanies. In particular, it has provided some insights regarding how managers can approach technological development to unveil quiescent meanings. Revealing the processes and the sub-criteria embodied in the two phases is useful for both practitioners and researchers to comprehend better how to create and approach technology epiphanies. This step is particularly important with respect to exploration and gathering opportunities. In other words, companies and managers can truly exploit technological development through exploration. Considering the costs and efforts that a new technology development process requires, companies should be interested in being able to enhance the potentiality of the impact of technological development. In particular, the exploration in this instance is not casual but guided, and the basic assumption is that the exploration can occur in two directions: either following a previously addressed activity chain or within the experience in which the first application was launched. It is especially important that, after the first explorative application, the firm can enlarge its horizons by creating a list of different application fields in which the newly developed technology can be applied. All these opportunities are then evaluated with a structured approach during the selection phase and converge in the selection of a single application field. This convergence process helps to leverage the four criteria and assists managers in choosing one application field at a given time. Understanding the technology and exploring the opportunities offered are just two of the important areas to examine when developing a new technology. The investigation also revealed the idea that managers should create a multidisciplinary team to address the development of the technology. Indeed, adding different perspectives in both the explorative and the selection phase can lead to real insights into the progress of the technology.

Bearing in mind that this is an exploratory study, the evidence and the clues outlined are not generalizable, which is one of the most relevant limitations to this investigation. Nevertheless, this growing attention to R&D effectiveness is an important factor in creating knowledge and consciousness around the technology epiphany concept, because it can help companies to create both new markets and more meaningful applications and—as a result—radical innovations. Thus, this area represents one of the most significant follow-ups for further research in the field. Technology epiphanies are an under-researched topic that is relevant to several sectors—not just the digital technology sector—and several nations. Finally, a more quantitative and structured approach can be used to enhance the knowledge around the two-step process identified in this paper.

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