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Cross-fertilization of Key Enabling Technologies: An empirical study of nanotechnology-related projects based on innovation management strategies

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A R T I C L E I N F O

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A B S T R A C T

In this empirical study, we have analysed three innovation management strategies that could be influencing the process of cross-fertilization of KETs (Key Enabling Technologies), currently being fostered by European initiatives. To do so, we have interviewed Nanotechnology-related project leaders participating in Horizon 2020. Results from a MCA (Multiple Correspondence Analysis) have shown that higher levels of cross-fertilization of KETs are associated with customer/market-oriented projects developed in informal networks characterized by a moderately heterogeneous knowledge, with a high level of involvement in nanotechnologies. With these outcomes, we argue that absorptive capacities and dynamic capabilities of organizations are decisive in a technologically convergent approach, lead by open innovation strategies.

1. Introduction

Key Enabling Technologies (KETs)[1] are related to six knowledge domains: 1) Advanced Manufacturing Technologies; 2) Advanced Materials; 3) Photonics; 4) Industrial Biotechnology; 5) Micro and Nano-electronics; and 6) Nanotechnology. These technologies have a direct and indirect capacity to address major societal challenges, enhance competitiveness, generate jobs, and contribute to economic growth. This concept, coined by the European Commission (EC), is currently being used in European funding programmes such as Horizon 2020 (H2020) to enhance innovation and competitiveness in the region (Aschhoff et al., 2010; European Commission, 2009). In particular this initiative fosters the *cross-fertilization* of KETs, so that new and unique product properties or technology features can be created. This integration of different KETs is considered a vital activity in Horizon 2020, since around 30% of the budget allocated to KETs will go to integrated KETs projects (European Commission, 2014a).

The EC defines *cross-fertilization* as the process of integrating different KETs in order to obtain new technological components or products with the potential to lead to unforeseen advances and new markets (European Commission, 2014a). According to the innovation system literature, cross-fertilization is defined as a new combination of previously distinct technologies. This process

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[1] "*knowledge intensive and associated technologies with high R&D intensity, rapid innovation cycles, high capital expenditure and highly skilled employment which enable process, goods and service innovation throughout the economy and are of systemic relevance*" (Commision, 2012)(pp. 2–3).

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results in a *recombinant innovation*, which occurs when two or more different technologies recombine to create a new improved technology (Fleming, 2001; Frenken et al., 2012; Maine et al., 2014b; Van den Bergh, 2008). Authors from this innovation literature also agree that this process, where technologies are hybridising[2] with each other, could lead to the improvement of existing product attributes and functionalities (Leifer et al., 2002), opening the way to generating radical innovations (Maine et al., 2014b). Furthermore, and according to the innovation evolutionary economics, radical and recombinant innovations accelerate the progress and transition of a technology, raising the likelihood of its long-term success (Frenken et al., 2012).

In this context, *innovation management strategies* are essential in a convergent scenario since they could influence the productivity and performance of their developers. A previous study focused on the convergence of Nano and Biotechnologies from Maine et al. (2014b), found three central innovation management strategies in this convergence: i) *to import ideas from broad networks*, ii) *to create environments for deep collaboration* and iii) *technology-market-matching*. The first strategy refers to the search and synthesis of concepts or ideas that could be taken up from networks with different technology streams. The second strategy involves the dynamic flow of knowledge between R&D groups. Finally, these two strategies need to be complemented by considering market needs, which is the third strategy.

The present study is grounded in the three aforementioned strategies, taking into account other aspects related to network theories, absorptive capacity and dynamic capabilities' literature. The aim is to obtain an expanded vision of these three strategies and the possible influence they could have on the cross-fertilization of KETs. We have focused on nanotechnology as one KET that is having a great impact on major societal challenges. This study is also centred in the healthcare domain, since this is one societal challenge that is being significantly addressed at the nano-scale manipulation. For that end, we have selected projects with current or future applicability in healthcare from the Leadership and Industrial Technologies (LEIT) call of H2020, where the cross-fertilization of KETs is strongly encouraged. Project leaders were interviewed in order to get insights about the level of applicability of nanotechnologies in their organizations (herein called "actors"), the level of cross-fertilization of KETs in their projects, and their innovation management strategies.

Answers were statistically treated by using Multiple Correspondence Analysis. Results showed that market-oriented projects, with actors strongly motivated to search for ideas through broad informal networks and where their partners do not have specific technological knowledge', are factors that boosts higher levels of cross-fertilization of KETs. Another interesting finding in this study showed that organizations that have a substantial inclusion of nanotechnologies are the ones with higher levels of cross-fertilization.

This document is organized as follows: In Section 2, theoretical background is explained and research hypotheses are generated regarding the managerial strategies in the process of cross-fertilization of KETs. Section 3 describes the methodology used in this study in order to prove our hypotheses. Section 4 shows the results obtained and to finish, Section 5 presents the discussion and conclusions of this work.

2. Theoretical background and research hypotheses

2.1. Cross-fertilization of Key Enabling Technologies

Combining diverse technological streams frequently underlies the development of new and significant inventions (Maine et al., 2014b). Yet, not only the combination, but the convergence of technologies could generate and transform products that could be shared across diverse fields, resulting in radical innovations (Björkdahl, 2009; Heide et al., 2013; Roco and Bainbridge, 2005). In this process, value is generated from sharing knowledge and equipment and from the alignment of different stakeholders and skilled specialists (Mangematin and Walsh, 2012; Organisation for Economic Co-operation and Development OECD, 2014)

As well as the concept of hybridization, the concept of *convergence of technologies* is often associated with the process of cross-fertilization. The rationale is that "convergence" specifically involves conflation between previously distinct knowledge, technology, product or industry domains (Jeong and Lee, 2015). According to Katz (1996), the concept of convergence has broad implications for economic welfare and could shape the structure of industry (Katz, 1996). Technological convergence has become a current phenomenon aimed at enhancing previous solutions for a specific product or service (Gauch and Blind, 2015). In this line, it is expected that the convergence or cross-fertilization of KETs could drive radical change, supporting the development of other technologies (Australian Government, 2012). To this end, the six KETs have been selected by the EC as the most strategically relevant at H2020, according to their economic potential and their capital and technological intensity (Aschhoff et al., 2010; Butter et al., 2014; European Commission, 2009).

Individually, each KET has a huge potential for innovation. However, cross-fertilization of KETs could offer even greater possibilities for fostering innovation and creating new markets (Butter et al., 2014). The relevance of this combining process lies in the creation of new unique product properties or technology features, which could not have been obtained with a single technology. This convergent scenario in areas such as microelectronics, microfluidics, micro-sensors and biocompatible materials enables the availability of cheaper and faster new medical devices of small dimensions (Juanola-Feliu et al., 2012; Páez-Avilés et al., 2015a).

In the field of healthcare, several radical innovations have already been enabled and are expected to have a great impact in the coming years through the cross-fertilization of KETs. Such advances include effectively targeted drug delivery, rapid diagnostics, and

[2] The terminology *technological hybridization* could also be used to explain the EC-originated concept of cross-fertilization since hybridization means marring two technologies to produce a new form of technology practice, attempting to combine the usefulness and power of diverse technologies to generate new combination (Drengson, 1995).