



# Anticipation of converging technology areas – A refined approach for the identification of attractive fields of innovation



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## ABSTRACT

A series of product innovations owe their economic success and origin to the impetus and know-how from disciplines and industries that were hitherto unfamiliar to the actors in the industries concerned. This phenomenon, known as “convergence”, leads to emerging industry segments and offers a wide array of opportunities for synergies. Against this background, a significant emphasis has been put on anticipating technology convergence as well as identifying and understanding the changing innovation patterns and industry structure associated with convergence. The timely recognition of converging technological fields enables the innovating enterprises to exert a positive influence on the changing value-chain.

This paper introduces a refined methodological approach for the anticipation of converging technology areas based on the concept of knowledge flow. The proposed method is illustrated using patents related to the areas of Nutraceuticals and Functional Food (NFF), Nanotechnology and Wearables.

Our results indicate that the emerging technology convergence can be expressed by the concept of “weak signals”. The indices derived from the proposed approach are capable of uncovering the relationships between the individual technological sectors and provide numerical metrics to measure the presence of converging technologies.

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## 1. Introduction

Innovations are key factors for determining the economic viability of a business and are considered to be the starting point for creating competitive advantages and its sustainable preservation (Drucker, 2009; Danneels, 2002). Forward-looking companies strive to further extend or solidify its competitive and technological edge by means of continuous innovation activities. However, the rate, at which the present framework and boundary conditions change, has caused fundamental and structural transformations in a competitive environment. A remarkable aspect in this context is the blurring and redefinition of existing boundaries between two or more industries (Hacklin et al., 2009; Curran and Leker, 2011). This can be characterized as a special form of technological change and innovation, whereby formerly distinct technological/market trajectories begin to overlap and merge to form a new product with different functionalities that satisfy the complementary needs of consumers in a single transaction (Katz, 1996; Greenstein and Khanna, 1997; Karvonen et al., 2010).

The term “convergence” has become a buzzword over the recent past and received strong media coverage as well as public awareness (OECD, 1992; Weaver, 2007; Curran et al., 2010). Especially, the remarkable success of Apple's iPhone as the main outcome of digital technology convergence, adding not only new functions to the existing base product, but also creating new business opportunities for content-based services, reignited the discussion regarding the theory and practice of technology convergence. The common ground in literature regarding technology convergence is that the key to future growth and innovation lies in properly understanding and interpreting the convergence of various technologies, managing the cooperation between businesses as well as in re-shaping the attitude of management towards converging markets (Eselius et al., 2008; Nyström, 2009). Scholars and practitioners have emphasized the fact that whether or not converging technologies are going to have an immediate impact on the society, there will definitely be a shift going on in how formerly separated industries merge and interact with each other (Doorn and Rip, 2006). More and more innovations do not emerge and evolve within the framework of a single discipline, but rather between fields of knowledge. Brew emphasizes in this respect: “Disciplines are more like water than land in that they can be separated yet come together, can combine, merge and recombine in an almost infinite number of ways.” (Brew, 2008). As social values are constantly changing and socio-economic issues are becoming more complex, relying solely on a single knowledge domain to find

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innovative solutions is perceived as inadequate (Jeong and Lee, 2015). Thus, managers and policy makers need to understand the new challenges and the long-term implications arising from the blurring of boundaries between sectors by converging value propositions, technologies and markets (Choi and Valikangas, 2001). The shift is accompanied by far-reaching implications on the business environment and there is often great uncertainty with regard to the strategic consequence of convergence (Hacklin et al., 2013). For instance, Stieglitz (2004) differentiates between substitutive and complementary product convergence. In case of substitutive convergence, the competition between former and converged product would naturally increase. Curran (2013) conclude that technological developments enable firms to supply the market with new or enhanced products, but lead to changes in customer structures and behavior that emphasize the role of demand-driven convergence.

In such a context, a significant emphasis has been put on exploring technological convergence as well as anticipating the changing business developments associated with the convergence (Curran and Leker, 2011; Karvonen and Kässi, 2013). The timely recognition of converging technological fields enables the innovating enterprises to exert a positive influence on the changing value-chain and to link their internal and external capabilities more efficiently. However, despite the importance of this issue, previous studies entitled with anticipation of convergence relied on the monitoring of converging technology fields. This implies that the authors have acknowledged the convergence in the field of Nutraceuticals and Functional Food (NFF) as a given fact in advance and the analysis findings provided a subsequent confirmation of what was already known from earlier studies and well-examined in practice (Brännback et al., 2002). For instance, the authors were aware of the specific keyword such as “phytosterol”, which was used to create the sample data (Curran et al., 2010). There are a substantial portion of quantitative-empirical studies, which use patent literature for the design of procedural methods to analyze trajectory patterns of technology fusion and to reconstruct the development path of technologies in a converging setting (No and Park, 2010; Choi and Park, 2009). Although preceding studies certainly contributed to the expansion of knowledge base in convergence research and can help scientists and managers make a suggestion for improvement in the organization's innovation pipeline, the forecasting power of previous methods varies from case to case. For example, the analysis based on the exploitation of citation information rather provides the opportunity to explore the evolutionary path of technology fusion. There is a risk that the significance of newly registered patents is underestimated, if the predictive model is solely based on the use of citation information. A few novel studies have suggested the use of network indices such as entropy (Gauch and Blind, 2015) and gravity (Choi and Kim, 2014) in order to measure the technological convergence and the relatedness between the fields of technology, but they also tend to deal with the exploration of specific patterns of fading boundaries in known technology fields.

To dive deeper into this issue, this paper introduces a refined methodological approach for the anticipation of converging technology areas based on the concept of knowledge flow. Approaching the aforementioned issue from a more theoretical point of view, the objective of this paper is to provide a conceptual framework to obtain a better outlook on the converging technologies. The proposed method is illustrated using patents related to the areas of Nutraceuticals and Functional Food (NFF), Nanotechnology and Wearables.

The organization of this paper is as follows: Section 2 of this paper provides an overview of key characteristics of convergence. This is followed by a brief introduction of the overall research design and methods. Herein, a refined perspective for the understanding of converging technology areas is proposed. Section 4 describes the results of the patent analysis and a discussion about the findings of the study is given. Section 5 will conclude with an outlook on possible future research and implications for the management.

## 2. Characteristics of convergence

### 2.1. Concept and definition

Convergence is not necessarily a new phenomenon in academia and industry. It has been the subject of many studies in the last two decades, whereby a prevailing view on this topic was that the industries and markets would merge through a growing overlap between technologies, services and firms. The digital technology and the evolution of the ICT became “the centerpiece of the hitherto somewhat disparate branches of the industry” (von Tunzelmann, 1999). This is somewhat true that the digital technology had the most profound impact on all types of industries. There is almost no single industry that can delay the need to exploit the benefits coming from the application of digital technology (Pralhalad, 1998). Examples of convergence can be seen in the areas of health, personal care and nutrition. The trend towards healthy lifestyle resulted in the emergence of Cosmeceuticals (a combination of cosmetics and pharmaceuticals) as well as Nutraceuticals and Functional Foods (NFF: a combination of nutrition and pharmaceuticals) (Bröring, 2010). The increasing electrification of vehicles led to the emergence of the term “electromobility”, whereby the reconstruction of the entire value chain is associated with a skill shift from mechanics to “me-chem-tronic” (mechanic, chemical and electronics) (McKinsey, 2011).

Although the term convergence has received a considerable attention in the past decade, the magnitude of what is to be understood as convergence varied greatly by author (Katz, 1996). Convergence is a fairly elastic term that has different meanings depending on the context. According to Jenkins, media convergence is “the flow of content across the media platforms, the cooperation between multiple media industries, and the migratory behavior of media audiences” (Jenkins, 2006). This understanding of convergence shows, in particular, that convergence does not only affect the traditional industry structure, but also allow two different worlds or behavioral patterns to collide.<sup>1</sup> When speaking of digital convergence, the starting point is the notion that the boundary between the virtual and physical world is increasingly becoming blurred and the digital synthesis of data and applications permeates our everyday lives. Therefore, a coherent concept is required to bring more analytical clarity to the notion of convergence. Consequently, the idea of what shall be understood by the term convergence has been continuously revised and adjusted to the latest requirements. Yoffie (1997) defined convergence as “the unification of functions – the coming together of previously distinct products that employ digital technologies”. Tarjanne (2000) saw convergence as “the blurring of borders between telecoms, computing and media”. They both narrowly defined the convergence referring solely to the developments in the ICT industries. Thielmann (2000) considered convergence to be an interaction process of companies with their external environment, which leads to the structural link between formerly separated markets. Bröring (2005) advocated this conception and characterized convergence as overlapping of “two formerly separated industries starting to produce similar products”.

Despite the diversity of definitions available, most scientists agree that convergence is related to the process of coming together of different properties, whereby a property can be either know-how, technology, market or industry segment. In this sense, the term technology convergence refers to a process, whereby the different sectors come “to share a common knowledge and technological base” (Athreye and Keeble, 2000). Recognizing that there is no one definitive definition of convergence in literature, this study has adopted the following description from Curran and Leker (2011). Herein, they define convergence as “the blurring of boundaries between at least two hitherto disjoint areas of science, technology, markets or industries. Through this convergence, a

<sup>1</sup> In setting of media convergence, the formerly passive consumer (the receiver) plays an increasingly active role in the production, promotion and management of digital contents.

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