Diffusion of 3D Printing Technology: An Evolutionary Perspective With Patent Mapping

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ABSTRACT

3D printing technology has been perceived as a disruptive technological innovation in many areas as it can revolutionize existing systems. It has many potential advantages in various areas such as medicine, aerospace and customized goods in terms of integrity, cost and speed. This study aims to visualize the evolution of 3D printing technology related patents by patent mapping, in the process, diffusion of 3D printing technologies to different business fields can be traced and evaluated. Patents represent the scientific knowledge that has been already commercialized or is ready to be marketed. The historical evolution and current framework have been demonstrated by using social network analysis on CPC codes of the related patents. Results of the study suggest that most technologies connected with 3D printing depend on B29C (shaping or joining of plastics; shaping of substances in a plastic state, in general; after-treatment of the shaped products, e.g., repairing.).

KEYWORDS

3D Printing, CPC Codes, Patent Analysis, Social Network Analysis

INTRODUCTION

3D printing technology is one of the most innovative technologies that bring radical changes to business models and stir the debate of the Third Industrial Revolution (Rifkin, 2012). The expiration of patents has led to 3D technologies have become more accessible and defined as a “manufacturing revolution” (Coon, Pretzel, Lomax, & Strlič, 2016). Gartner predicts that 3D printing technology will continue thriving and by the year 2019, 5.6 million units will be sold, compared to the year 2014’s 106,000 units (Basiliere, 2015; Kietzmann, Pitt, & Berthon, 2015). The total market for 3D printing is currently around $ 2B and expected to grow at approximately 19%. By the year 2015, only 10% of addressable businesses have adopted technology (Gordon, 2015). This is a sharp increase in sales and B2B transactions, and it points out to a significant potential for innovation and economic growth. 3D printing technologies also have potential to affect the future generations and different industries as applications of these technologies vary from creating consumer goods, industrial tooling, medical applications, scaling, and fashion to prototyping for new designs.

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The terms 3D printing and additive manufacturing are usually used interchangeably, but it should be noted that ‘3D printing’ is a blanket term that refers to a family of additive manufacturing technologies and the definition of “3D printing” is somewhat inexact (Weller, Kleer, & Piller, 2015). While some experts in the field would restrict the definition of 3D printing to additive manufacturing of units with inkjet-based print heads that create an object on a layer-by-layer basis, others would apply this term to the production of usually single items (prototypes) using additive manufacturing technologies that are relatively low-cost and easy to use (Berman, 2012; Coon et al., 2016). In general, 3D printing refers to not one, but multiple technologies and manufacturing processes that enable users to create tangible objects from digital three-dimensional models (Rogers, Baricz, & Pawar, 2016). 3D printing technology is rapidly adopted by different levels of users which varies from household users to industrial firms (D’Aveni, 2015). There is a growing community of “makers” who develop and share 3D models, sell 3D printed products on marketplaces, and a steadily growing number of 3D printers for home and industrial use extends the scale and scope of manufacturing options (Weller et al., 2015). Currently, 3D printing has a large variety of methods such as stereolithography, selective laser sintering, fused deposition modelling, laminated object manufacturing that are appeared in the late 1980s and began operation in the early 1990s (I. Lee & Kim, 2015; Markillie, 2012; Rayna & Striukova, 2016).

In the knowledge economy era, science and technology play crucial roles in the process of economic growth not only in developed countries but also for emerging economies to catch up and to maintain sustainable economic growth. Science and technology are driving forces in value creation that stems from new knowledge (Acs, Anselin, & Varga, 2002). The production of new knowledge is characterized by the interaction of codified and tacit knowledge. Scientific papers and patents are codified forms of new knowledge in a particular type. Patents are important representation forms of technology that conveys the history of technological development, and also, they carry technological innovations. Accordingly, patent data is extensively used in the analysis of innovation in developed economies (Kim, Suh, & Park, 2008).

The main reason of analyzing patent information is that patent information relates to the current information contained in patent documents, which can help avoid erroneous investment due to research duplications previously conducted by others (Chen, 2009). Patent information is not the only source of information that can stimulate innovation to develop new products and processes as long as the resulting invention does not infringe existing patents. The insufficient use of patent information has caused a considerable expenditure of funds in R&D projects, whose results may be threatened by the return on the investment made in already existing patented technologies (Maravilhas, 2016; Ukwuani & Bashir, 2017).

Patents provide an ample source of technical and commercial information; therefore, patent analysis has long been considered a vital tool for R&D management, market value and competitive intelligence by many researchers. “Although early research on patents was mostly conducted under a legal or economic perspective, in more recent years, the number of articles dealing with a technological mining and innovation point of view has been gathering pace” (Soranzo, Nosella, & Filippini, 2016). Although 3D printing technology has been argued frequently in academic and industrial basis, empirical research regarding the technological applications of 3D patents with the patent analysis is rare comparatively. The aim of this study is to visualize the evolution of 3D printing technologies by patent mapping, in the process, diffusion of 3D printing technologies to different business fields can be traced and evaluated. It contributes to the literature as it compares the historical evolution and current framework of 3D printing technologies in regard to application areas using patent analysis. Although patent analysis has been performed in previous research with different objectives, this study fills a gap in the literature in two dimensions. First, the study approaches 3D patents in terms of historical evolution in order to determine the earlier areas of application and how are they connected with other areas by visualization of technical properties. Second, this study has used triadic patents from Derwent World Patents Index (DWPI) and patent

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