Towards Industry 4.0: Mapping digital technologies for supply chain management-marketing integration

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Abstract

Purpose – Supply chain management-marketing (SCM-M) integration has been deemed to play a key role for delivering customer value and, hence, achieving superior financial performance. To better managing the interface between supply chain management and marketing functions, the digitization of firm process appeared to be necessary. Indeed, according to the principles of Industry 4.0, it supports the complex information processing mechanisms that are needed to integrate supply-focused and demand-focused processes. However, a clear vision of the digital technologies enabling such integration has yet to be provided. Therefore, we aim at offering a comprehensive outline of the enabling technologies for managing the interface between supply chain management and marketing processes and presenting a complete picture of the innovative efforts undertaken over time to develop those solutions.

Design/methodology/approach – Patent analysis is used to carry out this study. In detail, first, we identified the subset of enabling technologies for Industry 4.0 that appear to be the most relevant for effective SCM-M integration from an information processing point of view (i.e., Cloud computing, Industrial IoT, Cyber security, Big Data analytics & customer profiling). Second, we carried out a patent analysis aimed at providing a comprehensive overview of the patenting activity trends characterizing the set of digital technologies under investigation, hence highlighting their innovation dynamics.

Findings – This research provides insightful information regarding the digital technologies that best relate to the Industry 4.0 domain and can be used for SCM-M integration. Moreover, we highlight the organizations and countries more involved in the development of those solutions over time and offer an examination of their technological impact. In this way, it is possible to better identify where the technological knowledge underlying such digital solutions origin, and the organizations that may act as competitors or partners during firms' digital transformation.

Originality/value – So far, much has been said about why marketing and SCM should be integrated. However, how the SCM-M interface should be integrated and which tools may be adopted have yet to be revealed. In turn, it can be recognized the absence of a clear picture of the solutions developed within the domain of Industry 4.0. Thus, our paper contributes to the literature on SCM-M integration and Industry 4.0 by highlighting the enabling technologies for Industry 4.0 that may particularly serve for managing the SCM-M interface from an information processing perspective.

Keywords Supply chain management-marketing integration, Industry 4.0, Supply chain management, Marketing, Patent analysis, Innovation, Internet of Things, Cloud computing, Cyber security, Big Data analytics, Customer profiling

Paper type Research paper

1. Introduction

Creating customer value is pivotal for firm survival and the achievement of superior financial performance (Woodruff, 1997; Lindman *et al.*, 2016). Despite the key role played by the marketing function, this activity requires the integration of functional areas that are not conventionally associated with marketing (Jüttner *et al.*, 2007; Trkman *et al.*, 2015). Indeed, on the one hand, the adoption of a market-oriented strategy is necessary to keep pace with the volatile demand characterizing current markets and identify the most valuable products to offer (e.g., Slater and Narver, 1995). On the other hand, supply-focused processes (e.g., operations and inbound/outbound logistics) are also needed to efficiently and effectively deliver value to customers, hence letting companies maintain high service levels and avoid stock-outs (e.g., Esper *et al.*, 2010a; Macchion *et al.*, 2015). Thus, it has been argued that the ability of firms to integrate and coordinate supply chain management and marketing functions, i.e., the supply chain management-marketing (SCM-M) integration, is important to reduce mismatches between demand and supply of relevant products for a given market (Pero and Lamberti, 2013; Jüttner *et al.*, 2010).

Although firms that better manage the SCM-M interface are deemed to outperform companies that create differential advantages in only one of the marketing or SCM functions (Boyer and Hult, 2005; Esper *et al.*, 2010b; McKinsey & Co., 2017), current organizational practice still lacks a comprehensive set of tools favoring the integration of marketing and SCM processes. This issue mainly reflects the challenges of establishing the information generation and processing mechanisms that allow serving consumers with the appropriate products, while understanding the constraints that emerge throughout supply chain transactions (Esper *et al.*, 2010b; Alvarado and Kotzab, 2001). Likewise, extant research has fallen short of offering insights about the nature and mechanisms for SCM-M integration (Mentzer and Gundlach, 2010; Pero and Lamberti, 2013). Therefore, this paper seeks to provide new insights about the management of the interface between supply chain management and marketing processes.

Since the key to success for SCM and marketing functions is the acquisition and exchange of market and operational information in a timely manner (Mentzer, 2001; Slater and Narver, 1995; Bhosale and Kant, 2016), facilitating these practices has the potential to enable SCM-M integration (Esper *et al.*, 2010b). To do so, academics, executives, and policymakers are calling for a digital transformation of companies, as suggested in the principles of the fourth industrial revolution (Industry 4.0) (Kagermann *et al.*, 2013; Theorin *et al.*, 2017; Deloitte, 2015). Notably, in the vision of Industry 4.0, the digitization of firm processes may bring down the walls between firm functions and between organizations in a supply chain, so that “the chain becomes a completely integrated ecosystem that is fully transparent to all the players involved — from the suppliers of raw materials, components, and parts, to the transporters of those supplies and finished goods, and finally to the customers demanding fulfillment” (Schrauf and Berttram, 2016:4).

In order to accomplish this digital transformation, the adoption of certain “enabling technologies” (e.g., information systems and improved Big Data analytics techniques) is necessary. However, given the high investments and important challenges related to digitization, some recent studies have underlined that firms are often reluctant towards this process, hence hampering the implementation of digital supply chains and more advanced marketing techniques (Ranganathan *et al.*, 2011; Melville, 2010). Among the most relevant challenges and sources of increasing digitization costs is the inability to actually screen and select the available technologies that may sustain the digitization course and, hence, SCM-M integration. Indeed, a clear definition and overview of the digital technologies that may serve for this purpose is missing (Deloitte, 2015; McKinsey & Co., 2015). In other words, an integrative view of the enabling technologies required to digitize firm processes, especially SCM-M integration, has been loosely defined, as well as information about the available technologies in this field, their development trends, and technological impact is still scant, thus limiting the possibility of firms to have a complete overview of the most relevant solutions to adopt. Therefore, the present paper aims at filling this gap in the literature on SCM-M integration by providing a classification of the digital technologies for managing the interface between supply chain management and marketing processes and presenting a complete picture of the innovative efforts undertaken over time to develop those solutions.

In detail, starting from the list of digital technologies enabling Industry 4.0 (Calenda, 2016; PwC, 2016; Rüßmann *et al.*, 2015), we identify those that may be the most appropriate for SCM-M integration and provide a complete map of respective innovation dynamics by conducting technology- applicant- and country-level patent analysis. Thank to this patent analysis, firms aiming at engaging in a digital transformation may be aware of the technologies that best relate to the Industry 4.0 domain and can be used for SCM-M integration. Moreover, we highlight the organizations and countries more involved in the development of those solutions over time and offer an examination of their technological impact. In this way, firms may better identify where the technological knowledge underlying digital solutions origin, and the organizations that may act as competitors or partners during their digital transformation.

The rest of the paper is structured as follows. Section 2 presents the theoretical background. Section 3 shows the methodology used for this study. Section 4 offers the results of patent analysis. Finally, Section 5 discusses main theoretical and practical implications.

2. Theoretical background

2.1. SCM-M integration

The idea of a close relationship between SCM and marketing functions dates back to Porter's (1985) value chain framework. Such a framework outlines that customer value is created by two interrelated sets of processes as demand-focused processes and supply-focused processes. The former involves marketing and customer relationship management activities aimed at collecting market knowledge and meet customer demands. Instead, the latter consists of operations and inbound/outbound logistics that serve to realize and deliver customer value. From this insight, it emerges that without one of the two sets of processes firms may fail to fully satisfy customer requirements (McKinsey & Co., 2017; Pero and Lamberti, 2013).

Notwithstanding, historically, SCM and marketing functions have worked independently, and companies have specialized in only one functional area (Esper *et al.*, 2010b). As a result, firms more focused on marketing processes have become particularly effective in identifying customer needs, but have failed to achieve efficiency in production and distribution, hence manifesting problems such as diminished service levels and stock-outs (Saldanha *et al.*, 2013; Kulp *et al.*, 2004; Campo *et al.*, 2000). For instance, the main reason why some Internet grocers (e.g., Webvan, Streamline, Homegrocer) initially failed is due to the fact that their marketing strategy of offering products at lower prices was not matched with a supply chain strategy that enables to respond concurrent to customer online requests and may, hence, support a decrease in product prices (Boyer and Hult, 2005). Conversely, firms more focused on supply-focused processes have found difficulties in delivering products that perfectly match the market demand despite being efficient and effective in operation activities (Pero and Lamberti, 2013; Jüttner *et al.*, 2010). In other words, "isolation of demand and supply processes results in enduring mismatches between demand (i.e., shortages of products that customers want and/or surpluses of products that are not wanted) and supply (i.e., what is actually available in the marketplace)" (Esper *et al.*, 2010b:6).

According to the foregoing discussion, recent research and executives stress that companies have to integrate demand-focused activities and supply-focused activities (e.g., Alvarado and Kotzab, 2001; McKinsey & Co., 2017) to actually deliver customer value. Three main activities are needed for an effective SCM-M integration, especially in the current economic landscape characterized by the necessity to timely understand volatile customer demands and adjust the supply chain accordingly: managing the integration between demand and supply processes; managing the structure between the integrated processes and customer segments, and managing the working relationships between marketing and SCM (Jüttner *et al.*, 2007). However, these activities are complex in their nature because they ask companies to implement knowledge management processes to leverage market information throughout the overall supply chain and, in turn, use supply-side information to help firms to efficiently deliver their products.

Given the requirement of extensive collection and diffusion of market and operational information, some studies called for the need of effective ways to enhance information sharing and processing between functions and throughout the supply chain (Jüttner *et al.*, 2010). The most effective solution to this issue has been identified in the digitization of firm processes, in line with the principles of Industry 4.0. Accordingly, firms that digitize their processes will improve their capacity to acquire, analyze, and distribute market and operational knowledge by adopting cutting-edge digital technologies (cloud computing, Big Data analytics, etc.) (PwC, 2016; Ranganathan *et al.*, 2011).

In the following, we discuss the origin of the idea of the fourth industrial revolution by highlighting related enabling technologies. Furthermore, we propose a subset of them for further analysis since they may best relate to the possibility of improving SCM-M integration.

2.2. Towards Industry 4.0: enabling technologies

The tem Industry 4.0 was coined in 2011 by the German association “Industrie 4.0”. The association, composed of executives, scholars and policymakers, proposed the idea of a fourth industrial revolution based on the digitization of firm processes (Kagermann *et al.*, 2011). Indeed, at the basis of Industry 4.0 there was the vision of running businesses by the use of cutting-edge digital technologies that can help companies to create connections between their machinery, supply systems, production facilities, products, and customers in order to gather and share real time market and operational information. The German government first supported the vision underlying Industry 4.0, which was implemented into the “High-Tech Strategy 2020 for Germany” (Kagermann *et al.*, 2013). Following Germany, a number of countries launched Industry 4.0 initiatives. For instance, the United Kingdom (UK) initiated the “UK CATAPULT – High Value Manufacturing”[1]. This was a *s*trategic plan that encompasses universities and industrial players to promote the introduction of digital technologies in UK manufacturing industries. Moreover, the American “Manufacturing USA”[2], the French “Industrie du Futur”[3], and the Dutch “Smart Industry”[4] strategies provided fiscal benefits, facilitated financing, and tax credits to companies aiming at devising industrial approaches compliant with the Industry 4.0 vision. More recently, the Italian Ministry of Economic Development launched the Italian plan for Industry 4.0, with the aim of increasing public and private R&D spending for digitizing businesses (Calenda, 2016).

Summing up, the goal of the Industry 4.0 is to boost the digitization and, thus, integration of firm processes both horizontally (i.e., across functional areas) and vertically (i.e., across the entire value chain, from product development and purchasing through manufacturing, distribution, and customer service). In this way, all data about planning, operations processes, process efficiency, and market needs will be available real-time. As a result, digital enterprises will work together with customers

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[1] See https://catapult.org.uk/.
[2] See https://www.manufacturing.gov/nnmi/.
[3] See http://www.economie.gouv.fr/lancement-seconde-phase-nouvelle-france-industrielle.
[4] See https://www.smartindustry.nl/en/.

and suppliers in an industrial digital ecosystem that allow them to better manage the interface between SCM and marketing functions (Ranganathan *et al.*, 2011; Schrauf and Berttram, 2016).

Of course, a wide variety of digital technologies are needed to achieve this goal, and these technologies should assure interoperability between diverse IT systems to minimize implementation costs and time for information processing. Thus, there is the necessity to clearly identify the most relevant solutions that support the transition towards Industry 4.0. First attempts have been conducted by the Boston Consulting Group (BCG), Pricewaterhousecoopers (PwC), and the Italian Ministry for Economic Development (Rüßmann *et al.*, 2015; Calenda, 2016; PwC, 2016), each of which suggested a set of enabling technologies for Industry 4.0. Among the three classifications there are many commonalities, which let us recognize the eight solutions that are more probably required for an effective digitization of firm processes (see Table 1 for more details): (i) Advanced manufacturing, (ii) Additive manufacturing, (iii) Augmented reality, (iv) Simulation, (v) Cloud computing, (vi) Industrial Internet of Things (IoT), (vii) Cyber security, and (viii) Big Data analytics & customer profiling.

Nonetheless, a clear picture of who is able to develop these technologies, which the most relevant solutions are, and where their underlying knowledge origin, is far from being reached. In addition, despite the relevance of all the eight proposed enabling technologies, we contend that only a subset of these is particularly important for SCM-M integration. The next section describes the four enabling solutions we believe require further analysis for managing the interface between SCM and marketing functions, hence being the subjects of our patent analysis.

<Insert Table I about here>

2.3. Enabling technologies for SCM-M integration

In the last section, the enabling technologies related to Industry 4.0 have been presented. We argue that the last four of them are particularly relevant for SCM-M integration. Notably, while Advanced manufacturing, Additive manufacturing, Augmented reality, and Simulation only have a focus on the digitization of the production process, Cloud computing, Industrial IoT, Cyber security, and Big Data analytics & customer profiling better relate to the possibility to process real time information across the value chain, and so favor the management of the SCM-M interface.

Accordingly, first, information sharing and processing requirements are key reasons for a firm to adopt cloud computing (Cegielski *et al.*, 2012). Indeed, cloud computing eases real-time information sharing and rapid organization of information thank to shared IT structures that supports interoperability and remote access, hence reducing the costs of implementing complex and dedicated IT systems within the company and across the supply chain (IBM, 2010). In turn, ease of communication associated with cost reduction allows more resource-constrained companies and organizations (e.g., small-medium enterprises) to digitize their process, thus further facilitating the transition towards more integrated supply chains (Sultan, 2013). Moreover, cloud computing can support the development of applications for better customer relationship activities, in that customers are more and more willing to adopt online services to select and evaluate firm products. In turn, customer information may directly be available to the supply chain through could resources (Xu, 2012).

Second, industrial IoT includes the set of technologies (e.g., Radio-Frequency IDentification and Near Field Communication) that allow real-time information processing and monitoring of almost every activities in the supply chain, ranging from design, raw material acquisition, storage, production, transportation, distribution, and after-sales service. This facilitates automatic tracking of stock-outs, sales, and shoplifting. With this information, manufacturers may be more efficient in the production and supply of the right quantities of products at a certain time, thus avoiding overproduction or underproduction (Atzori *et al.*, 2010; Del Giudice, 2016). Furthermore, with appropriate tags on products, it is possible to obtain information on their life-cycles, hence having data on the production stage of a product and whether its distinctive characteristics are preserved. For example, industrial IoT is used for fresh products and drugs to assure that products are on time and maintain conservation status (temperature, humidity, etc.) (Bandyopadhyay and Sen, 2011). Additionally, when products are embedded with sensors, companies can also monitor the interactions that customers have with them. For instance, Zipcar, a car sharing company, uses data from the interaction between cars and customers to better serve customers in the future with the cars that they feel more comfortable (McKinsey & Co., 2010). Taken together, these examples highlight how the use of IoT solutions helps companies to gather and make readily available supply- and demand-side information.

Industrial IoT and cloud computing allow generating and sharing reams of data about organizations' processes and customers' habits. Although those data are extremely valuable for companies, especially for integrating SCM and marketing functions, the adoption of IoT and cloud computing solutions have an important drawback. Indeed, since these technologies work on the Internet, the data they collect and store may be stolen and misused, hence leading to important security issues in terms of competitiveness - at the organizational level - and privacy - at the customer level (Sultan, 2013). The European Commission is aware of these security issues. In fact, it provided European members with the EU Data Protection Directives 95/46, 99/5 and 2002/58 (No. 2) on the design and operation of information networks[5] (Weber, 2010). These directives highlight that key to avoiding risks of information leakage and, thus, reluctance towards SCM-M integration through digital solutions, is the use of technologies that enhance cyber security (Xu, 2012).

Finally, besides the possibility to acquire and protect a wide amount of operational and market information, it is also relevant for a firm aiming at managing the SCM-M interface to affectively analyze those data. Accordingly, recent studies revealed that there are often hidden (and valuable) patterns inside data, especially regarding customers' purchase transactions and their interactions with digital products. In particular, these patterns have been extensively used by the marketing functions to launch new products, but they may be also helpful for the SCM function to deliver customer value in prompt and more cost-effective ways (Chen *et al.*, 2015). Thereby, Big Data analytics and customer profiling technologies are also important for managing the interface between SCM and marketing processes.

3. Methodology

3.1. Patent analysis

We adopt patent analysis to provide a comprehensive overview of the innovation dynamics characterizing the enabling technologies for SCM-M integration. With the term patent analysis, we refer to the examination of the patenting activity related to a certain industry or technology domain (Kim and Lee, 2015). So far, many studies have adopted this tool to analyze several characteristics of technology evolution and innovation activities such as temporal trends, technology life-cycles, knowledge flows, and organization- and country-level comparisons. For instance, Albino *et al.* (2014) revealed temporal trends, organizations and countries mainly involved in patenting activities, and most relevant patented solutions related to the green energy field. Instead, Zheng *et al.* (2014) studied international collaborations for the development of nanotechnologies, while Kim and Bae (2017) attempted to provide a novel approach to identify most relevant wellness care solutions.

Results of this type of analyses may have a relevant impact at both policy and managerial levels. At the policy level, patent analysis has been widely used to establish public policy, as in the case of energy policies (Mueller *et al.*, 2015). From the perspective of technology management planning, analyses of patented inventions allow organizations to identify R&D trends, potential competitors, technology leaders and followers, and whether it is beneficial to enter or continue to operate in a

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[5] COM (2009) 278 final.

certain sector (Ernst and Omland, 2011). Eventually, a patent analysis of the technologies for SCM-M integration may actually help firms to recognize them and better support their implementation.

3.2. Data collection

The USPTO is the database used to collect patents for the identified categories (i.e., Industrial IoT, Cloud computing, Cyber security, and Big Data analytics & customer profiling). Although the USPTO only limits the protection of an invention to the US area, it has been proven that the USPTO is not subject to country bias (Kim and Lee, 2015). Accordingly, a number of non-US patents can be retrieved. For example, in the energy conservation technology domain, Japanese organizations filed for more patents than US ones (Albino *et al.*, 2014). Furthermore, we did not limit the time period for patent search, so we collect all the patents registered at the USPTO that match our search criteria. The data collection procedure ended in January 2017.

The search strategy followed a keyword approach. Indeed, a well-established classification for technologies pertaining Industry 4.0 does not exist. Table 2 presents the search terms used for patent retrieval. These come from the description provided by the BCG, PwC, and the Italian Ministry for Economic Development. We searched for these terms in the description of the patent. Table 2 also shows the number of retrieved patents for each category at the end of the search process. After patent retrieval, we also collected all the relevant information for each patent (e.g., filing and granting years, inventors, applicants, and citations made and received).

<Insert Table II about here>

4. Results

This section provides a comprehensive outline of the patenting activity related to the four digital technologies that we have considered as the most relevant for SCM-M integration. In detail, at the technology level, patent count per year is used as the measure for the innovation efforts undertaken over time. Moreover, the average number of citations to non-patent documents is adopted as the proxy to assess the reliance on basic research during innovation activities. Indeed, it has been proven that the majority of non-patent citations refer to scientific publications (Narin *et al.*, 1997). Patent count analyses are replicated at the country level, so that we can offer cross-country comparisons of innovation efforts. To associate a patent to a country, as made by prior research, we consider the country where the first inventor of the patent resides (Albino *et al.*, 2014).

Furthermore, we also offer insights on the overall distribution of patents across diverse countries and whether this distribution reflects the distribution of the most valuable patents (i.e., breakthrough patents). In other words, we examine the extent to which a country is able to develop breakthrough solutions. Specifically, breakthroughs are identified by means of forward citations. Since citations rate may change over time, and older patents have had more chances to be cited, we correct for this issue by dividing the number of citations received by a patent by the average number of citations received by all the patents filed for in the same year (Ernst and Omland, 2011).

Finally, analyses at the applicant level are conducted. Accordingly, we seek to highlight the organizations more involved in the development of Industry 4.0 solutions for SCM-M integration and whether they are involved in inter-organizational collaborations through of joint patent analysis (Hagedoorn, 2003). However, all the considered categories have a share of joint patents less than 1%. Therefore, we do not dig into this phenomenon, and we can only conclude that collaborating is not a prevalent innovation strategy in the domain of Industry 4.0.

4.1. Cloud computing

Figure 1(a) presents the innovation efforts undertaken over time in the Cloud computing area. Development trends are proposed with regard to the filing and granting years. The filing year better reflect the time period when a patent has been developed. Looking at the number of patents analyzed according to the filing year (hereafter, filed patents), the patenting activity trend seems degreasing from 2013. Nevertheless, this may be caused by the fact that the granting process usually takes 3-to-5 years, so the actual number of patents filed and, also, granted in 2014, 2015, and 2016 may be underestimated. To control for this issue, we also considered the granting year. Looking at the number of patents analyzed according to the granting year (hereafter, granted patents), the patenting activity trend is steadily growing. Although further analyses are needed, we can argue that the interest in Cloud computing technologies is rising. Therefore, it is important to keep pace with their technological evolution to remain competitive in the market and adopt the latest technological advancements. Figure 1(b) compares the patenting activity trend of filed patents with the inclinations towards the use of basic research. The figure clearly illustrates that, on average, the references to scientific publications decrease over time. This may suggest that innovating organizations are more focused on the industrial use of cloud solutions; thereby the link to basic science is rather neglected.

<Insert Figure 1(a) and Figure 1(b) about here>

Figure 2(a) and Figure 2(b) go deeper into the analysis of the patenting activity trend by distinguishing the contribution of diverse countries. The figures show that Cloud computing technologies are mainly developed in the US, while the contribution of the other countries is minor. Although only the 26.33% of the patents are non-US-based, it is interesting to note that developing countries as India (4.76%) and the People's Republic of China (PRC) (2.22%) are among the most productive countries. Additional important contributions are thanked to the entire Europe (6.23%), Canada (5.26%), and Japan (3.33%).

<Insert Figure 2(a) and Figure 2(b) about here>

Figure 3 adds to figures 2(a) and 2(b). In particular, on the left, it compares the most patent intensive countries (top 10) in terms of number of patents, while, on the right, it compares their productivity in terms of breakthrough patents. From the analysis of the breakthrough patents, it emerges that the relative importance of each country remains consistent, except for South Korea, which has not produced any technological breakthrough.

Finally, Table 2 lists the most patent intensive organizations (top 30). The first column presents the name of the organizations, whereas the second, third, and fourth columns reveal related number of patents, number of breakthroughs, and share of breakthroughs over the total number of patents, respectively. What emerges is that the table only includes private companies. This implies that neither research organizations nor governmental organizations play a key role in developing cloud solutions. Among the included companies, we can consider Sprint communication, Digimarc, Red Hat, LinkedIn, and Symantec as the most innovative. Indeed, these are the companies whose technology portfolios contain more breakthroughs in relative terms.

<Insert Figure 3 about here>

<Insert Table III about here>

4.2. Industrial IoT

Figure 4(a) and Figure 4(b) present temporal trends of patent development for Industrial IoT solutions. Looking at the granted patents, the innovative efforts in this domain are growing [see Figure 4(a)]. Moreover, probably given the novel nature of these technologies and their relevance in the context of Industry 4.0, two interesting considerations may be highlighted. First, patent application started between 2008 and 2009 even though the term IoT has been coined in the late 1990s. Second, according to Figure 4(b), the link to basic science is more accentuated than the previous category, thus reflecting its relevance during the emergence of a new technological paradigm.

<Insert Figure 4(a) and Figure 4(b) about here>

Differently from cloud solutions, Industrial IoT technologies are more distributed across the world [Figure 5(a) and Figure 5(b)]. This is reasonable because, nowadays, many countries have the IT competencies to enter this domain and, particularly, multiple governments set R&D policies to stimulate the economic development of respective countries based on the IoT paradigm. In detail, Figure 5(a) shows that the US, France, and the PRC started the IoT development race, followed by Canada, Switzerland, and the other countries. Figure 5(b) further stresses that the US, France, and the PRC together with South Korea developed almost all the industrial IoT solutions. Despite this, Figure 6 reveals that breakthrough patents are dispersed in a more homogeneous manner. Accordingly, countries that do not figure as the most patent intensive (e.g., Taiwan, Switzerland and Canada) can be compared to the US and the PRC in terms of number of breakthroughs. Conversely, France and South Korea have not created breakthroughs despite the high number of patents they have applied for.

<Insert Figure 5(a) and Figure 5(b) about here>

At the applicant level, one-third of the Industrial IoT solutions can be referred to Cisco Technology (see Table 3), and one-sixth of them come from Samsung Electronics' laboratories. The rest of the patents are distributed among other several companies (Table 3 only shows organizations with, at least, 3 patents). Also in this case, no research or governmental organizations figure in the table. Among the identified organizations, SkyBell Technologies and Cognitive Systems companies appear to be the most innovative in terms of breakthrough patents, in that they have a patent portfolio composed of 100% and 50%, respectively, of breakthroughs.

<Insert Figure 6 about here>

<Insert Table IV about here>

4.3. Cyber security

As made for the two previous enabling technologies, temporal trends have been analyzed for Cyber security. According to Figure 7(a), the innovation efforts conducted over time for Cyber security are similar to the trends of Cloud computing and Industrial IoT. Instead, Figure 7(b) depicts that the reliance on basic research does not seem to have a clear trend. However, considering the period when most of the patents have been applied for, i.e., 2009-2013, the tendency to cite scientific publications is quite constant.

<Insert Figure 7(a) and Figure 7(b) about here>

Figure 8 reveals that the US owns almost all the Cyber security patents (91.42%). This means that the trend exposed in Figure 7(a) mainly reflects the patenting activity of the US. The contribution of the other countries, each year, is negligible. Similarly, the 99% of breakthroughs is due to the US[6]. Table 4 presents the most patent intensive organizations, showing that only companies are present.

<Insert Figure 8 about here>

<Insert Table V about here>

4.4. Big Data analytics & customer profiling

Big Data analytics & customer profiling is the last category of enabling technologies we consider. Figure 9(a) shows that the patenting activity trend of this category recalls that of the previous enabling technologies. Regarding the link to basic research, from Figure 9(b), it emerges that the propensity to cite non-patent documents has a decreasing trend, which may imply that this set of solutions is being refined for industrial use, so scant attention to scientific knowledge is paid.

<Insert Figure 9(a) and Figure 9(b) about here>

From a country-level perspective, Big Data analytics & customer profiling present commonalities with Cyber security, in that most of the related patents are US-based, with few contributions from Europe (6.48%), India (5.05%) and the PRC (2.15%). Nevertheless, about the total amount of technological breakthroughs have the basis in the US. Finally, Table 5 presents all the organizations with no less than 10 patents. Again, only private companies have been identified. Among them, Microsoft Technology, American Express, Intertrust Technologies, and SAS are the most devoted to cutting-edge research activities, as revealed by the high share of breakthrough patents over the total number of patents they own.

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[6] For the sake of brevity we did not include a pie chart showing that all the breakthrough patents belong to the US. In any case, data are available upon request.

<Insert Figure 10 about here>

<Insert Table VI about here>

5. Discussion and conclusions

This paper is one of the first attempts to provide a comprehensive overview of the digital technologies supporting SCM-M integration, which has been recognized as a key success factor to remain competitive and achieve superior financial performance (e.g., Boyer and Hult, 2005). Specifically, starting from the enabling technologies identified in the domain of Industry 4.0, first, we recognized the set of digital solutions that may better sustain the implementation and management of the information processing mechanisms that are required for an effective SCM-M integration (i.e., Cloud computing, Industrial IoT, Cyber security, Big Data analytics & customer profiling). Second, we carried out a patent analysis aimed at providing a comprehensive overview of the patenting activity trends characterizing the set of technologies under investigation, hence highlighting their innovation dynamics. To do so, a novel and unique dataset of patents granted at the USPTO has been collected and examined.

Several interesting findings have emerged from patent analysis. Among them, we highlight that the innovation efforts underlying all the four categories of the considered digital technologies present a growing trend. This reveals the rising interest in these solutions, probably caused by the number of government initiatives aimed at digitizing firm processes (e.g., Calenda, 2016; Kagermann *et al.*, 2013). On the other hand, it is worth mentioning that those innovation efforts appear to be scantly based on basic research, except for Industrial IoT, as revealed by the poor tendency to refer to scientific publications during technology development. Relatedly, applicant-level analysis shows that companies are the most patent intensive organizations, which may reflect the central role of profit-oriented organizations as catalysts of innovation, while government organizations only seem to provide some stimuli, but never contribute to the actual technology progress. In any case, the absence of research organizations remains unclear. Additionally, inter-organizational collaborations in patenting activities are revealed to be not so frequent. This would suggest that the knowledge underlying the investigated solutions tends to be bounded, possibly with negative consequences for standardization and interoperability. Finally, country-level analysis offers evidence of the domain of the US. Nonetheless, it is worth mentioning that emerging countries, as India and PRC, play a key role in the technology progress for Industry 4.0 and SCM-M integration compared to more developed countries (e.g., European countries and Japan). These findings let us provide relevant theoretical, managerial, and policy implications.

Specifically, so far, much has been said about why marketing and SCM should be integrated. However, how the SCM-M interface should be integrated and which tools may be adopted have yet to be revealed (e.g., Pero and Lamberti, 2013). Hence, this paper adds to the literature on SCM-M integration (Jüttner *et al.*, 2007) by highlighting the enabling technologies for Industry 4.0 that may particularly serve for managing the SCM-M interface from an information processing perspective. Furthermore, we also contribute to this stream of literature by providing several information about where the technological knowledge of those solutions is located, which organizations have a leading role in their development, and what the patterns of collaboration are, which may help to design firms' digitization process. In turn, given the absence of a clear picture of the solutions developed within the domain of Industry 4.0 (e.g., Theorin *et al.*, 2017), our patent analysis may also contribute to the literature examining how to foster the fourth industrial revolution from a technology point of view.

Instead, from a policy and managerial perspective, our suggestions are twofold. First, inter-organizational collaborations should be initiated in order to favor interoperability, avoid over-diversification between digital solutions and, hence, facilitate the development of more effective information sharing mechanisms among firm functions, actors within the supply chain, and customers. To this aim, policymakers may set ad-hoc policies aimed at stimulating collaborations among innovating organizations. Second, it has been evidenced that the research sector is not active in developing the considered technologies even though their interest in Industry 4.0 and, more specifically, SCM-M integration is growing (Jüttner *et al.*, 2010). Therefore, a stronger coordination between corporate executives, policymakers, and academics may be beneficial to better analyze the technical, scientific, economic, and political aspects related to the implementation and management of effective SCM-M interfaces.

As with most studies, this research has some limitations that should be acknowledged. First, although the use of patent data for studying innovation dynamics is well established, some drawbacks exist. For instance, patent data may not capture some innovations because they are not patentable or patenting in not the best protection mechanisms (OECD, 2009). Therefore, this study may be refined by including additional secondary data (e.g., publications and ongoing research and industrial projects) or primary data through interviews with industry experts and policymakers. Second, most of our attention has been devoted to the developing trends of the enabling technologies. Future research should also better analyze their implementation and usage. Relatedly, an assessment of the impact that the implementation of those technologies may have had on firm (financial and operational) performance should be further examined.

References

Albino, V., Ardito, L., Dangelico, R.M. and Messeni Petruzzelli, A. (2014), "Understanding the development trends of low-carbon energy technologies: A patent analysis", *Applied Energy,* Vol. 135, pp. 836-54.

Alvarado, U.Y. and Kotzab, H. (2001), "Supply Chain Management: The Integration of Logistics in Marketing", *Industrial Marketing Management,* Vol. 30 No. 2, pp. 183-98.

Atzori, L., Iera, A. and Morabito, G. (2010), "The Internet of Things: A survey", *Computer Networks,* Vol. 54 No. 15, pp. 2787-805.

Bandyopadhyay, D. and Sen, J. (2011), "Internet of Things: Applications and Challenges in Technology and Standardization", *Wireless Personal Communications,* Vol. 58 No. 1, pp. 49-69.

Beier, J. (2016), *Simulation Approach Towards Energy Flexible Manufacturing Systems,* Springer International Publishing.

Bhosale, V.A. and Kant, R. (2016), "Metadata analysis of knowledge management in supply chain: Investigating the past and predicting the future", *Business Process Management Journal,* Vol. 22 No. 1, pp. 140-72.

Boyer, K.K. and Hult, G.T.M. (2005), "Extending the supply chain: Integrating operations and marketing in the online grocery industry", *Journal of Operations Management,* Vol. 23 No. 6, pp. 642-61.

Calenda, C. (2016), "Italy's plan INDUSTRIA 4.0", in Development, I.M.o.E. (Ed.), Available at http://www.sviluppoeconomico.gov.it/images/stories/documenti/2017_01_16-Industria_40_English.pdf.

Campo, K., Gijsbrechts, E. and Nisol, P. (2000), "Towards understanding consumer response to stock-outs", *Journal of Retailing,* Vol. 76 No. 2, pp. 219-42.

Cegielski, C.G., Jones-Farmer, L.A., Wu, Y. and Hazen, B.T. (2012), "Adoption of cloud computing technologies in supply chains: An organizational information processing theory approach", *The International Journal of Logistics Management,* Vol. 23 No. 2, pp. 184-211.

Chen, F., Deng, P., Wan, J., Zhang, D., Vasilakos, A.V. and Rong, X. (2015), "Data Mining for the Internet of Things: Literature Review and Challenges", *International Journal of Distributed Sensor Networks,* Vol. 11 No. 8, pp. 431047.

McKinsey & Co. (2010), "The Internet of Things", in, McKinsey & Co. Available at http://www.mckinsey.com/industries/high-tech/our-insights/the-internet-of-things.

McKinsey & Co. (2015), "Digital manufacturing: The revolution will be virtualized", in, McKinsey & Co. Available at http://www.mckinsey.com/business-functions/operations/our-insights/digital-manufacturing-the-revolution-will-be-virtualized.

McKinsey & Co. (2017), "Putting customer experience at the heart of next-generation operating models", in, McKinsey & Co. Available at http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/putting-customer-experience-at-the-heart-of-next-generation-operating-models.

Del Giudice, M. (2016), "Discovering the Internet of Things (IoT) within the business process management: A literature review on technological revitalization", *Business Process Management Journal,* Vol. 22 No. 2, pp. 263-70.

Deloitte. (2015), "Industry 4.0: Challenges and solutions for the digital transformation and use of exponential technologies", in, Deloitte AG. Available at http://www.industrie2025.ch/fileadmin/user_upload/ch-en-delloite-ndustry-4-0-24102014.pdf.

Ernst, H. and Omland, N. (2011), "The Patent Asset Index – A new approach to benchmark patent portfolios", *World Patent Information,* Vol. 33 No. 1, pp. 34-41.

Esper, T.L., Defee, C.C. and Mentzer, J.T. (2010a), "A framework of supply chain orientation", *The International Journal of Logistics Management,* Vol. 21 No. 2, pp. 161-79.

Esper, T.L., Ellinger, A.E., Stank, T.P., Flint, D.J. and Moon, M. (2010b), "Demand and supply integration: a conceptual framework of value creation through knowledge management", *Journal of the Academy of Marketing Science,* Vol. 38 No. 1, pp. 5-18.

Gibson, I., Rosen, D. and Stucker, B. (2014), *Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing,* Springer New York.

Hagedoorn, J. (2003), "Sharing intellectual property rights—an exploratory study of joint patenting amongst companies", *Industrial and Corporate Change,* Vol. 12 No. 5, pp. 1035-50.

IBM. (2010), "Getting cloud computing right", in, IBM. Available at http://public.dhe.ibm.com/common/ssi/ecm/en/ciw03078usen/CIW03078USEN.PDF.

Jüttner, U., Christopher, M. and Baker, S. (2007), "Demand chain management-integrating marketing and supply chain management", *Industrial Marketing Management,* Vol. 36 No. 3, pp. 377-92.

Jüttner, U., Christopher, M. and Godsell, J. (2010), "A strategic framework for integrating marketing and supply chain strategies", *The International Journal of Logistics Management,* Vol. 21 No. 1, pp. 104-26.

Kagermann, H., Lukas, W. and Wahlster, W. (2011), " Industrie 4.0: Mit dem Internet der Dinge auf dem Weg zur 4. industriellen Revolution", in, VDI nachrichten, 13.

Kagermann, H., Wahlster, W. and Helbig, J. (2013), "Recommendations for implementing the strategic initiative Industrie 4.0", in, Final report of the Industrie 4.0 Working Group.

Kim, G. and Bae, J. (2017), "A novel approach to forecast promising technology through patent analysis", *Technological Forecasting and Social Change,* Vol. 117, pp. 228-37.

Kim, J. and Lee, S. (2015), "Patent databases for innovation studies: A comparative analysis of USPTO, EPO, JPO and KIPO", *Technological Forecasting and Social Change,* Vol. 92, pp. 332-45.

Kipper, G. and Rampolla, J. (2012), *Augmented Reality: An Emerging Technologies Guide to AR,* Elsevier Science.

Kulp, S.C., Lee, H.L. and Ofek, E. (2004), "Manufacturer Benefits from Information Integration with Retail Customers", *Management Science,* Vol. 50 No. 4, pp. 431-44.

Li, S., Xu, L.D. and Zhao, S. (2015), "The internet of things: a survey", *Information Systems Frontiers,* Vol. 17 No. 2, pp. 243-59.

Lindman, M., Pennanen, K., Rothenstein, J., Scozzi, B. and Vincze, Z. (2016), "The value space: how firms facilitate value creation", *Business Process Management Journal,* Vol. 22 No. 4, pp. 736-62.

Macchion, L., Moretto, A., Caniato, F., Caridi, M., Danese, P. and Vinelli, A. (2015), "Production and supply network strategies within the fashion industry", *International Journal of Production Economics,* Vol. 163, pp. 173-88.

Melville, N.P. (2010), "Information systems innovation for environmental sustainability", *MIS Q.,* Vol. 34 No. 1, pp. 1-21.

Mentzer, J.T. (2001), *Supply Chain Management,* Sage, Thousand Oaks, CA.

Mentzer, J.T. and Gundlach, G. (2010), "Exploring the relationship between marketing and supply chain management: introduction to the special issue", *Journal of the Academy of Marketing Science,* Vol. 38 No. 1, pp. 1-4.

Mueller, S.C., Sandner, P.G. and Welpe, I.M. (2015), "Monitoring innovation in electrochemical energy storage technologies: A patent-based approach", *Applied Energy,* Vol. 137, pp. 537-44.

Narin, F., Hamilton, K.S. and Olivastro, D. (1997), "The increasing linkage between U.S. technology and public science", *Research Policy,* Vol. 26 No. 3, pp. 317-30.

OECD. (2009), *OECD Patent Statistics Manual*, OECD Publishing.

Pero, M. and Lamberti, L. (2013), "The supply chain management-marketing interface in product development: An exploratory study", *Business Process Management Journal,* Vol. 19 No. 2, pp. 217-44.

Porter, M.E. (1985), *Competitive Advantage: Creating and Sustaining Superior Performance.*

PwC. (2016), "Industry 4.0: Building the digital enterprise", in, Pricewaterhousecoopers. Available at https://www.pwc.com/gx/en/industries/industries-4.0/landing-page/industry-4.0-building-your-digital-enterprise-april-2016.pdf.

Ranganathan, C., Teo, T.S.H. and Dhaliwal, J. (2011), "Web-enabled supply chain management: Key antecedents and performance impacts", *International Journal of Information Management,* Vol. 31 No. 6, pp. 533-45.

Rüßmann, M., Lorenz, M., Philipp, G., Waldner, M., Pascal, J.J., Harnisch, E. and Harnisch, M. (2015), "Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries", in, Boston Consulting Group Perspectives. Available at https://www.bcgperspectives.com/content/articles/engineered _products_project_business_industry_40_future_productivity_growth_manufacturing_industries/.

Saldanha, T.J.V., Melville, N.P., Ramirez, R. and Richardson, V.J. (2013), "Information systems for collaborating versus transacting: Impact on manufacturing plant performance in the presence of demand volatility", *Journal of Operations Management,* Vol. 31 No. 6, pp. 313-29.

Schrauf, S. and Berttram, P. (2016), "Industry 4.0: How digitization makes the supply chain more efficient, agile, and customer-focused", in, PwC Strategy&, Germany. Avaiable at http://www.strategyand.pwc.com/reports/industry4.0.

Slater, S. and Narver, J. (1995), "Market orientation and the learning organization", *Journal of Marketing,* Vol. 59 No. 3, pp. 63.

Sultan, N. (2013), "Knowledge management in the age of cloud computing and Web 2.0: Experiencing the power of disruptive innovations", *International Journal of Information Management,* Vol. 33 No. 1, pp. 160-65.

Theorin, A., Bengtsson, K., Provost, J., Lieder, M., Johnsson, C., Lundholm, T. and Lennartson, B. (2017), "An event-driven manufacturing information system architecture for Industry 4.0", *International Journal of Production Research,* Vol. 55 No. 5, pp. 1297-311.

Trkman, P., Mertens, W., Viaene, S. and Gemmel, P. (2015), "From business process management to customer process management", *Business Process Management Journal,* Vol. 21 No. 2, pp. 250-66.

Waldeck, N.E. (2014), *Advanced Manufacturing Technologies and Workforce Development,* Taylor & Francis.

Weber, R.H. (2010), "Internet of Things – New security and privacy challenges", *Computer Law & Security Review,* Vol. 26 No. 1, pp. 23-30.

Woodruff, R.B. (1997), "Customer value: The next source for competitive advantage", *Journal of the Academy of Marketing Science,* Vol. 25 No. 2, pp. 139.

Xu, X. (2012), "From cloud computing to cloud manufacturing", *Robotics and Computer-Integrated Manufacturing,* Vol. 28 No. 1, pp. 75-86.

Zheng, J., Zhao, Z.-y., Zhang, X., Chen, D.-z. and Huang, M.-h. (2014), "International collaboration development in nanotechnology: a perspective of patent network analysis", *Scientometrics,* Vol. 98 No. 1, pp. 683-702.

Tables

Table I.
Industry 4.0 enabling technologies

Enabling technology	Description
(i) Advanced manufacturing	Advanced manufacturing refers to the latest technological advancements that firms can adopt to manufacture improved firm products and/or processes. Examples of these technologies are advanced robotics, CAD, CAE, and CAM solutions, and automation solutions (Waldeck, 2014).
(ii) Additive manufacturing	Additive manufacturing reflects the set of technologies to develop three-dimensional objects layer by layer under computer control. The most representative technologies in this field are 3-D printings (Gibson *et al*., 2014).
(iii) Augmented reality	Augmented-reality-based systems are technological solutions currently in their infancy. They turn the environment around workers into a digital interface by placing virtual objects in the real world, with the aim of enhancing one's current perception of reality (Kipper and Rampolla, 2012).
(iv) Simulation	Simulation relates to technologies that will be mostly used in plant operations to simulate production techniques, hence allowing operators to test and optimize the machine settings for the next product line before the physical changeover (Beier, 2016).
(v) Cloud computing	Cloud computing allows the share of IT software and hardware resources over the internet, so that information can be easily stored and accessed remotely by diverse actors (Sultan, 2013).
(vi) Industrial IoT	Industrial IoT refers to the use of IoT technologies in demand-focused and supply-focused process (Del Giudice, 2016). It favors the interoperability between devices and machines that use different protocols and have different architectures, thus allowing to have real-time data across the value-chain (see Li *et al*., 2015 for a review).
(vii) Cyber security	With the increased connectivity and use of shared IT resources, the need to protect critical information grows dramatically. Thus, technologies that avoid cyber security threats, so providing secure and reliable communications, are essential (Xu, 2012).
(viii) Big Data analytics & customer profiling	In an Industry 4.0 context, a huge amount of data comes from many different sources, e.g., production equipment and systems, supply chain actors, and customer-management systems. Big Data analytics & customer profiling include the technological solutions that allow analyzing large datasets and support real-time decision making (Chen *et al*., 2015).

Table II.
Search terms and sample dimension

Enabling technology	Search term	Number of patents
Industrial IoT	[“industrial” AND (“IoT” or “Internet of Things”)]	335
Cloud computing	[“Cloud computing”]	26,158
Cyber security	[“Cybersecurity” or “Cyber security” or “Cyber-security”]	501
Big Data analytics & customer profiling	[“Big data” or “Customer profiling”]	3,047

Table III.
Patent intensive organizations in the domain of Cloud computing

Applicant	Patents	Breakthroughs	Share
Microsoft	1,440	37	2,57
Google	1,376	113	8,21
Amazon Technologies	1,186	89	7,5
Symantec	791	75	9,48
SAP	427	12	2,81
Broadcom	350	6	1,71
Sprint Communication	327	95	29,05
Cleversafe	309	6	1,94
EMC	307	18	5,86
CA Technologies	288	3	1,04
Sony	284	2	0,7
Intel	274	2	0,73
Cisco	252	7	2,78
salesforce.com	244	18	7,38
HP	209	4	1,91
Oracle	202	7	3,47
eBay	195	7	3,59
Red Hat	177	18	10,17
Verizon	171	7	4,09
AT&T	170	9	5,29
Adobe System	162	8	4,94
Samsung	152	1	0,66
LinkedIn	148	19	12,84
Canon	145	0	0
Digimarc	134	30	22,39
Citrix	131	18	13,74
Intuit	114	2	1,75

Table IV.
Patent intensive organizations in the domain of Industrial IoT

Applicant	Patents	Breakthroughs	Share
Cisco Technology	130	7	5,38
Samsung Electronics	43	0	0
ZTE	13	1	7,69
M2M and IoT Technologies	9	0	0
Leeo	8	1	12,50
PCT	7	0	0
Intel Corporation	5	0	0
LG Electronics	5	0	0
SkyBell Technologies	5	5	100
Cognitive Systems	4	2	50
Convida Wireless	4	0	0
IBM	3	0	0
Microsoft Technology	3	0	0
Splunk	3	0	0

Table V.

Patent intensive organizations in the domain of Cyber security

Applicant	Patents	Breakthroughs	Share
The Boeing Company	35	0	0
IBM	31	0	0
Bromium	21	2	9,52
Palantir Technologies	16	7	43,75
Harris Corporation	13	1	7,69
Tyfone	12	0	0
Johnson Controls Technology	11	0	0
General Electric	10	0	0
FireEye	9	2	22,22
Sandia	9	2	22,22
AT&T	8	0	0
Flextronics	8	2	25
Lockheed Martin	8	0	0
Intralinks	6	2	33,33
Lookingglass	6	0	0
Autoconnect Holdings	5	0	0
DJ Inventions	5	0	0
HRL Laboratories	5	0	0
salseforce.com	5	0	0
Saudi Arabian Oil Company	5	0	0
Accenture	4	0	0
Bank of America Corporatino	4	0	0
Battelle Memorial Institute	4	0	0
BlackRidge Technology Holdings	4	0	0
Honeywell International	4	0	0
Inbay Technologies	4	0	0
Kontek Industries	4	0	0
Rockwell Collins	4	0	0
SAS	4	0	0
Wombat Security Technologies	4	0	0

Table VI.
Patent intensive organizations in the domain of Big Data analytics & customer profiling

Applicant	Patents	Breakthroughs	Share
IBM	1310	36	2,75
Microsoft Technology	59	23	38,98
American Express	54	21	38,89
SAP	45	0	0
Intertrust Technologies	44	19	43,18
Google	41	0	0
Accenture Global	37	4	10,81
Adobe Systems	34	0	0
EMC Corporation	31	2	6,45
Causam Energy	24	0	0
Citrix Systems	22	1	4,55
HP	22	0	0
Diebold	19	0	0
General Electric	19	0	0
SAS	18	5	27,78
AT&T	17	0	0
Oracle	17	0	0
salesforce.com	15	0	0
Jasper Technologies	14	0	0
Lenovo	14	0	0
West Corporation	14	0	0
Cisco Technology	13	0	0
MasterCard	13	0	0
SanDisk	13	0	0
Smartuve	13	0	0
Globalfounderies	12	2	16,67
Intel	12	1	8,33
Xerox	12	0	0
Endurance	11	0	0
Juniper	11	0	0
LexisNexis	10	0	0
Symphny Advanced Media	10	0	0
Verizon	10	0	0

Figures

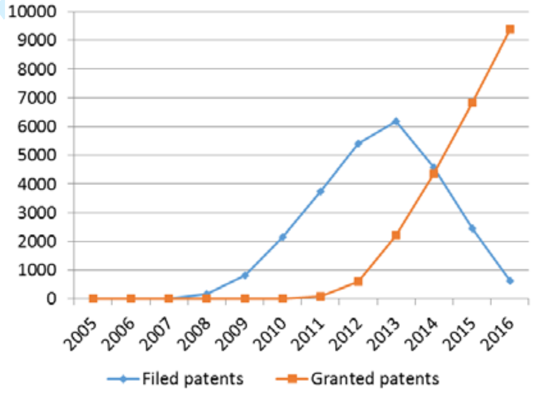

Figure 1(a).
Temporal trends in the domain of Cloud computing

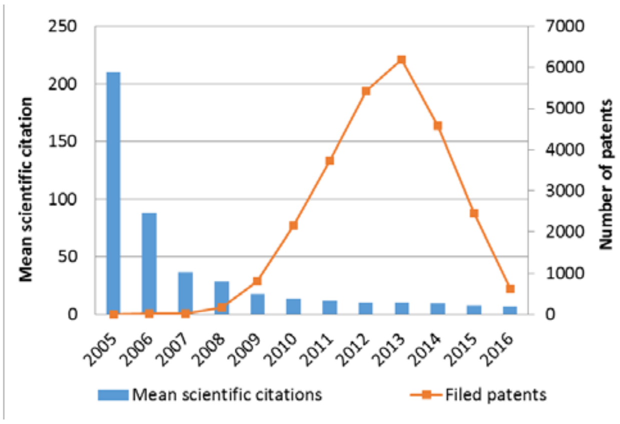

Figure 1(b).
Patent-science linkage in the domain of Cloud computing

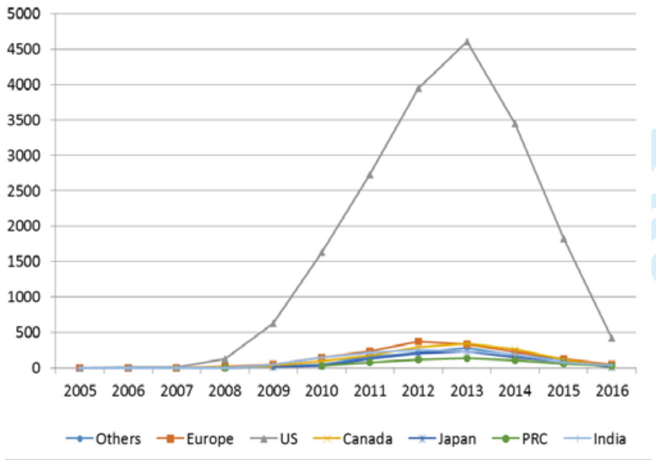

Figure 2(a).
Temporal trends per country in the domain of Cloud computing

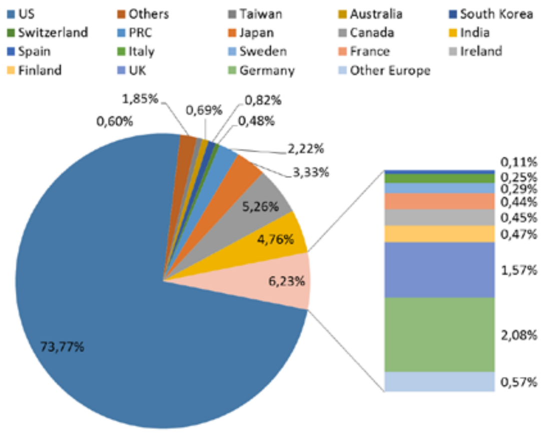

Figure 2(b).
Geographical distribution of patents in the domain of Cloud computing

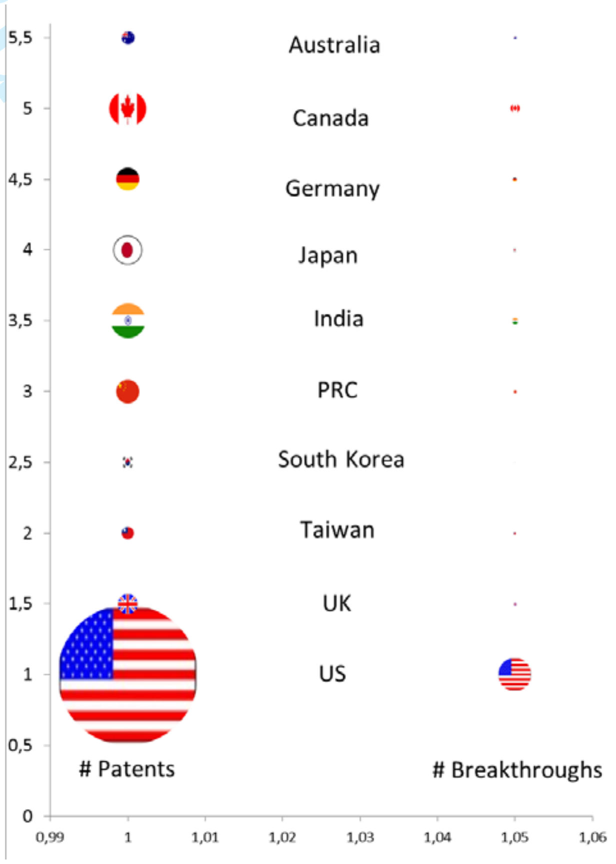

Figure 3.
Cross-country comparison in the domain of Cloud computing

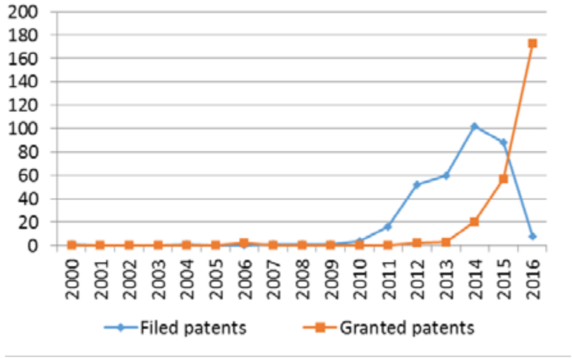

Figure 4(a).
Temporal trends in the domain of Industrial IoT

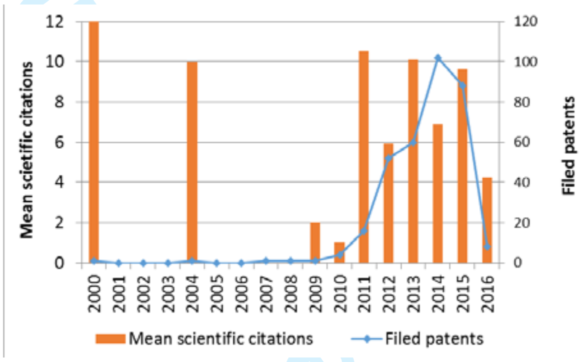

Figure 4(b).
Patent-science linkage in the domain of Industrial IoT

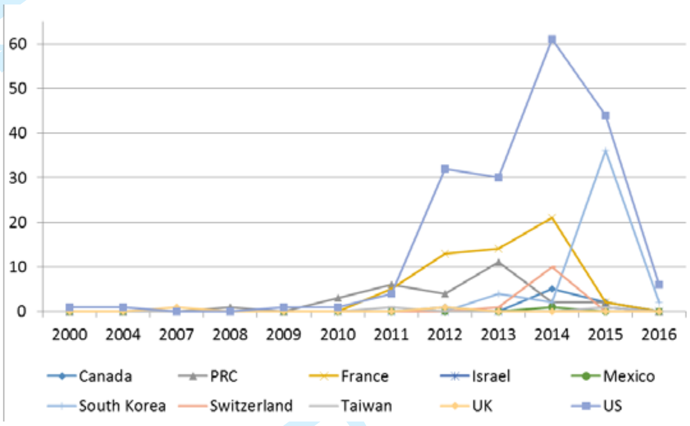

Figure 5(a).
Temporal trends per country in the domain of Industrial IoT

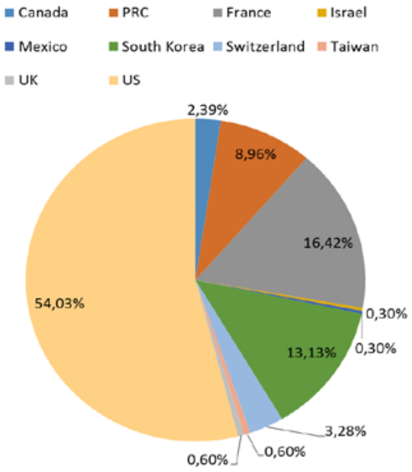

Figure 5(b).
Geographical distribution of patents in the domain of Industrial IoT

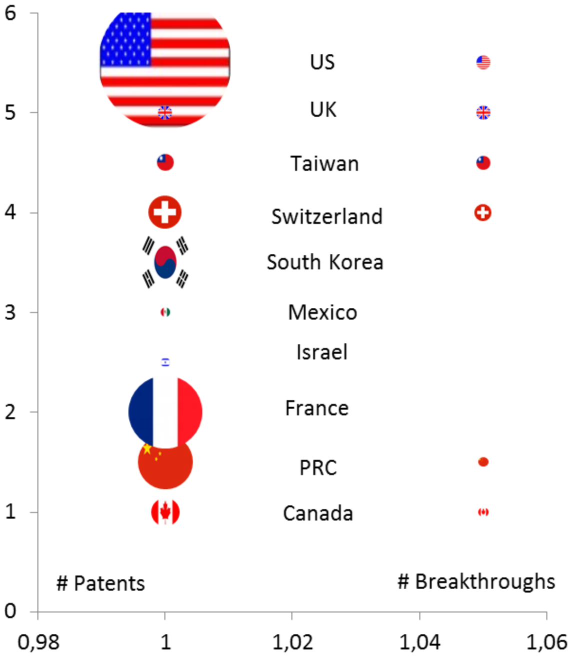

Figure 6.
Cross-country comparison in the domain of Industrial IoT

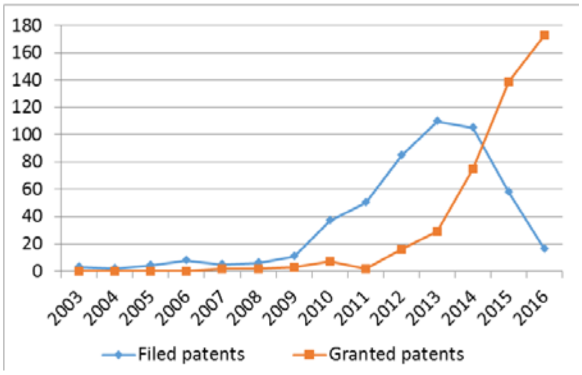

Figure 7(a).
Temporal trends in the domain of Cyber security

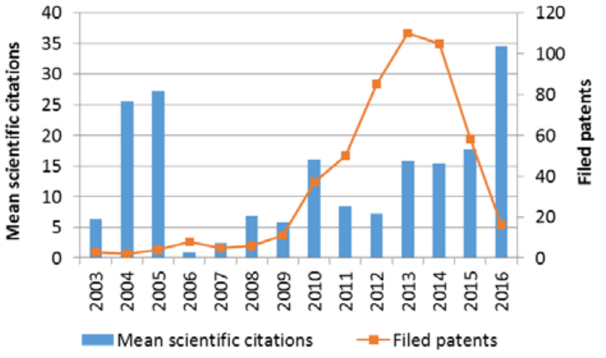

Figure 7(b).
Patent-science linkage in the domain of Cyber security

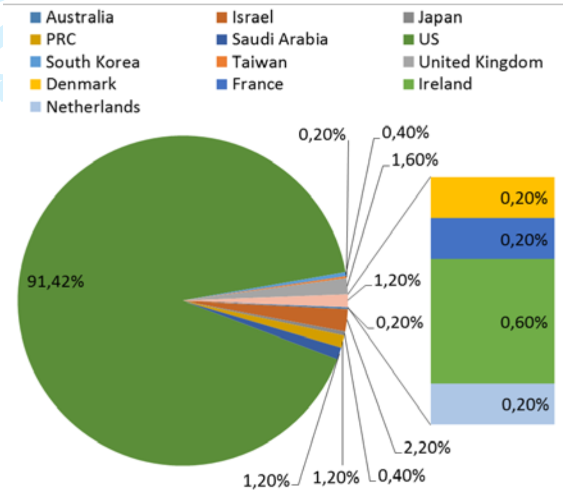

Figure 8.
Geographical distribution of patents in the domain of Cyber security

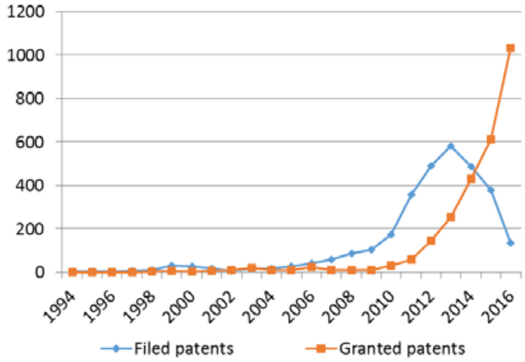

Figure 9(a).
Temporal trends in the domain of Big Data analytics & customer profiling

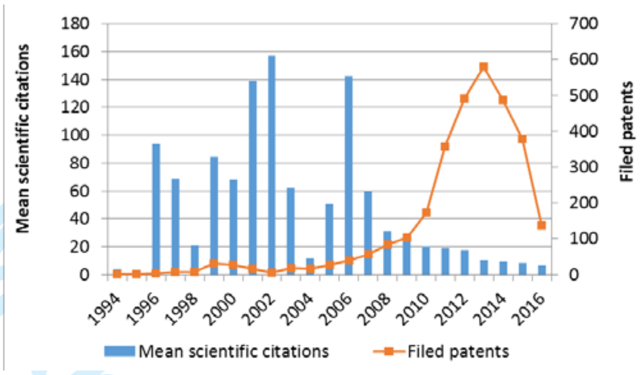

Figure 9(b).
Patent-science linkage in the domain of Big Data analytics & customer profiling

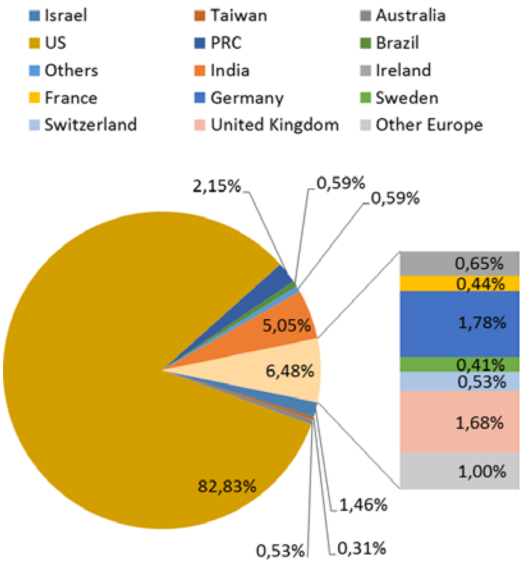

Figure 10.
Geographical distribution of patents in the domain of Big Data analytics & customer profiling