# Towards Industry 4.0

## Mapping digital technologies for supply chain management-marketing integration



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**Abstract**

**Purpose** – The purpose of this paper is to present a comprehensive picture of the innovative efforts undertaken over time to develop the digital technologies for managing the interface between supply chain management and marketing processes and the role they play in sustaining supply chain management-marketing (SCM-M) integration from an information processing point of view.

**Design/methodology/approach** – Patent analysis and actual examples are used to carry out this study. In detail, first, the authors identify the subset of enabling technologies pertaining to the fourth industrial revolution (Industry 4.0) that can be considered the most relevant for effective SCM-M integration (i.e. Industrial Internet of Things, Cloud computing, Big Data analytics and customer profiling, Cyber security). Second, the authors carry 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 and applications.

**Findings** – This research provides insightful information about which digital technologies may enable the SCM-M integration. Specifically, the authors highlight the role those solutions play in terms of information acquisition, storage and elaboration for SCM-M integration by relying on illustrative actual examples. Moreover, the authors present the organisations more involved in the development of digital technologies for SCM-M integration over time and offer an examination of their technological impact in terms of influence on subsequent technological developments.

**Originality/value** – So far, much has been said about why marketing and supply chain management functions should be integrated. However, a clear picture of the digital technologies that might be adopted to achieve this objective has yet to be revealed. Thus, the paper contributes to the literature on SCM-M integration and Industry 4.0 by highlighting the enabling technologies for the Industry 4.0 that may particularly serve for managing the SCM-M interface from an information processing perspective.

**Keywords** Innovation, Marketing, Internet of Things, Patent analysis, Cloud computing, Supply chain management, Big Data analytics, Industry 4.0, Cyber security, Supply chain management-marketing integration, 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). Although this activity is especially enabled by the marketing function, it is further supported by functional areas that are not conventionally associated with marketing, as the supply chain management (SCM) function (Jüttner *et al.*, 2007; Trkman *et al.*, 2015). In fact, on the one hand, the marketing function is necessary to keep pace with the volatile demand characterising current markets and identify the most valuable products to offer (e.g. Slater and Narver, 1995). On the other hand, the SCM function, which is responsible for the management of supply-focussed processes (e.g. operations and inbound/outbound logistics), is also needed to effectively deliver value to customers since it lets companies maintain high service levels and avoid stock-outs (e.g. Esper, Defee and Mentzer, 2010; Macchion *et al.*, 2015). Thus, it has been argued that the ability of firms to integrate and coordinate SCM and marketing functions, i.e., 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).

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Firms that can manage the SCM-M interface are deemed to outperform companies that create differential advantages in only one of the marketing or SCM function (Boyer and Hult, 2005; Esper, Ellinger, Stank, Flint and Moon, 2010; McKinsey & Co, 2017a). Yet, the current organisational practice still lacks a comprehensive understanding of the tools supporting the information processing mechanisms that allow serving customers with the appropriate products, while reducing the constraints that emerge throughout supply chain transactions (Esper, Ellinger, Stank, Flint and Moon, 2010; Alvarado and Kotzab, 2001). Notably, the key to success for SCM and marketing functions is the acquisition, exchange, and elaboration of market and operational knowledge in a timely manner (Esper, Ellinger, Stank, Flint and Moon, 2010; Mentzer, 2001; Slater and Narver, 1995; Bhosale and Kant, 2016). Thereby, information processing mechanisms are considered of foremost importance to effectively manage the interface between SCM and marketing processes.

To improve information processing mechanisms, academics, executives and policymakers are calling for a digital transformation of companies, as suggested by the principles of the fourth industrial revolution (Industry 4.0) (Kagermann *et al.*, 2013; Theorin *et al.*, 2017; Deloitte, 2015). Accordingly, in the vision of the Industry 4.0, the digitisation of firm processes may facilitate the integration of firm functions and supply chain members, 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 fulfilment" (Schrauf and Berttram, 2016, p. 4). The adoption of certain "enabling technologies" (e.g. information systems and improved Big Data analytics techniques) is necessary to accomplish this digital transformation. However, the implementation of digital supply chains and more advanced marketing techniques is hindered by the high investments and important challenges related to the digitisation process (Ranganathan *et al.*, 2011; Melville, 2010). One the most relevant determinants of digitisation costs is the inability to actually screen and select the available technologies that may sustain the digitisation process and, thus, SCM-M integration. Indeed, an integrative view of the enabling technologies required to digitise firm processes, such as SCM-M integration, has been loosely defined; moreover, information about the available technologies for SCM-M integration, their development trends, and their technological impact is still scant, ultimately limiting the possibility of firms to have a complete overview of the most relevant solutions to adopt (Deloitte, 2015; McKinsey & Co, 2015). Therefore, the present paper aims at filling this gap in the literature by providing a comprehensive overview of the digital technologies, and the role they play, for managing the interface between SCM and marketing processes and presenting a complete picture of the innovative efforts undertaken over time to develop those solutions. That is, according to the notion that some digital technologies support the Industry 4.0 from an information processing perspective (Jüttner *et al.*, 2007), we aim at elucidating which digital technologies are especially suitable for SCM-M integration and their application.

Starting from the list of digital technologies enabling the Industry 4.0 (Calenda, 2016; PwC, 2016; Rüßmann *et al.*, 2015), we identify those that may best support SCM-M integration and provide a complete map of respective innovation dynamics by conducting technology- and organisational-level patent analysis. As a result of the 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 organisations 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 most relevant organisations driving the 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 the patent analysis. Finally, Section 5 discusses main theoretical and practical implications.

## 2. Theoretical background

### *2.1 SCM-M integration*

A first attempt to bridge supply- and demand-focussed processes refers to the collaborative planning, forecasting and replenishment (CPFR) practice (Fliedner, 2003), which has become well-established in the last few decades. The most important promise of CPFR is the accuracy in forecasting the demand and replenishment quantity for existing products by having the buyers and suppliers collaborating through a joint planning process based upon effective information sharing mechanisms. Thus, the ultimate aim of CPFR is to create value for supply chain members and final customers by improving overall supply chain performance, such as higher service levels, lower procurement costs, shorter cycle times, smaller inventories, reduction in forecasting errors and quicker interactions across the value chain (Attaran and Attaran, 2007; Fliedner, 2003). This discussion highlights that CPFR mainly pertains the SCM function and is devoted to building effective supply-focussed processes. On the other side, CPFR will likely fail to accomplish the specific demand-focussed processes that allow companies to manage demand shocks and select the most valuable products over time (Yao *et al.*, 2013), which are usually in charge of the marketing function. In fact, only the marketing function provides firms with a steady scanning of customer needs and competition on the market and the adequate channelling choices for new products (Moorman and Rust, 1999). Thereby, it has been claimed that without one of the demand-focussed or supply-focussed process firms may fail to deliver customer value, hence calling for the integration of SCM and marketing functions (McKinsey & Co, 2017b; Pero and Lamberti, 2013).

Actually, the idea of a close relationship between SCM and marketing functions dates back to Porter's (1985) value chain framework. Notwithstanding, so far, SCM and marketing functions have worked independently, and companies have only specialised in one functional area (Esper, Ellinger, Stank, Flint and Moon, 2010). As a consequence, firms more focussed on marketing processes have become particularly effective in identifying customer needs but have failed to achieve efficiency in production and distribution tasks, thus 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 while supporting a decrease in product prices (Boyer and Hult, 2005). Conversely, firms more dedicated to supply-focussed processes, such as those mainly devoted to CPFR, have found difficulties in delivering products that perfectly match the market demand despite being efficient and effective in operations and logistics 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, Ellinger, Stank, Flint and Moon, 2010, p. 6). According to the foregoing discussion, recent research and executives stress that companies must integrate demand-focussed activities and supply-focussed activities (e.g. Alvarado and Kotzab, 2001; McKinsey & Co, 2017b) to timely understand volatile customer demands and adjust the supply chain accordingly.

Three main activities are needed for an effective SCM-M integration: 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 functions (Jüttner *et al.*, 2007). These activities are complex in their nature because they ask companies to implement knowledge management procedures to leverage market information across the supply chain and, in turn, use supply-side information to let firms efficiently deliver their products. Given the requirement of extensive collection and diffusion of market and operational information, some studies have pointed out 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 digitisation of firm processes, in line with the principles of the Industry 4.0. Notably, firms that digitise their processes will improve their capacity to acquire, analyse, and distribute market and operational knowledge by adopting cutting-edge digital technologies (cloud computing, Big Data analytics, etc.) (PwC, 2016; Ranganathan *et al.*, 2011).

The next section discusses 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 sustain SCM-M integration.

*2.2 Towards Industry 4.0: enabling technologies*

The term Industry 4.0 was coined by the German association "Industrie 4.0" in 2011. The association, composed of executives, scholars, and policymakers, hinted a fourth industrial revolution based on the digitisation of firm processes (Kagermann *et al.*, 2011). Indeed, the main idea underlying the Industry 4.0 is running businesses by adopting digital technologies that can help firms to create connections between their machinery, supply systems, production facilities, final products, and customers in order to gather and share real-time market and operational information. The German Government first supported the vision of the Industry 4.0, which was implemented into the "High-Tech Strategy 2020 for Germany" (Kagermann *et al.*, 2013). Afterwards, several countries launched Industry 4.0 initiatives. For instance, the UK initiated the "UK CATAPULT – High Value Manufacturing"[1]. This was a strategic 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 digitising businesses (Calenda, 2016).

Summing up, the goal of the Industry 4.0 is to boost the digitisation and, thus, the 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 operations, inbound/outbound logistics, market needs and product-customer interactions will be available real-time. As a result, digital enterprises will work together with customers and suppliers in an industrial digital ecosystem that allows them to better manage the interface between SCM and marketing functions (Ranganathan *et al.*, 2011; Schrauf and Berttram, 2016).

Of course, many digital technologies are needed to achieve this goal, and these technologies should assure interoperability between diverse information technology (IT) systems to minimise implementation costs and time for information processing. Thus, it is necessary to clearly identify the most relevant solutions to support the transition towards the Industry 4.0. First attempts have been conducted by the Boston Consulting Group (BCG) (Rüßmann *et al.*, 2015), PricewaterhouseCoopers (PwC) (PwC, 2016), and the Italian Ministry of Economic Development (Calenda, 2016), each of which suggested a set of enabling technologies for the Industry 4.0. Among the three classifications, there are many commonalities. The classifications by Rüßmann *et al.* (2015) and Calenda (2016) perfectly match in terms of naming and meaning. The classification by PwC (2016) have in common five digital technologies with those provided by Rüßmann *et al.* (2015) and Calenda (2016), i.e., additive manufacturing, augmented reality, cloud computing, cyber security, and big data analytics. Yet, PwC (2016) also refers to technologies for customer profiling, which can be linked to Big Data analytics solutions, according to Calenda (2016), and some specific technologies (e.g. sensors and mobile devices) that may be associated with Industrial Internet of Things (IoT) solutions, according to both Rüßmann *et al.* (2015) and Calenda (2016). Finally, in all classifications, it emerges the need to secure information flows with cyber security technologies. Following this analysis, we identified a set of solutions that all three classifications highlight. To improve the reliability of our selection process, we also asked three academic experts in the field of digital transformation to evaluate our selection in terms of clarity, specificity and representativeness. First, the three experts were selected based on their research and consulting experience in projects involving the implementation of digital technologies in firm contexts. Each expert was asked to independently identify similarities and differences among the three mentioned classifications, as well as to propose additional technologies that may potentially be added to the classifications. The experts then met to come up with a final list of digital technologies to be shared and discussed with all the authors. By considering the experts' feedback and advice, the final list of enabling technologies is: advanced manufacturing; additive manufacturing; augmented reality; simulation; cloud computing; industrial IoT; cyber security; and Big Data analytics and customer profiling (see Table I for more details). Despite all the eight enabling technologies defined above may be considered as relevant in the Industry 4.0 domain, the next section discusses the subset of them that is particularly important for SCM-M integration.

| 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 optimise 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-focussed and supply-focussed process (Del Giudice, 2016). It favours 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 (Li *et al.*, 2015) |
| (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 and 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 and customer profiling include the technological solutions that allow analysing large data sets and support real-time decision making (Chen *et al.*, 2015) |

**Table I.** Industry 4.0 enabling technologies

*2.3 Enabling technologies for SCM-M integration*

As stated in Section 2.1, a critical issue for SCM-M integration is the possibility to favour and support information processing of market and operational knowledge (Jüttner *et al.*, 2007). Thus, among the eight digital technologies defined in the previous section, only the subset of them devoted to sustaining information processing tasks is considered.

On the one hand, advanced manufacturing, additive manufacturing, augmented reality, and simulation have a focus on the digitisation of the production process, but they neither collect relevant information during the production process nor track products' life-cycle within and beyond the factory. On the other hand, as corroborated by the information management literature and the Data–Information–Knowledge–Wisdom (DIKW) model (Rowley, 2007), Industrial IoT, cloud computing, Big Data analytics and customer profiling, and cyber security are actually devoted to running today's businesses from an information processing point of view. This may be particularly true for SCM and marketing activities (e.g. Porter and Heppelmann, 2014; Ardolino *et al.*, 2017). Accordingly, Industrial IoT is essential to gather and transmit raw data about products across the supply chain and product-customer interactions (McKinsey & Co, 2010; Ranganathan *et al.*, 2011). These data can be stored in cloud solutions and constitute available information for firms (and their SCM and marketing functions). In turn, to effectively deliver customer value, information needs to be converted into relevant knowledge by employing Big Data analytics and customer profiling solutions (Ardolino *et al.*, 2017; Jüttner *et al.*, 2010). In this process, since data are shared on the internet, the role of cyber security is also pivotal in order to avoid the risk that information and data are stolen and misused. Therefore, we contend that Industrial IoT, cloud computing, Big Data analytics and customer profiling, and cyber security are the most relevant digital technologies for SCM-M integration.

## 3. Methodology

*3.1 Patent analysis*

We adopt patent analysis to provide a comprehensive overview of the innovation dynamics characterising the enabling technologies for SCM-M integration. With the term patent analysis, we refer to the examination of several characteristics of the technology progress and innovation activities characterising a certain industry or technology domain (Kim and Lee, 2015). For instance, Albino *et al.* (2014) adopted patent analysis to present the organisations and countries mainly involved in the development of low-carbon energy technologies over time. Zheng *et al.* (2014) examined joint-patenting activities to study international collaborations for the development of nanotechnologies, and Kim and Bae (2017) attempted to provide a novel approach to identify the most relevant wellness care solutions through patent citation analysis. Similar investigations have been made in the context of digital solutions (e.g. Chang and Fan, 2016; Ardito *et al.*, 2017), hence highlighting the suitability of patent analysis in this specific domain.

Results of this type of analyses may lead to relevant policy and managerial implications. From a policy point of view, 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 let organisations identify innovation trends, technology leaders and followers, and whether it is beneficial to enter or continue to operate in a certain technology domain (Ernst and Omland, 2011). Eventually, patent analysis may help firms to recognise the digital technologies for SCM-M integration and better support their implementation. To complement such analyses illustrative actual examples are adopted to better comprehend the roles of the identified technologies.

*3.2 Data collection*

The United States Patent and Trademark Office (USPTO) is the database used to collect patents for the identified categories (i.e. Industrial IoT, cloud computing, cyber security and Big Data analytics and customer profiling). Although the USPTO only limits the protection of an invention to the US area, it is not subject to the country bias (Kim and Lee, 2015). Accordingly, several non-US patents can be retrieved. For example, in the energy conservation technology domain, Japanese organisations have filed for more patents than US ones (Albino *et al.*, 2014). Furthermore, we did not limit the time period for patent search, so we collected 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 related to the Industry 4.0 does not exist. Table II presents the search terms used for patent retrieval. These come from the description provided by the BCG, PwC and the Italian Ministry of Economic Development. We searched for these terms in the description of the patent. Table II 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, patent owners, and citations made and received).

## 4. Results

This section provides a comprehensive outline of the patenting activity related to Industrial IoT, cloud computing, Big Data analytics and customer profiling, and cyber security at the technology and organisational levels. In detail, first, we carry out patent count analysis at the technology level. Patent count per year is used as the measure for the innovation efforts undertaken over time. Moreover, we provide a fine-grained investigation of how the identified technologies may support SCM-M integration by relying on examples from the managerial practice. Second, analyses at the organisational level are conducted. Accordingly, we seek to highlight the organisations more involved in the development of Industry 4.0 solutions for SCM-M integration. Specifically, we offer analyses of the most patent-intensive organisations; furthermore, we examine the extent to which those organisations are able to develop breakthrough solutions. Breakthroughs are identified by means of forward citations. Since citations rate may change over time, and older patents have more chances to be cited, we corrected for this issue by dividing the number of citations received by a patent over the average number of citations received by all patents filed for in the same year (hereafter, citation rate) (OECD, 2009; Ernst and Omland, 2011). Additionally, we examine whether organisations are involved in inter-organisational collaborations through joint patent analysis (Hagedoorn, 2003).

*4.1 Technology-level analysis*

Figure 1 presents temporal trends of patent development for Industrial IoT solutions. Development trends are proposed respect to the granting year. Although the filing year better reflects the period when a patent is actually developed, it may lead to biased results if

| 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 | ["Cyber security" or "Cyber-security"] | 501 |
| Big Data analytics and customer profiling | ["Big Data" or "Customer profiling"] | 3,047 |

**Table II.** Search terms and sample dimension

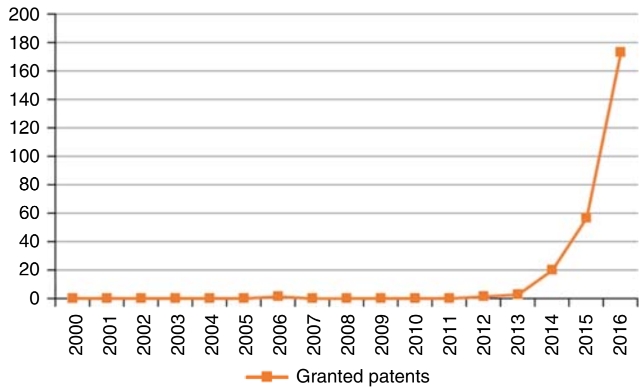


**Figure 1.**
Temporal trends in the domain of Industrial IoT

temporal trends are examined because the duration of the examination process usually takes three to five years, on average (Haupt *et al.*, 2007), so more recent patents are likely to be not identified. Therefore, we analyse patent count by relying on the granting year, showing that the patenting activity trend is steadily growing (see Figure 1). Furthermore, the figures show that despite some technologies within Industrial IoT might be more mature (e.g. Radio-Frequency Identification (RFID)), the patenting activity trend starts increasing in the recent years even though we have not limited data collection to a specific period.

As per definition (Li *et al.*, 2015), Industrial IoT includes different kinds of technologies, which can be divided into more and less mature solutions. The former type comprises QR codes (e.g. patent numbers 9,592,964, 9,754,097, and 9,849,364) (mid-1990s), RFID readers and tags (e.g. patent numbers 9,418,263, 9,405,942, 9,070,061) (early 2000s), and near field communication (NFC) solutions (e.g. patent number 9,398,531) (mid-2000s), whose development started between mid-1990s and mid-2000s. The latter type refers to the new generation of wireless sensors and actuators that have appeared in the late 2010s and are deemed to be the future of Industrial IoT (Lee and Lee, 2015), such as smart sensors and ubiquitous and in-store positioning technologies (e.g. patent numbers 9,344,963, 9,294,169, 9,264,115, 8,787,290). Although some technologies are more mature (e.g. RFID and NFC), their large-scale adoption by companies (e.g. Zara, Wal-Mart, Decathlon and Macy's Inc.) for real-time information processing and monitoring across their SCM and marketing functions has started in the recent years. For instance, the recent Wal-Mart's RFID strategy asked suppliers to tag forklifts, shelves and pallets, so that Wal-Mart will be able to capture data about the flow of pallets across the supply chain. Furthermore, Wal-Mart's suppliers tagged the cases and pallets of promoted products in order to reduce information asymmetries between supply chain members, with the aim of facing the bullwhip effect in promotional periods. Nowadays, Wal-Mart also networked its suppliers for maintaining the inventory in its stores by building store-level point-of-sale/positioning systems and wireless networks; in this way, shelves are consistently stocked, and inventory is closely watched (Lu, 2014)[5]. In all cases, operational efficiency was improved, and, in turn, the marketing function of Wal-Mart was provided with elaborated data that allowed it to build a marketing strategy based on the goal of providing customers with the goods they wanted whenever and wherever they wanted them[6]. In other words, supply-focussed and demand-focussed processes were enabled by the data acquisition of such digital technologies to actually deliver customer value. Another approach in this sense is the use of Industrial IoT solutions on products and customers first (McKinsey & Co, 2017a), so designing the supply chain based on the data acquired from them. For example, Zipcar, a car sharing company, gathered data from advanced ubiquitous positioning technologies and smart sensors, as well as more conventional tags and NFC solutions, that assess how cars and drivers interact. These data, after elaboration, were helpful to the marketing function to analyse and better understand how customers feel and their attitudes during the drive. Once defined a customer profile, the SCM function of Zipcar could make available to customers the cars they perceive 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 raw data, subsequently elaborated and used to match demand and supply strategies. It is worth mentioning that in both cases more and less mature IoT technologies are adopted simultaneously. The coexistence of the two types of solutions may explain the growing patent activity trend previously discussed (Figure 1). In fact, mature, more reliable technologies are likely being improved and still contribute to the expansion of Industrial IoT in firm contexts for SCM-M integration; at the same time, novel solutions are being developed and implemented in this field.

Figure 2 presents the innovation efforts undertaken over time in the cloud computing area. Considering granted patents, we can argue that the interest in cloud computing technologies is rising, and this is likely related to the emergence of modern high-speed networks, which enable a fast access to remote data. Therefore, it is important to keep pace with their technological evolution to remain competitive in the market and adopt the latest technological advancements.

Cloud computing includes technologies enabling various types of services, such as Infrastructure as a Service (IaaS) (e.g. patent numbers 9,442,669, 9,197,543, 8,660,129), Software as a Service (SaaS) (e.g. patent numbers 9,461,996, 9,043,458, 8,700,745), Platform as a Service (PaaS) (e.g. patent numbers 9,344,487, 9,342,299, 8,850,514), and Data as a Service (DaaS) (e.g. patent numbers 9,633,090, 9,628,578, 8,850,593). These services mainly serve to structure, share, and customise remote network infrastructures (IaaS), IT platforms (PaaS), operating systems and applications of third-party organisations (SaaS), or raw data (DaaS). In sum, Cloud computing eases sharing and rapid organisation of multiple types of structured information (e.g. market and operational information) thanks to distributed IT structures that support 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). Accordingly, the migration to cloud-based solutions is rising, especially with the aim of integrating information originating from the supply chain and the market (Accenture, 2014). For instance, after that Pfizer migrated to cloud solutions, its supply chain network was able to remotely access real-time products' information across the value chain,

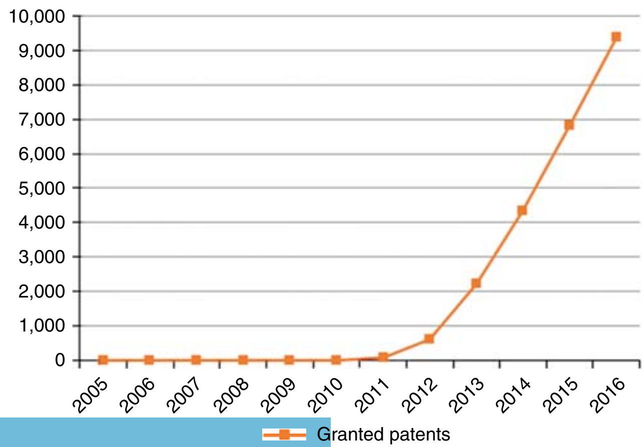


**Figure 2.**
Temporal trends in the domain of Cloud computing

and Pfizer was able to have information from portions of the world where it was not possible to trace products (e.g. Kenya) (*Financial Times*, 2012). Eventually, both Pfizer's SCM and marketing functions were able to access market and operational information, and Pfizer reduced the efforts towards the integration of the functions through a cloud solution. A similar strategy was adopted by Canon, which developed the cloud platform eMaintenance® (based on patents such as 9,341,973 and 7,636,771) in order to use remote diagnostics to control over all the networked Canon devices (Ardolino *et al.*, 2017). Indeed, by sharing information about Canon's devices on the cloud, it was easier to provide more responsive post-sale services in the maintenance or substitution of damaged products. In other words, the post-sale service provided by the marketing function became closer to the inventory and distribution management activities of the SCM function. This discussion highlights that, differently from Industrial IoT, cloud solutions are more complex and manage multiple information flows, both inflows and outflows.

Figure 3 shows that the patenting activity trend of Big Data analytics and customer profiling recalls that of the previous enabling technologies and reflects the novelty of this technological domain, which has emerged in last few years.

The variety of technologies used in this domain is disparate since a "dominant design" (e.g. Suárez and Utterback, 1995) is far from to be reached. Industrial IoT mainly comprises systems and algorithms for targeted marketing (e.g. patent numbers 9,177,323, 9,100,214, 8,655,719, 6,925,441), systems for managing RFID, NFC and other sensor-related information (e.g. patent numbers 9,641,969, 8,933,808, 8,669,845), and more general applications for predictive analytics, data mining, text mining, forecasting, and data optimisation (e.g. patent numbers 9,639,562, 8,521,177, 8,478,702, 8,417,499). Recently, some specific initiatives have been set for helping firms to manage the SCM-M interface based on these solutions. One example is MiSCAN. It is a new marketing and supply chain analytics lab located at DeGroote's Ron Joyce Centre and funded by the Canada Foundation for Innovation and the Ontario Research Fund. By utilising the power of Big Data analytics and customer profiling techniques, the lab combines market and operational information to generate actionable business intelligence that could not be attained without one of the two sets of information. Notably, its main goal is to derive strategic decisions integrating SCM with marketing and customer relationship management. Given this possibility, some companies are establishing functional areas devoted to analysing (big) data. So far, these areas are mainly set within the marketing function (Wedel and Kannan, 2016) but, in the future, a dedicated "analytics" function may be set to support all firms' functions or may be integrated within the functions where

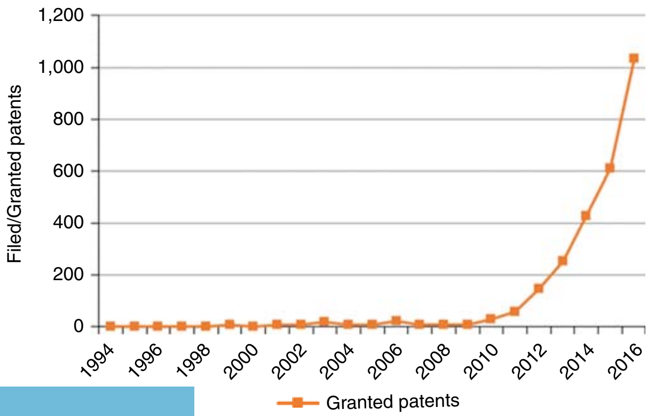


**Figure 3.**
Temporal trends in the domain of Big Data analytics and customer profiling

data are particularly relevant (e.g. the SCM function) (Hazen *et al.*, 2016). Amazon and Wal-Mart are among the most active adopters of big data analytics and customer profiling solutions. They utilise those technologies to monitor, track, and secure millions of items in their inventories and rely on forecasting analytics for their "anticipatory shipping", thus predicting when a customer will purchase a product and pre-ship it to a depot close to the final destination (Rozados and Tjahjono, 2014)[7]. Similarly, after having recognised that linking marketing promotions to increased order volumes was difficult without a clear picture and analysis of market and operational information, Sunny Delight Beverages Co. decided to adopt big data analytics to integrate and analyse marketing and supply chain information, so that the firm could finally see how decisions in marketing and SCM functions interacted and affected market demand, operational costs, and service levels[8].

Cyber security is the last category of enabling technologies we consider. Per Figure 4, the innovation efforts conducted over time for cyber security are similar to the trends of cloud computing and Industrial IoT.

As anticipated earlier, Industrial IoT and cloud computing allow generating and sharing reams of market and operational information. Yet, IoT and cloud technologies work on the internet; therefore, the data they collect and store may be stolen and misused, hence leading to important security issues in terms of competitiveness – at the organisational and supply chain level – and privacy – at the customer level (Sultan, 2013). Indeed, if any node of the supply chain is attacked, all members will be affected and may fail to attain the desired service levels. Moreover, if customers' information is stolen, customers will not provide their data anymore, negatively influencing the possibility to design marketing campaigns and products' orders. Both the European Commission and the USA are aware of these security issues. In fact, they provided ad-hoc directives on the design and operation of information networks, i.e., the EU Data Protection Directives 95/46, 99/5 and 2002/58 (No. 2)[9] (Weber, 2010) and the US Department of Defence Cyber Strategy. Although these solutions must be improved since the threat of cyber-attacks is growing, these directives call for methods and apparatus for identifying and detecting threats to an enterprise or e-commerce systems (e.g. patent number 9,661,025), adopting multiple computing devices to verify identity in the network (e.g. patent number 9,529,986), and developing methods to securely transfer large volumes of data between networks having different levels of network protection (e.g. patent number 9,223,991). A relevant example refers to the investments in cyber security by the UK automotive industry. That is, companies required improvements in cyber security technologies before connecting their factories and storing vast amounts of sensitive data

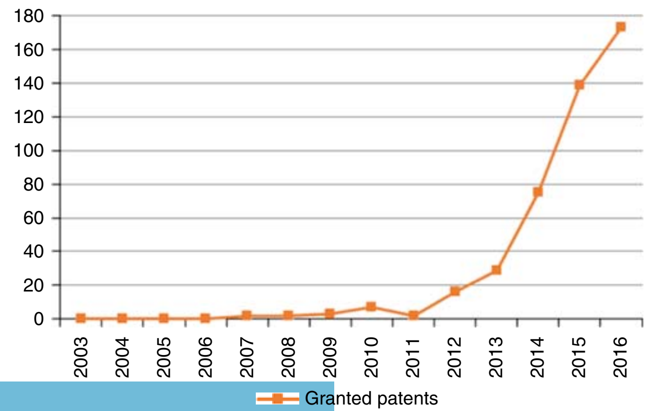


**Figure 4.** Temporal trends in the domain of Cyber security

about their supply chain activities and product-customer interactions in the cloud (KPMG, 2016). Thus, investments in cyber security enabled further digitisation efforts sustaining the integration between SCM and marketing functions, with the ultimate aim of better delivering customer value.

### *4.2 Organisational-level analysis*

Tables III–VI list the most patent-intensive organisations (top 30) for each digital technology under investigation. The first column presents the name of the organisations, whereas the second, third and fourth columns reveal the related number of patents, number of breakthroughs, and share of breakthroughs over the total number of patents, respectively. According to Table III, one-third of the Industrial IoT solutions can be referred to Cisco Technology, and one-sixth of them come from Samsung Electronics' laboratories. The rest of the patents are distributed among other several companies. It is worth mentioning that no research or governmental organisations figure in the table. This implies that neither research organisations nor governmental organisations play a key role in developing technologies in the IoT domain. Among the identified organisations, 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 per cent of breakthroughs. Finally, we can conclude that collaborating is not a prevalent innovation strategy in the IoT domain since only three patents are the result of joint innovation efforts.

**Table III.** Patent-intensive organisations 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 | 12.5 |
| 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 |
| International Business Machine | 3 | 0 | 0 |
| Microsoft | 3 | 0 | 0 |
| Splunk | 3 | 0 | 0 |
| Bastille Networks | 2 | 0 | 0 |
| Belkin International | 2 | 0 | 0 |
| Digimarc Corporation | 2 | 0 | 0 |
| General Electric | 2 | 0 | 0 |
| Huawei Device | 2 | 0 | 0 |
| Innovasic | 2 | 0 | 0 |
| InterDigital Patent Holdings | 2 | 0 | 0 |
| iRobt Corporation | 2 | 0 | 0 |
| Motion Games | 2 | 0 | 0 |
| National Instruments Corporation | 2 | 0 | 0 |
| PB | 2 | 0 | 0 |
| Power Fingerprinting | 2 | 0 | 0 |
| RedSky Technologies | 2 | 1 | 50 |
| SAS | 2 | 0 | 0 |
| Shenzhen Hac Telecom | 2 | 0 | 0 |
| Tego | 2 | 0 | 0 |
| Westvalley Digital Technologies | 2 | 0 | 0 |

| Applicant | Patents | Breakthroughs | Share |
|---|---|---|---|
| IBM | 4,242 | 28 | 0.90 |
| 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 Corporation | 307 | 18 | 5.86 |
| CA Technologies | 288 | 3 | 1.04 |
| Sony | 284 | 2 | 0.7 |
| Intel Corporation | 274 | 2 | 0.73 |
| Cisco Technology | 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 Systems | 162 | 8 | 4.94 |
| Samsung | 152 | 1 | 0.66 |
| LinkedIn | 148 | 19 | 12.84 |
| Canon | 145 | 0 | 0 |
| Digimarc | 134 | 30 | 22.39 |
| Citrix Systems | 131 | 18 | 13.74 |
| Intuit | 114 | 2 | 1.75 |
| Elwha LLC | 106 | 0 | 0 |
| Emoire Technology Development | 105 | 0 | 0 |

**Table IV.** Patent-intensive organisations in the domain of Cloud computing

With regard to cloud computing, it emerges that the only private companies are included (Table IV). 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. In total, only 193 joint patents have been developed, with the 22 per cent of them involving a university. Although the number of joint patens is small, a huge percentage (74 per cent) presents a citation rate close or higher than the mean citation rate of the patent sample, hence suggesting that patents resulting from collaboration may have a greater impact in this filed.

Table V presents patent developers for the category Big Data analytics and customer profiling. Again, only private companies have been identified. Among them, Microsoft, 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. Table VI presents the top 30 organisations in the cyber security domain, still showing that only companies are present. Finally, in both these areas, the collaboration pattern recalls that of Industrial IoT, presenting only a few joint patents.

From Tables III–VI, it is interesting to note the cloud computing domain reflects most of the innovation efforts, probably because there is nowadays fierce competition among IT houses in developing the diverse cloud solutions. Indeed, such efforts appear to be quite distributed, with IBM as the most patent-intensive company. Instead, in the areas of data

| Applicant | Patents | Breakthroughs | Share |
|---|---|---|---|
| IBM | 1,310 | 36 | 2.75 |
| Microsoft | 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 | 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 |
| Global founderies | 12 | 2 | 16.67 |
| Intel Corporation | 12 | 1 | 8.33 |
| Xerox | 12 | 0 | 0 |
| Endurance | 11 | 0 | 0 |
| Juniper | 11 | 0 | 0 |

**Table V.**
Patent-intensive organisations in the domain of Big Data analytics & customer profiling

analytics and Industrial IoT, there are some firms that own most of the patents, e.g., IBM and Cisco, which are the leaders in the respective areas (analytics and network infrastructure). Overall, IBM seems to be the firm that leads the technological development of digital technologies. This can be explained by the strategy of IBM towards the creation of integrated digital solutions, for instance by developing big data analytics solutions specifically customised for its cloud solutions[10]. However, it is also true that in terms of breakthrough technologies other companies look more effective than IBM, at least in relative terms (e.g. Microsoft). This may be related to the IBM strategy of developing technologies more focussed on its requirements and protocols, so being less attractive as the basis for future technological advancements by other organisations.

Figure 5 and Table VII dig into the innovation efforts of patent developers. Figure 5 distinguishes organisations according to the total number of patents they have developed and the number of technological classes their patents relate to, as a measure of diversification. We assigned a high level to patent intensity when an organisation owns more patents than the sample mean plus two standard deviations (SD)[11], a low level when the number of patents is below the sample mean, and a medium level in the remaining cases. Instead, we assigned a high value to diversification when an organisation has patented in three domains (no firms have patented in four domains), a medium level when it has patented in two domains, and a low level when it has patented in one domain. The first two rows of the table, thus, identify the organisations with the highest levels of diversification. These may favour integration between diverse types of

| 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 Corporation | 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 |

**Table VI.**
Patent-intensive organisations in the domain of Cyber security

| | Patent intensitiy: High | Patent intenstiy: Medium | Patent intensity: Low |
|---|---|---|---|
| Diversification: High | Microsoft<br>IBM | Cisco Technology<br>Intel Corporation<br>AT&T | General Electric<br>SAS |
| Diversification: Medium | Google | SAP<br>EMC Corporation<br>salesforce.com<br>HP<br>Oracle<br>Adobe Systems<br>Verizon<br>Citrix Systems | Accenture<br>Digimarc |
| Diversification: Low | Amazon Technologies<br>Symantec<br>Palantir Technologies | Broadcom<br>Sprint Communication<br>Cleversafe<br>CA Technologies<br>Sony<br>eBay<br>Red Hat<br>Samsung | Other 63 companies |

**Figure 5.**
Patent intensity-diversification applicant matrix

**Table VII.**
Patent-intensive organisations: summary

| Firm | Total patents | Technological domains | Industrial IoT Patents (%) | Cloud computing Patents (%) | Big Data and customer analytics Patents (%) | Cyber security Patents (%) |
|---|---|---|---|---|---|---|
| IBM | 5,583 | 3 | 0 | 75.98 | 23.46 | 0.56 |
| Microsoft | 1,502 | 3 | 0.2 | 95.87 | 3.93 | 0 |
| Cisco Technology | 395 | 3 | 32.91 | 63.8 | 3.29 | 0 |
| Intel Corporation | 291 | 3 | 1.72 | 94.16 | 4.12 | 0 |
| AT&T | 195 | 3 | 0 | 87.18 | 8.72 | 4.1 |
| General Electric | 31 | 3 | 6.45 | 0 | 61.29 | 32.26 |
| SAS | 24 | 3 | 8.33 | 0 | 75 | 16.67 |
| Google | 1,376 | 2 | 0 | 100 | 2.98 | 0 |
| SAP | 472 | 2 | 0 | 90.47 | 9.53 | 0 |
| EMC Corporation | 338 | 2 | 0 | 90.83 | 9.17 | 0 |
| salesforce.com | 259 | 2 | 0 | 94.21 | 5.79 | 0 |
| HP | 231 | 2 | 0 | 90.48 | 9.52 | 0 |
| Oracle | 219 | 2 | 0 | 92.24 | 7.76 | 0 |
| Adobe Systems | 196 | 2 | 0 | 82.65 | 17.35 | 0 |
| Verizon | 181 | 2 | 0 | 94.48 | 5.52 | 0 |
| Citrix Systems | 153 | 2 | 0 | 85.62 | 14.38 | 0 |
| Digimarc | 136 | 2 | 1.47 | 98.53 | 0 | 0 |
| Accenture | 41 | 2 | 0 | 0 | 90.24 | 9.76 |

technologies, hence reducing digitisation costs. In particular, those with a high and medium level of patent intensity can be considered as the firms that will probably lead the digitisation process, being also the developers of the majority of digital technologies (e.g. Microsoft, IBM, Cisco Technology, Intel Corporation, AT&T and Google). Instead, although less diversified and patent-intensive firms will less likely trigger interoperability between technologies and the transition towards the Industry 4.0, they may still play a key role if they focus on the development of cutting-edge digital solutions, as in the case of Sprint Communication and Intertrust Technologies (see also Tables IV and V).

Table VII further examines the organisations that applied for patents in multiple technological domains and highlight their total number of patents (column 1), the number of domains covered (column 2), and the share of patents belonging to each domain over the total number of patents (columns 3–6). The table hints that only 18 organisations have a diversified portfolio of patents with regard to the considered digital technologies. Among them, Cisco Technology, Adobe Systems, Citrix Systems, AT&T and General Electric are the most diversified, in that respective patents are more equally distributed among the diverse categories.

On the basis of Figure 5 and Table VII, we may consider the most patent-intensive and diversified firms as rivals to each other since they all have the technological resources and competencies to build comprehensive IT systems, thus competing for establishing the dominant IT network for integrating SCM and marketing functions. Instead, less-patent intensive organisations with many breakthroughs likely act as providers of cutting-edge solutions towards those big players, which will further build on them to innovate. Similarly, companies strongly focalised in one technological domain may serve as a support to big players for some specific IT applications that require a relevant knowledge of a given domain.

## 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 recognised as a key success factor to remain competitive and achieve superior financial performance (e.g. Boyer and Hult, 2005). Starting from the enabling technologies identified in the domain of Industry 4.0, first, we recognised the set of digital solutions that may better sustain the implementation 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 and customer profiling). Second, we carried out a patent analysis aimed at providing a wide-ranging outline of the technology- and organisational-level trends characterising the set of technologies under investigation, hence highlighting their innovation dynamics and in which ways they can be adopted for SCM-M integration. To do so, a novel and unique data set of patents granted at the USPTO has been collected and examined; patent data have been complemented by cases from the managerial practices.

Several interesting findings have emerged from the study. Among them, we underline that some companies (e.g. Amazon, Wal-Mart and Zipcar) already attempted to digitise their processes using the identified technologies. In particular, the proposed examples reveal the important and complementary role those technologies play for SCM-M integration. Indeed, each type of technology is especially relevant for a facet of SCM-M integration. As it mainly refers to sensors and data acquisition systems, Industrial IoT is important to collect raw data about inbound/outbound logistics across the supply chain and product-customer interactions. Cloud computing is devoted to storing raw data in structured information. Such information can be accessed by and exchanged between SCM and marketing functions, which may, in turn, use the structured information as the input for data analytics and customer profiling techniques. Finally, Big Data analytics and customer profiling extracts the knowledge that is actually important for marketing and SCM functions. Both structured information in the cloud and generated knowledge may be steadily shared with supply chain members to better match supply- and demand-focussed processes. Overall, this information/knowledge flow should be protected by cyber security solutions to limit data theft. This summary provides some additional hints regarding SCM-M integration. It recalls the DIKW model, hence suggesting that SCM-M integration requires the transformation of raw data into information and information in knowledge, and this is enabled by different digital technologies (Rowley, 2007). It emerges that industrial IoT solutions are more pervasive in terms of activities, actors and types of data involved. Indeed, they are employed by distributors, retailers and products to acquire several types of data (e.g. the location of a component/product, time in production/assembly, customer data). Cloud services also manage all types of raw data, but with the aim of storing structured information that may be helpful to supply chain members and further used to extract more relevant knowledge. Thereby, the data flow underlying industrial IoT is predominantly unidirectional, flowing from the supply chain/market to the cloud. Instead, cloud services not only receive real-time data from tags and sensors, but also provide information to SCM and marketing functions, store generated knowledge, and allow supply chain members to access information in the cloud, hence managing a multidirectional flow of data/information and serving for multiple functions. Big data analytics solutions are not directly employed for managing knowledge flows. Rather, they convert information into knowledge that will be useful for a better strategic integration of SCM and marketing functions. Cyber security stands for the shield protecting information flows. Figure 6 provides a graphical systematisation of the foregoing discussion.

The examples and patent analysis also allow us to identify some of the main benefits that SCM and marketing functions may attain from each digital technology, as well as main impacts on SCM-M integration (see Table VIII). Industrial IoT, as stated, enable real-time acquisition of market and operational data, hence benefiting marketing and SCM functions, respectively. This data acquisition process does not directly affect SCM-M integration but represents its basis. Cloud computing structures data pertaining each function and allow

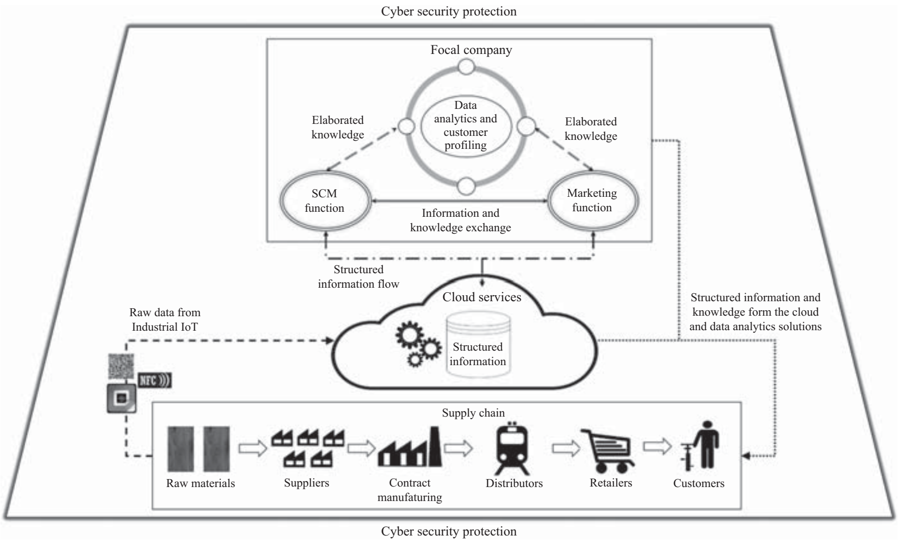


**Figure 6.**
Systematisation of findings

**Table VIII.**
Main benefits of each digital technology to marketing and SCM functions, and SCM-M integration

| | Main benefits to the marketing function | Main benefits to the SCM function | Main benefits to SCM-M integration |
|---|---|---|---|
| Industrial IoT | Real-time acquisition of market data (customer data and product-customer interactions) | Real-time acquisition of operational data (e.g. products life-cycle and material flow) | Possibility to elaborate and integrate both market and operational data |
| Cloud computing | Storing and structuring market information acquired through IoT solutions<br>Real-time sharing of market information with the SCM function | Storing and structuring operational information acquired through IoT solutions<br>Real-time sharing of operational information with the marketing function<br>Real-time access to operational information across the supply chain<br>Quicker interactions across the value chain | Possibility to steadily inspect and merge market and operational information |
| Data analytics and customer profiling | Customer profiling<br>Targeted marketing (e.g. product recommendations)<br>Predictive analytics (e.g. customer needs foresight)<br>Improved customer relationship management | Forecasting the demand and replenishment quantity<br>Higher service levels<br>Lower procurement costs<br>Smaller inventories<br>Reduced stock-outs | Data optimisation<br>Concurrent planning of market-and supply-focussed activities<br>Improved decision-making process at the company and supply chain levels |
| Cyber security | Securing customer data | Securing product and supply chain members data | Securing all data flows |

marketing and SCM functions to share information with each other. With regard to the SCM function, the cloud represents a repository of information that can be of use to all supply chain members, thus providing advantages in terms of interaction among members and a better understanding of each stage of the supply chain. Eventually, cloud computing enables the possibility to steadily inspect and merge market and operational information for better managing the SCM-M interface. Data analytics and customer profiling can extract relevant knowledge from market and operational information. Such knowledge is helpful for specific activities of both marketing (e.g. customer profiling, targeted marketing, predictive analytics, improved customer relationship management) and SCM (e.g. forecasting the demand and replenishment quantity, improving service levels, lowering procurement costs and reducing inventories) functions. Moreover, data analytics conducts the data optimisation tasks that might support the concurrent planning of market- and supply-focussed activities and improve decision-making process at the company and supply chain levels. Cyber security secures all data flows.

Concerning patenting activity trends, the innovation efforts underlying all the four categories under analysis present a growing trend. This reveals the rising interest in these solutions, probably caused by the number of government initiatives aimed at digitising firm processes (e.g. Calenda, 2016; Kagermann *et al.*, 2013). Relatedly, the organisational-level analysis shows the organisations that are technology leaders in terms of patent productivity and diversification (e.g. Microsoft, IBM, Cisco Technology), which will probably lead the digitisation process in this fourth industrial revolution. However, those organisations may still be sustained by other firms more devoted to developing cutting-edge solutions (e.g. Intertrust Technologies) or specialised in specific technological areas (e.g. Broadcom and Symantec).

So far, much has been said about why marketing and SCM functions should be integrated. However, a clear picture of the digital technologies that may be adopted to achieve this objective and their respective roles has 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. Accordingly, we depict a comprehensive framework (Figure 6) that helps to highlight the benefits of each digital technology for SCM-M integration. Furthermore, we also contribute to this stream of literature by providing a number of information about which organisations have a leading role in their development and what the patterns of collaboration are, which may help to design firms' digitisation process. Indeed, an integrative view of the enabling technologies favouring 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, ultimately limiting the possibility to have a complete overview of the most relevant solutions to adopt (Deloitte, 2015; McKinsey & Co, 2015). In turn, given the absence of a clear picture of the solutions developed within the domain of Industry 4.0 either (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 managerial perspective, our suggestions are twofold. First, we advise managers that it is important for firms to adopt interrelated digital solutions (e.g. Industrial IoT, cloud computing and Big Data analytics) for SCM-M integration given their complementary role from an information processing perspective. Second, and related to the first advice, it is important that, on the one hand, firms build the internal capacity to exploit the full potential of each digital technology. For instance, it is important that firms build the capabilities to design the implementation of IoT and cloud solutions across the supply chain, so that valuable market and operational data/information may be acquired and shared between SCM and marketing functions. Moreover, firms should hire data scientists that can select and analyse proper information to be turned into knowledge. On the other hand, the top management must develop a systemic view of the use of digital technologies in order to better seize the current and future opportunities offered by the complex information flow generated by the digitisation of demand- and supply-focussed firm processes.

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 is 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 analyse 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.

## Notes

1. See https://catapult.org.uk/
2. See www.manufacturing.gov/nnmi/
3. See www.economie.gouv.fr/lancement-seconde-phase-nouvelle-france-industrielle
4. See www.smartindustry.nl/en/
5. See also www.directionsmag.com/article/3471
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9. COM (2009) 278 final.
10. See www.ibm.com/developerworks/cloud/library/cl-ibm-leads-building-big-data-analytics-solutions-cloud-trs/index.html
11. Results remain consistent if we consider the mean plus one SD.

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