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Positioning RFID technology into the innovation theory landscape: a multidimensional perspective integrating case study approach

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Publication Details

Fosso Wamba, S. (2011). Positioning RFID Technology into the Innovation Theory Landscape: a Multidimensional Perspective Integrating Case Study Approach. 15th Pacific Asia Conference on Information systems (PACIS), 9-11 July 2011, Brisbane, Australia.

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Disciplines

Physical Sciences and Mathematics

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POSITIONING RFID TECHNOLOGY INTO THE INNOVATION THEORY LANDSCAPE: A MULTIDIMENSIONAL PERSPECTIVE INTEGRATING CASE STUDY APPROACH

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Abstract

The main objective of this paper is to analyze RFID technology as an innovation concept through the lens of the diffusion of innovation theory. Drawing on the extant literature on the diffusion of innovations –with an emphasis on innovation classifications and the “open innovation”–, as well as on an analysis of a longitudinal case study conducted in a Canadian beverage supply chain currently exploring the potential of RFID technology, this research study suggests that RFID technology is a multidimensional concept that encompasses the traditional classifications of innovations (e.g., technological and organizational innovation, product and process innovation, incremental and radical innovation, interactive innovation) and emerging classifications such as open innovation. Therefore, any study on the assessment of the impact of RFID-enabled supply chain optimization should be aware of the locus of interest of each supply chain stakeholder with regard to RFID technology in order to better capture the network effect associated with the technology.

Keywords: RFID technology, diffusion of innovation, open innovation, living laboratory.

1 INTRODUCTION

Radio frequency identification (RFID) is a ‘wireless automatic identification and data capture (AIDC)’ technology (p. 615) (Fosso Wamba et al. 2008) that uses radio frequencies to identify item level products automatically in real time (Poirier and McCollum 2006). RFID is view by some scholars as “one of the most pervasive computing technologies in history” (p. 18) (Roberts 2006) that is able of achieving the Mark Weiser vision of ubiquitous computing where technology is seamlessly integrated into our daily lives (Weiser 1991). Some scholars even suggested that RFID is a “disruptive technology” that will profoundly change our lives and the way of conducting business (Krotov and Junglas 2008). For example, the “Future Directions for IEEE Conference Business” identified RFID technology as one of the ten new and emerging technologies that, when successfully adopted and used, can lead to high impact and high strategic business value in addressing key global issues and challenges that are inter-related disaster management, security, megacities management, energy, environment, and healthcare (p. 1) (Ward-Callan 2007). Likewise, (Bardaki et al. 2007) argue that the effective use of RFID technology within a supply chain (SC) and supply chain management (SCM) is “expected to revolutionize many of the collaborative supply chain processes and to empower new collaboration scenarios, such as anti counterfeiting, product recall and reverse logistics, collaborative in-store promotion management and total inventory management” (p. 110). It is probably for these reasons that (Srivastava 2004) views RFID technology as “the next revolution in SCM” (p. 60). Against these backgrounds, (CEA-Ramirez 2006) argued that all progress concerning RFID technology constitute the outcome of the continue evolution of onboard electronic equipment, which has led to the decentralization of information processing capacities, therefore, RFID technology can not be viewed as a disruptive innovation. These conflicting views represent a serious problem when it comes to analysing the real business value of RFID technology as a new wave of innovation. Furthermore, little has been written on the analysis and classification of RFID technology through the lens of the diffusion of innovation theory. Therefore, this research is an initial effort towards bridging the existing knowledge gap in the literature. More precisely, this research draws on earlier studies on RFID technology research agendas by (Curtin et al. 2007) to examine the following research question (p. 97):

RQ: Are traditional innovation classifications appropriate to analyse RFID technology?

In order to address this question, this research draws on extant literature on the diffusion of innovations with an emphasis on innovation classifications and the “open innovation” as well as an analysis of a longitudinal case study conducted in a five tightly inter-related firms of a Canadian beverage SC which are currently exploring the potential of RFID technology.

The remainder of this paper is structured as follows: the next section present a primer of RFID technology. The subsequent section positions RFID technology into the diffusion of innovation landscape. The section after that describes the research methodology. The following section discusses a longitudinal case study of a five tightly inter-related firms of a Canadian beverage SC which are currently exploring the potential of RFID technology to identify the RFID innovation focus for each stakeholder. The penultimate section is the conclusion.

2 RFID TECHNOLOGY: AN INTRODUCTION

RFID is a considered as an emerging inter-organizational information system (IOS) that allows the integration of intra- and inter-organizational business processes as well as with intra- and inter-organizational applications, and thus positioning the technology as “the next big thing for management” (p. 154) (Wyld 2006) and “the next revolution in supply chain” (p. 1) (Srivastava 2004). However, RFID is not a “new technology”. Indeed, the first industrial application of RFID technology dates back to World War II when it was used by the British army. However, recent advanced progress on on-board electronic and nanotechnology has created a momentous renewed interest in RFID technology. A basic RFID system is made of chips -which are also RFID tags or transponders tag

which acts as an electronic database and can be embedded or attached to a physical item to be identified and tracked-, one or more readers or interrogators, and a host computer or middleware that ensure communication between the RFID infrastructure and the different intra- and inter-organisational systems to support business transactions (Asif and Mandviwalla 2005). RFID technology offers greater capabilities when compared to traditional AIDC systems (e.g., bar coding). For example, it enables a real-time and unique identification of items/entities and products with the so-called intelligent tags throughout the SC, a high-level integration of data, and access to much richer data, and with the desired granularity (ex. item, box or pallet).

3 BACKGROUND OF THE STUDY

3.1 RFID as a Technological and Organizational Innovation

Innovation plays an important role in the current digital economy. For example, innovation enables firms to introduce new goods and services in the market in order to ensure their economic sustainability (Boly 2004). An innovation is “any idea, practice, or material artifact perceived to be new by the relevant unit of adoption” (p.10) (Rogers 2003). When an innovation implies the adoption of an idea influencing directly the firm’s key processes, we are dealing with a technological innovation. Concerning organizational or administrative innovation, it includes changes that impact on the firm’s organizational policies, resource allocation, and any other factor associated with the firm’s social structure (Cooper 1998). For instance, the adoption of a production system to support the activities of a manufacturing firm may be considered a technological innovation, while a change in the firm's organizational structure -to enhance the implementation of a new business strategy- is viewed as an organizational innovation (Hadaya 2004). For (Cooper 1998), there is a reciprocity relationship between the organizational and the technological innovations. Indeed, the introduction of technological innovation into the firm is generally followed by an organizational-transformation process dictated by the requirements of organizational innovation, and vice-versa.

The few definitions of innovation above suggest that RFID technology is both a technological and organizational innovation. RFID is indeed a practice considered as new to many firms (Gogan et al. 2007). In addition, RFID technology stands as an enabler for the implementation of collaborative practices such as the collaborative planning, forecasting and replenishment (Lefebvre et al. 2005) or build-to-order practices (Gunasekaran and E.W.T. 2005). RFID adoption in a SC requires an in-depth re-definition of (i) the business strategy of each network member; (ii) the competences within the business network (Fosso Wamba et al. 2008). RFID also allows the collection of product data in real time and automatically, thus contributing to increase the accuracy of data, reduce uncertainty level in the SC (Cannon et al. 2008), and enhance the decision making process within SC (Lin et al. 2006). These few examples show the potential of RFID technology as a technological innovation, and its potential impact on the management of organizations. These organizational changes are well commensurate with the requirements of any organizational innovation, and illustrate the dimension of “organizational innovation” that RFID technology possesses.

3.2 RFID as a Product and Process Innovation

Innovation can traditionally imply a product or a production process. Product innovation refers to the introduction of a new product or improved version of an old product in the market; on its part, process innovation is related, on the one hand, to changes in the sequence of activities, and on the other hand, to the emergence of new techniques or the improvement of the already existing ones to support the production of goods or services (Habhab 2006; Utterback 1994). Product innovation is market-oriented and focused on the satisfaction of the end customer. Process innovation has a rather internal orientation to develop new capabilities and competences that increase organizational efficiency (Utterback and Abernathy 1975). Many authors argue that there is a considerable interdependence between product innovation and process innovation. Indeed, changes in a product generally give rise to other changes in the production process of the product.

Concerning RFID technology, the innovation is clearly centered both on the product and the process (Chao et al. 2007b; Roberts 2006). In 1926 indeed, a variety of RFID systems with different forms, operating models and performances were developed to take into account the various needs and constraints of RFID applications (Gogan et al. 2007). This multiplicity of RFID systems' product innovations results in (i) a high rate of patents for the said systems (around 3,952 patents between 1973 and 2008, with a record of 2,781 patents for North-America from 1987 to 2007 (Govada et al. 2008), and (ii) a massive number of new types of RFID components in the market. For example, the tag "Memory Spot" that has been recently developed by the HP Laboratories' researchers is considerably advanced in terms of product innovation. This new generation of RFID tags actually has impressive characteristics: a size smaller than a rice grain (2 to 4 mm²), a memory in read-and-write mode capable of storing several megabits, an integrated antenna, a data transfer rate of approximately 10 megabits per second (10Mbps) (HP 2006). Furthermore, RFID components are increasingly used as enablers of the emergence of new high-value-added products. For instance, the use of RFID tags by the processing industry stakeholders is redefining the perception of product packaging units. Indeed, the concept of "intelligent packaging" is taking shape and is emerging with the use of RFID tags. Such packaging is able to provide information on the products, and therefore enable a more efficient management of their life cycle (manufacturing date, name of producer, production place, expiry date, date and place of the last handling place, recycling place etc.) (Rundh 2008). Moreover, not only does packaging plays its primary role of product protection, but also it is suggested that it may serve as a vehicle for environmental information such as the reusable or recyclable characteristic of the pack (Rundh 2008), thus transforming the purchasing experience of consumers. This is both a product innovation (from the perspective of the processing industry stakeholders) and process innovation (from the consumer's viewpoint). Concerning RFID process innovations, their production techniques have experienced an important breakthrough, which aims to lower the unit prices of RFID technology's components, improve on operational quality, and therefore speed up the adoption of the technology (Chao et al. 2007a). An example is the case of Alien Technology, which recently developed a revolutionary assembly technique called "Fluidic Self Assembly". This enables a larger production of RFID tags (some 2,000,000 per hour, as compared with 10,000 per hour with the current techniques) (ALIEN-TECHNOLOGY 2008).

3.3 RFID as an Incremental and Radical Innovation

Classifying an innovation as being incremental or radical is undoubtedly one of the mostly-used concepts to describe an innovation (Cooper 1998; Habhab 2006). A radical or breakthrough innovation can be defined as "an innovation impacting significantly on a market and on the economic activity of firm in that market" (p. 68) (OCDE 2005). Radical innovation generally enables organizations to develop new products for which there is not yet any competition, largely redefine their business networks, and even change the rules of the game within the industry for their own profit (Garcia and Calantone 2002). Moreover, radical innovation can help make obsolete the existing products, services or processes (Christensen 1997; Tushman and Anderson 1986). However, for many researchers radical innovations are at the base of large economic circles and appear as powerful enablers of firms tools helping organizations to achieve their competitive advantages whether for introducing new products and services into the market or accessing new markets to ensure their survival (Schumpeter 1934). Incremental innovation- also called progressive or continuous innovation-, on its part, concerns minor improvements on an existing product, service or process. They may be minor enrichments around a radical innovation, therefore making the incremental innovation become complementary to radical innovation (Habhab 2006). The incremental innovation is also known to contributing to the accumulation process of organizational knowledge. It is easy to understand it (as it is already present in some way within the organization); it is simple to manage and implement it (Chouteau and Vievard 2007; Habhab 2006). The incremental innovation is also a powerful tool for realizing the competitive advantage concerning productivity gain, through continued improvements (Garvin 1988).

Other authors such as (Abernathy and Clark 1985) suggest going beyond the radical innovation-incremental innovation divide. By considering the relationship aspect and competences, the authors

estimate that the capacity of a firm to achieve a competitive advantage depends on its “transilience” or its capacity to influence the resources and key competences within the firm. To this effect, they propose a dynamic model called “transilience map”. This model presents four types innovation and describes the firms’ development and management modes: architectural, niche, regular or incremental, and revolutionary or breaking.

The architectural innovation is characterized by large forms of market and technological transilience, which are notably made of a destruction of the existing commercial relationships and a technological divide. Such an innovation affects (i) the industry's structure in terms of creation of new industries or in-depth reforms of the old ones; (ii) products through the emergence of a new architecture; and (iii) the production processes in order to support the entry of new types of products in the market. Niche innovation allows opening new business opportunities by capitalizing on the existing technologies. This type of innovation is more market-oriented and helps to maximize sales by bringing minor changes to the existing products in order to reach new customers (Dupuis 2002; Park 2007). The regular or incremental innovation is characterized by minor changes on the already existing technologies and production processes. With time these modifications may have major cumulative impacts on the costs, the production means, and the product and process performance. In general, the regular innovation is based on the firm's key competences, and is applied to a market and the existing customers. The contribution of the incremental innovations to organizations, especially as regards to knowledge accumulation and development of new implementation capacities for new products and processes, is largely acknowledged in the academic literature (Habhab 2006). Lastly, the revolutionary innovation makes renowned technologies and production competences become obsolete. However, it keeps and strengthens the existing commercial relationships. The revolutionary innovation is concerned with the market prospects, the technological solutions and the industry’s structure.

Given that RFID technology (tag, reader and middleware) and the different possible applications offered by the technology are composite, I believe that RFID technology constitutes a “hybrid innovation”, which comprises elements that are considered to stem from a revolutionary, architectural or incremental innovation. For instance, RFID adoption in the SC as the next generation of bar codes may be viewed as a revolutionary innovation. Indeed, using RFID technology as an optimization tool for SC activities that replaces the bar codes, need to make important investments in the infrastructure of the technology and in supplementary technologies, and for all stakeholders (manufacturers, suppliers and retailers) (Fosso Wamba and Chatfield 2009). In the end, RFID technology will render the bar code obsolete in the SC, while conserving business relationships between the SC players and the targeted market (Park 2007). Moreover, (Park 2007) argues that RFID technology enables the consolidation of the SC stakeholders' competitive position on the existing market by using mainly the current competences of their customers. However, putting in place RFID systems requires new competences that are completely different from those required for setting traditional AIDC systems such as the bar code (Park 2007). (Fosso Wamba et al. 2008) agree wholeheartedly with this and stress on the need to implementing new competences such as process managers, RFID data analysts, RFID systems technicians, RFID maintenance officers in the business network, in order to make it easy the materialization of RFID full potential. Furthermore, integrating RFID into the SC processes can generate impacts regarded as radical innovations (Cannon et al. 2008; Lefebvre et al. 2005). For example, adopting RFID technology in the business network may lead to the destruction of the existing competences, thus driving organizations to fully re-invent their key processes in order to survive (Cannon et al. 2008). Moreover, RFID technology imposes the complete re-engineering of warehouse activities in the SC (Lefebvre et al., 2005), and facilitates the emergence of new concepts such as the “intelligent process” (Fosso Wamba et al. 2006), the “communicative object” (Ferguson 2002)(Ferguson, 2002) or the “intelligent object” (Lampe et al. 2005; Wong et al. 2002), which are entities capable of communicating and even interacting with their environment. In the packaging industry the use of “intelligent packaging” is revolutionizing the process through which the products pass from the manufacturer to the consumers (Heiskanen et al. 2007), by making it easy (i) to shift from a passive management mode to a more proactive management mode based on exception management, and (ii) the implementation of strategies that allow an efficient fight against counterfeit products (Berkhout et al. 2007). More widely, coupling RFID technology with Internet or emerging

networks (e.g., the EPC network) allows an extension of the concept of “intelligent object” to that of “the Internet of objects” (Ranasinghe et al. 2004) or “the Internet of artifacts” (Gadh 2004), which is a situation where “intelligent objects” communicate through the Internet (Rundh 2008). In this regard, (Gadh 2004)(p. 1) says: “The wireless Internet of artifacts (things) is a phenomenon that’s going to become increasingly ubiquitous in some shape or form since it allows any artifact to become part of the Internet and to eventually be tracked”.

As for the RFID technology components, the development of the “Memory Spot” tag can be considered an architectural innovation in view of the very structure of the product and its operational performance. Indeed, this innovation gives way to new market perspectives owing to its capacity to henceforth enable an access to any digital information on any surface, object or document (e.g., hospital bracelets with the patient’s medical information, a passport with biometric data). By contrast, the “Memory Spot” innovation requires the implementation of new production processes either for massive production or for the output that will use the innovation, thus making the traditional technologies for producing RFID tags become obsolete (HP 2006).

While the two preceding examples fall in line with the radical or architectural innovation, it should be however noted that from the electronic industry’s perspective, all progress concerning RFID components constitute “the outcome of the natural evolution of onboard electronic domain equipment, which has led to the decentralization and incorporation of information processing capacities” (p. 15)(CEA-Ramirez 2006). So from this perspective, RFID technology can be viewed as an incremental innovation. The same can be said of RFID-enabled kanban systems within various industries (e.g., automotive industry). Indeed, this application implies that minor modifications have been effected on the current kanban systems, and that no impact is recorded on the existing production processes. On the other hand, it helps to optimize the management and circulation of automobile modules on production sites, and to reduce the number of scraps, thus positioning RFID technology as an important enabler of lean manufacturing (Poirier and McCollum 2006). For (Fine et al. 2006) despite claims about the disruptive potential of RFID technology, most of the applications involving this technology in the SCM are only incremental innovations for now.

Following the presentation of RFID technology with respect to the traditional classification of innovations (administrative vs. technological, product vs. process, incremental vs. radical), it appears that the technology is a multidimensional concept, and that any study on the assessment of its impacts on business networks should therefore consider this aspect. This ties up with the remarks of (Cooper 1998), who estimates that any innovation should be analysed from a multidisciplinary perspective. However, the previous classifications suggest that the generation process of an innovation is linear and hierarchical, characterized by a series of compulsory and ordered steps beginning with invention. Such a process presupposes that the organization evolves in an autarkic context and that all process steps are known beforehand by the organization, which can therefore foresee the requirements for the human, financial and material resources that are necessary to conduct the process. The existence of this linear model of process innovation depends on the presence of R&D activities, and does not give any option for the implementation of go-back strategies between consecutive steps (Chouteau and Vievard 2007). This conception of process innovation is more and more criticized. Many academic actually argue that process innovation is not a linear and hierarchical model, but rather an intrinsically interactive and cumulative process (Gallouj 2002; Kline and Rosenberg 1986; Youtie and Shapira 2008), which is distributed, open and which involves stakeholders from diverse sources (Chesbrough 2004; Christensen et al. 2005). In such a context the innovation performances of a firm largely depend on their capacity to absorb external sources of information, knowledge and technologies, and require a refocusing of R&D functions toward a greater cooperation with the customers, suppliers, rivals, universities and public research organisms (Blasco and Carod 2008). This repositioning of process innovation has generated new concepts such as the interactive innovation (Kline and Rosenberg 1986) and the open innovation (Chesbrough 2003b; Christensen et al. 2005). In the following sections, I will usher in new concepts and position RFID technology in relation to these concepts.

3.4 RFID as an Interactive Innovation

(Rogers 2003) estimates that an interactive innovation is less useful to the unit adopting it, unless other members of the social system adopt it as well (ex. mobile telephone, email and text message). So whether an interactive innovation is useful depends on the size of the user community (Mahler and Rogers 1999). On the other hand, the interactive innovation is a powerful tool for cross-cutting information exchanges (Rogers 2003). Also, adopting such an innovation is considered as the result of mutual influence between the users and producers of the innovation (Dimmick et al. 2007). For example, (Kline and Rosenberg 1986) see the interactive innovation as a whole of steps that are correlated and marked by ins and outs between all the possibilities offered by the innovation and the market. In some cases, the organization succeeds by fostering strategic and technological alliances that enable it to rapidly access to collective resources in order to address imperatives related to the innovation complexity management (e.g., key competences that a single organization cannot afford). Indeed, putting in place such alliances is generally regarded as the better way of initiating and keeping links between different actors around their resources (financial, human, and informational) and their activities (Hakansson et al. 1999). Moreover, what can drive a firm to alliance adhesion may be the desire to get access to the competences of one of the alliance members (Gulati 1998; Williams 2005), the facilitation of inter-organizational learning, and the willingness to serve as a lever to relational innovation (Hakansson et al. 1999), to reduce risks and uncertainties concerning a complex technology (e.g., RFID technology), and to achieve the economies of scale (Halilem and ST-JEAN 2007). It is not surprising that some authors conceptualize interactive innovations as a “network of participants” (Dimmick et al. 2007) where the critical mass, the network effects-also called the network’s positive externalities-, and the accounts with the existing standards become determinants in their adoption process (Dickinger et al. 2008). Indeed, in the case of interactive innovations, the adoption rate largely depends on the access to a critical mass of adopters who, once they are reached, speed up the adoption process, which will keep progressing in a self-sustained way (Rogers 2003). In addition, the usefulness of the interactive innovation increases as there are new adopters of the innovation, which generates a strong bidirectional interdependency relationship between the early adopters and the future adopters (Rogers 2003). Rogers therefore talks of a process depending on the past and the future to illustrate the fact that the benefits of the interactive innovation go both to the early adopters and the future adopters. This positive feedback coupled with the critical mass help not only to improve on the quality of the available information on the innovation-and therefore contribute to diminish the adoption risks faced by the new adopters-, but also to enhance learning by usage, thus contributing to enhance performances in the use of the innovation, and to reduce the adoption costs (Penard 2003). The compatibility of interactive innovation with established standards is important to impact on the adoption rate (Mahler and Rogers 1999). Also, the existence of standards gives rise to positive externalities that can enable the suppliers of the interactive innovation to achieve economies of scale, and therefore decrease the innovation adoption costs (Penard 2003).

From what precedes, I believe that RFID technology, like the telephone, the Internet and the electronic commerce appears as an interactive innovation. In SCM, the more the stakeholders adopt RFID technology, the more considerable are its impacts (Fosso Wamba and Chatfield 2009), which are expanded along the chain (Boeck and Fosso Wamba 2008; Bottani and Rizzi 2008; Quaadgras 2005; Whitaker et al. 2007). Regarding RFID tagging strategies for example, (Boeck and Fosso Wamba 2008) outline the importance of SC stakeholders collaboration to achieve them as far as possible upstream in the SC (ex. the contracting manufacturer who is far upstream), so as to maximize impacts (positive network externalities) at the overall SC level. (Quaadgras 2005) is not far from this viewpoint when the author suggests that, in the context of SCM or RFID alliance, the adoption and use of RFID technology must stand as a “collective activity”. For the author, strategic data from RFID infrastructure are essential for supporting information and communication flows -the author talks of information and communication loop- in the SC. Moreover, the absence or failure of the technology in any part of the loop leads to inefficiencies in the whole SC communication process. This way of viewing RFID technology in the SC highlights the strong bidirectional interdependency relationship concerning the adoption of the technology both by the early adopters and the late adopters. Clearly,

the value of RFID systems data will increase as SC participants adopt RFID technology and get involved in the exchange of data across the SC network (Fosso Wamba and Chatfield 2009).

Moreover, the selection and development of a robust RFID infrastructure imply that there is an interaction between many RFID industry players (ex. suppliers of RFID tags, readers, middleware, and complementary devices), which therefore requires the development of strong technological alliances and a large complementarity between the various stakeholders in the RFID technology industry (Adomavicius et al. 2006; Quaadgras 2005). (Adomavicius et al. 2006) and (Quaadgras 2005) borrow the ecosystem's metaphor ("RFID ecosystem" or "RFID business ecosystem") from the organization's ecological theory (Iansiti and Levien 2004) to underscore the complexity of business relationships within the RFID technology industry. For them, it is necessary to review the interdependency between the various RFID systems and the environmental factors that may influence their evolution and development. For example, the emergence of new standards for RFID technology enhances their interoperability and rekindles activities for developing supplementary technologies (Adomavicius et al. 2006). As for (Quaadgras 2005), the author argues that establishing technological alliances is a viable solution to deal with the complexity of RFID systems. More importantly, she believes that a single firm cannot define the standards for all RFID technology components, coordinate and integrate all RFID systems components (physical and software infrastructure, complementary devices). (Dew and Read 2007) share this opinion and highlights the fact that the existence of RFID-related network externalities increases coordination problems between the different RFID system suppliers and potential users. For instance, concerning direct externalities, the costs of RFID systems now appear as a considerable barrier to potential users. In this context, the advantages of RFID systems as compared with the bar codes should include very low costs for their components (tags, readers and middleware). This implies that a critical mass of users should agree on common adoption standards so as to reach a high number, thus reducing the production costs. With regard to indirect externalities, the one generated by any RFID infrastructure is an example. Any RFID system is made of sub-systems (RFID tags, RFID readers, middleware, etc.) which are useless if separated. An RFID tag producer will be more inclined to develop more efficient and cheaper new generations of these components for a given customer industry (for instance, a retail industry) if the customer proposes a wide base of potential adopters. An organization adopting RFID technology in a SC which already uses tags from the same producer will generate positive indirect network effects for the network stakeholders who have already adopted the technology, as by consolidating the installed RFID system base, the organization enhances the development of new tags (Park 2007; Penard 2003).

However, the emergence of RFID alliances of "EPCglobal type" helps to resolve coordination problems and start standardizing RFID systems, thus speeding up their adoption. Indeed, (AL-Kassab and Rumsch 2008) estimate that a sufficient level of RFID standards will undoubtedly help to reduce the costs of RFID systems in any industries owing to the economies of scale, and eventually enhance its large-scale adoption. (Curtin et al. 2007) agree on this, while arguing that RFID systems cost reduction and its fast diffusion in the business network will be supplementary arguments to be used by managers to justify the expenses incurred in RFID technology implantation projects. Later on, (Curtin et al. 2007) propose to firms engaged in RFID technology adoption projects to capitalize on their current business networks when implementing product tagging strategies. They estimate that with RFID technology, the phenomenon that came up during the adoption of the aforementioned interactive innovations shall again be observed: the more firms will adopt a precise RFID technology standard in the SC, the more this standard will be used and will eventually become the dominant standard. The possibility to use RFID systems in numerous applications that are deemed strategic constitutes an externality related to the decrease in RFID systems prices. For example, these systems may be used for the monitoring and tracking of cattle infected by the mad cow disease, thus minimizing the propagation of the pathology (Bitko 2006). It is well understood that to develop this type of application, a critical mass of adopters of the technology should be reached in the SC (Hingley et al. 2007). On the other hand, adopting RFID technology at the intra- and inter-organizational business process level offers many enhancement perspectives in procurement strategies, the development of new products, and inter-organizational alliances (Kauffman and Kumar 2008).

In spite of this seemingly idyllic situation, (Van DE Voort and Ligetvoet 2006) estimate that for now, the forces of the market do not favor a rapid adoption of RFID technology. The authors indeed argue that the causes are numerous and diversified, the major ones being (i) the asymmetry of information between the various players involved in the adoption of the technology at the SC level, (ii) the impossibility to test the various RFID applications, (iii) the high and risky level of the investments to be achieved in relation to RFID integration projects, (iv) lock-in risks in RFID ownership solutions, (v) dependency towards patents, and (vi) the existence of multiple stakeholders in the RFID solution implementation. Moreover, the authors estimate that even if it were necessary and praiseworthy to have standardization organizations such as EPCglobal, these organizations should go beyond a simple standardization mandate and promote the use of software of “open source” type in the development of the basic infrastructure of RFID technology. Such a strategy will enhance transparency within the RFID industry, and reduce RFID system adoption costs. More clearly, the author is promoting and “open innovation” approach.

3.5 RFID as an Open Innovation

Traditionally, many large firms used the R&D departments to supervise and monitor the creation process of innovations and support their growth (Chesbrough and Crowther 2006; Gassmann 2006). For many organizations, R&D departments had for a long time served as the main tool for competitive advantage creation and realization within markets with entry barriers (Chesbrough 2003b). However, organizations are now evolving in a more opened and globalized market, which is geographically much divided, segmented and marked with the reduction of products life cycle, and with increasingly sophisticated customers. Moreover, many technologies with considerable revolutionary capabilities and requiring competences that a single organization cannot afford to absorb them are introduced into the market in a frenetic way (Gassmann 2006). In such a context, many academics and practitioners suggest that organizations should get access to external sources (ex. knowledge, ideas, innovations etc.) not only to support their R&D activities, but also to facilitate their own internal innovation process (Bughin et al. 2008; Chesbrough 2003b). This new approach, which is called open innovation, has been initiated, developed and popularized by Henry Chesbrough, through his book “Open Innovation: The New Imperative for Creating and Profiting from Technology” (Chesbrough 2003b). This new technology management paradigm supports the idea that the benefits from the efforts of a focal firm’s R&D department are more important when the focal firm opens up to its external environment. This opening can be visible through inter-firm partnerships and collaborations, which may be particularly beneficial in terms of research cost sharing, supplementary revenue production, very fast access to new ideas, knowledge and low-cost technologies, experimentation of an emerging technology’s potential, or reduction of emerging technology adoption risks (Chesbrough 2006b). (Chesbrough 2007) (p. xiii) says: “open innovation offers that prospect of lower costs for innovation, faster time to market, and the chance to share risks with others”. The same author (Chesbrough 2003b) estimates that good ideas may come from outside rather than from within the organization, and that any enterprise seeking a viable competitive advantage in the current economic context should “ensure that its frontiers are porous” to external sources.

In this paradigm, any new technology in results from an intense inter-firm collaboration. It comes from a combination of both technologies internally developed by the focal firm’s R&D department, and technologies from external sources (Chesbrough 2003b). In the open innovation context, a firm is constantly searching for business opportunities in its environment (Kock and Torkkeli 2008). (Chesbrough 2003b) suggests that organizations can gain a better profit from their internally unexploited innovations and intellectual properties by transferring them out of the firm through mechanisms such as licenses, patents and spin-off. Equally, the operationalization of open innovation can result in the assessment, selection and establishment of a new technology in a business network in order to enhance its performance (Fredberg et al. 2008). For example, concerning the exploitation of a radical innovation by a focal firm, the use of an open-innovation approach is suggested and is economically beneficial to the developers of the said innovation (Lichtenthaler 2008a).

Nevertheless, an approach based on open innovation requires a certain number of prerequisites; they are: (i) the redefinition of the duties of the R&D department, which is traditionally meant to operate

on the “linear innovation” model (Chesbrough 2003a); (ii) the adjustment of the current business models in order to give the necessary flexibility for the operationalization of concepts such as co-development, inter-organization collaboration, and knowledge sharing (Chesbrough and Schwartz 2007); the aim is to create value in the business network and capture part of this value for the focal firm (Chesbrough 2006a); (iii) the redefinition of operational design concepts and organizational boundaries (Lichtenthaler 2007). According to (Lichtenthaler 2007), organizations should make sure the access to external resources is a strategic activity, which should be in accord with the current strategies of the firm; (iv) the development of an organizational culture and leadership geared toward open innovation. Indeed, organizations today are more orientated to intra-organizational optimization (Fredberg et al. 2008); (v) the use and tools, technologies and interfaces that can enable the operationalization of the open-innovation concept in the business network (Gassmann et al. 2006); and lastly (vi) a better management of intellectual properties, licenses and patents in the business network (Lichtenthaler 2008b).

This analysis shows that RFID technology can be considered an open innovation. Indeed, the inclusive nature of an open innovation enables the applicability of all proposals hitherto made on RFID technology, in relation to the different types of innovations that have previously been studied. However, the open innovation specially emphasizes the importance of sharing and transferring knowledge through the business network, inter-organizational collaboration, and business model re-engineering. As prerequisites to the success of the open innovation, these factors are being increasingly discussed in recent studies on RFID technology. Indeed, in the SC context, (Fosso Wamba and Chatfield 2009; Lefebvre et al. 2005; Lekakos 2007) highlight the fact that realizing the RFID technology impacts in a network of firms depends on the sharing level of information from RFID data, as well as the level of collaboration among the SC players.

In other words, if SC suppliers want to benefit from the potential of RFID technology, they have to share the data from the RFID infrastructure with the business partners, and jointly exploit these data so as to turn them into business intelligence (ex. market knowledge, consumption pattern, etc.) (Lekakos 2007). Information sharing may lead to a better coordination in the SC (Heese 2007), the implementation of lean manufacturing strategies (Poirier and McCollum 2006), the enhancement of replenishment decisions throughout the SC, and to the reduction of the “bullwhip effect” (Bottani and Rizzi 2008). Moreover, putting in place traceability applications in the SC requires a collaborative approach to attain sustainable benefits (Hingley et al. 2007).

For his part, (Adner 2006) discusses the necessity of assessing the risks resulting from emerging technologies such as RFID while insisting on the need to identify the interdependence relationships that may influence the success of a project of introducing this technology. (Bovenschulte et al. 2007) estimate that knowledge sharing between the early adopters of RFID technology and the firms exploring the potential of the technology may contribute to speed up its adoption in firms, and therefore appear as a solution to the concerns of (Adner 2006). Like (Lefebvre et al. 2005), they argue that RFID technology will facilitate the implementation of inter-organizational concepts such as CPFR, ECR and VMI. (Lefebvre et al. 2005) go further and demonstrate that RFID technology enables the putting in place of new and innovative business models.

The most cited case in academic literature concerning a firm using RFID technology in the whole SC is that of the European retail conglomerate Metro Group in Germany (Bovenschulte et al. 2007; Loebbecke 2007; Loebbecke and Huyskens 2008; Tim and De Man 2006). This project results from an intense collaboration between fifteen partners of different sizes and from various sources (for instance, technology suppliers, suppliers of Metro Group, integrators of solutions, etc.). Though coming from different places, all these partners had the same objectives, namely RFID technology operationalization in a network context, as well as the sharing of information gathered throughout the project (Bovenschulte et al. 2007). The focal firm Metro Group, through this open-innovation approach, succeeded in integrating its partners in its R&D process, and give them the opportunity to actively contribute to the development and implementation of RFID applications at the SC level; another victory of the firm was the sharing of costs and risks, as well as the profits from RFID applications implementation. Moreover, because the project is carried out in a real environment with real consumers among other things, this helps obtain their feedbacks, which allows, where necessary,

to adjust RFID applications, measure in real time the impacts of these applications on consumer efficiency, productivity and satisfaction, as well as on the level of sales (Tim and De Man 2006).

This approach by Metro Group contrasts with the RFID installation approaches hitherto adopted by many early adopters in retail industry's SCs. In these approaches, most of RFID installation costs are supported by the suppliers of originators (Spekman and Sweeney II 2006). (Bardaki et al. 2007) estimate that such an approach has a negative impact on the acceptance of RFID technology by the market and contributes to stall its diffusion among the network suppliers. These remarks support the need for a vision based on open innovation and in which the suppliers are regarded as business partners to be involved in the search of the best way to use RFID technology as a lever for creating value for all SC players and not only for one of them (Ruile and Wagner 2008). This view is shared by (Spekman and Sweeney II 2006) (p. 741), who say: "RFID in the SC is new and poorly understood by all but a few specialized firms, therefore the potential benefit for all participants in the collaborative SC is astronomical if the parties collaborate and mimic an open-source model to create a cooperatively built system of data sharing, system monitoring, and traceability throughout the entire value chain". In the end, it seems that there is a consensus within the academic community on the importance of open innovation. For now, however, there are relatively few tools, methodologies or models enabling its operationalization (Smart et al. 2007).

4 RESEARCH METHODOLOGY

The main objective of this study is to improve the theoretical and practical understanding of RFID technology as an innovation concept, the research design undoubtedly falls into the realm of exploratory research. Afterwards, a longitudinal case study was conducted in a five tightly inter-related firms (Focal Firm F, Retailer R, three first-tier suppliers SUP1, SUP2, SUP3) of a Canadian beverage SC which are currently exploring the potential of RFID technology. (Eisenhardt 1989) defined the case study as "a research strategy which focuses on understanding the dynamics present within single settings" (p. 534). This research approach allows to focus on emerging phenomena and ultimately induce theories (Benbasat et al. 1987). Case study approach is recognized by many academics as a appropriate methodology to answer research questions such as "why" and "how" things are done (Yin 1994), and is therefore appropriate to study RFID technology as a new "innovation concept", where research and theory are at their early and formative stages (Benbasat et al. 1987).

The focal firm (Firm F) is an important player within the Canadian beverage industry with about 6000 staff members and an overall annual volume of 15 million cases of products transiting through its Distribution Centers. Currently, Firm F relays on bar code systems to track the vast majority of its products. However, the firm also has experience with the implementation of more complex information systems for intra-and inter-organizational business process optimization including an enterprise resource planning, a B2B Web portal, a transportation management system and an EDI server. The suppliers are bottling plants that deliver their production to the focal firm on daily basis and are not very advanced technologically. They mostly use e-mail, fax and a paper system to communicate with the focal firm. The retailer selected for the study is one of North America's biggest companies and has an IS architecture similar to the one if the focal firm.

Multiple sources of evidence were used, including interviews, on-site observations, focus groups, time and motions studies and a proof-of-concept using the "Living laboratory" approach in order to increase construct validity (Yin 1994). The "Living Laboratory" represents a research methodology for sensing, validating and refining complex solutions (e.g., RFID technology) in multiple and evolving real-life contexts (Schumacher and Feurstein 2007), by engaging all project stakeholders at all stages of the project, and therefore gaining 'tacit knowledge' from users (Kristensson and Magnusson 2005), and ultimately improving user knowledge and acceptance of the innovation, product or service. In this project, the "Living Laboratory" was mainly used to simulate different scenarios of RFID-enabled SC optimization in terms of intra- and inter-organizational business processes optimization as well as intra- and inter-organizational applications integration. This step of the project involved twenty four persons, namely: seven key executives from the focal firm and its SC

partners, eight professionals and managers from technology firms (e.g., the middleware developers) and nine members of the research teams.

5 RESULTS AND DISCUSSION: FROM THE EXECUTION OF THE RESEARCH PROJECT TO IDENTIFICATION OF RFID INNOVATION TYPE FOR EACH STAKEHOLDER

This RFID research project began in July 2004 with an RFID workshop organized by a Canadian university based-research laboratory to raise the awareness on RFID technology within the community, and then initiated a discussion with different business and technological stakeholders on possible collaborations to assess the real business value of RFID-enabled SC transformation. Thereafter, two test beds SCs (one in the utility industry and one in the beverage industry) were selected based on the key business and technological stakeholder's interests towards RFID-enabled SC applications, as well as on their willingness to actively participate in the realization of the project. For example, the choice of key business stakeholders was based on their willingness to (i) allow the research team to access their sites to realize on-sites observations so as to analyze their current intra- and inter-organizational business processes and intra- and inter-organizational information systems, conduct interviews as well as time and motion measurements with key informants in order to facilitate the mapping of the current intra- and inter-organizational business processes and intra- and inter-organizational information systems, then gauge the feasibility of a range of RFID-enabled SC scenarios; and (ii) participate in all focus groups and RFID-enabled SC simulations scenarios buildings and assessments at the Canadian university based-research laboratory. In the end, the key technological stakeholders agreed to provide all the required equipments for the RFID-enabled SC scenarios. The beverage SC is a major focus of interest of this paper.

Within the framework of this research project, it was noticed that even if all key stakeholders had some common goals regarding RFID technology (e.g., "what is RFID technology?" –as a new type of product innovation), each of them was nurturing his/her own specific interest in relation to the technology. For example, the focal firm was more interested in "how best the firm can integrate the technology into its processes without major disruptions?", "How RFID technology can help the firm to solve the inventory discrepancy problem between its main distribution centres and its customers?", and "how RFID can help to reduce the warehousing cost?" (Type of technological and organizational innovation). More importantly, the managers of the focal firms were worried by the fact that RFID could be another "vendor push technology". Therefore, they were not willing to invest in RFID technology without having a full grasp of its potential on their business processes and IT infrastructure. For this reason, they were seduced by the idea of experiencing the potential of RFID technology in the Canadian university based-research laboratory without being locked in by a specific technology or without making any initial monetary investment (Type of open innovation). RFID middleware and reader vendors were more concerned about "how best to position their products in a new niche market" (Type of niche innovation) and "how to collaborate between them to smoothly integrate the different sizes of RFID middleware solutions at the SC level?" (Type of open innovation). The Canadian university based-research centre was more concerned by the best strategy to create an environment where each key stakeholder will actually capture the business value of RFID-enabled SC applications based on its business and technological requirements. The research centre also wants to assess the "interactive" and "open innovation" nature of RFID technology by building and offering an end-to-end RFID-enabled SC applications infrastructure to key project stakeholders in order to test and validate different scenarios integrating RFID.

Overall, even if the concept of open innovation seems new, I believe that it falls in line with the continuum of works initiated by (Teece 1986), who was among the first scholars to think about the best mechanisms that the firm could put in place to identify the supplementary assets that would enable the firm to benefit from its innovations (Teece 1986). This was without any doubt the first attempt to open the organizations to external innovation sources. Afterwards, the idea had been taken and formalized by many academics such as (Perks and Jeffery 2006), with the concept of "networks of innovation" or "transorganizational innovation", as well as by (Millar et al. 1997), who ushered in

the concept of "innovations in network", and finally by (Von-Hippel 1988), with the concept of "co-creation of innovation with the customer". All these concepts highlight the importance for a focal firm to use its network to, for instance, reduce its transaction costs or simply get access to additional resources (e.g., IT). For example, the technical cooperation and interactive apprenticeship in a firm network are considered as prerequisites to the success of any innovation (Debresson and Amesse 1991). Therefore, it becomes critical to study innovation not only from a focal firm focus but all from an the inter-organizational collaboration perspective (Powell et al. 1996).

New advancements from open innovation are definitely inclusive and integrate requirements and prerequisites (e.g., from innovations or inter-organizational relationships) to be met by organizations if they want to remain competitive in a complex and changing environment. The concept emphasizes the need for firms to open up their innovation processes in order to co-innovate with customers, suppliers, competitors, universities and research institutes. Indeed, in a context where the vast majority of firms rely on outside innovation for new services, products and processes, "increased co-operation in technology has become an important way of sourcing knowledge in order to generate new ideas and bring them quickly to the market"(p. 7) (De Backer et al. 2008). Open innovation allows firms to benefit from early involvement in new technologies or business opportunities, or to delay their financial commitment (Vanhaverbeke et al. 2008). However, the "openness" of firms to external knowledge may not be beneficial to them if they cannot identify the relevant knowledge and mechanisms to be incorporated into their innovation activities (West and Gallagher 2006). In such a context, the "Living Laboratory" approach offers a unique prospect to solve the said problem by offering a neutral real-life environment where the potential users of a given innovation, private organisations, solutions providers, academics, can capture and codify their experiences (Almirall and Wareham 2011).

6 CONCLUSION

This paper introduces RFID technology and positions the technology into the innovation diffusion landscape. It appears that RFID technology is a multidimensional concept that encompasses the traditional classifications of innovations as well as emerging classifications such as open innovation. The presentation of the focus of the interest of RFID technology by each key stakeholder in a case study confirms the multidimensional aspect of RFID technology as an innovation concept. This study presents a limitation in the sense that it only focuses on one case study. Further studies are needed to empirically assess the importance of "Living laboratory" in the diffusion process of innovation and to validate the multidimensional aspect of RFID technology as an innovation concept.

7 ACKNOWLEDGMENT

This work was done during my Ph. D. studies at the Polytechnic School of Montreal, Canada under the supervision of Professor Louis A. Lefebvre and Professor Elisabeth Lefebvre. I want to acknowledge the financial support of SSHRC and FQRSC.

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