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Rethinking the Business Model with RFID

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Abstract:

Radio Frequency Identification (RFID) is an enabling technology that can provide organizations with unprecedented improved visibility and traceability of items throughout their journey in the value chain. This paper explores how RFID can impact traditional business models or create new ones. In particular, we propose an RFID business model framework and use it to show how value can be created for organizations, suppliers, customers, and business partners. We also identify the major dynamic phases of RFID and their corresponding impact on RFID business models. A taxonomy of 12 specific RFID business models is also presented, reflecting the wide spectrum of potential directions and applications of the technology. Finally, we present a case study to test the practical and theoretical relevance of our conceptual models. The paper outlines the need for technology managers to take a holistic approach to RFID business model innovation, taking into account the interrelated technical, strategic, organizational, and external environmental factors.

Keywords: technology management, RFID, business models, innovation

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I. INTRODUCTION

Background Information

Ongoing changes in the global business environment are forcing companies to periodically review and adapt their business model if they want to sustain competitive advantage. These environmental changes are triggered by many factors, such as changes in customer and market requirements, globalization of labor and resources, regulatory constraints, and technological innovations. Strong rivalry and commoditization of products and services are also pushing organizations to seek innovative ways to survive.

Emerging technologies have always been major drivers for continuous business model innovation and have been key enablers for cost reduction opportunities. The Economist Intelligence Unit conducted a global survey for KPMG International involving 336 senior executives, one-quarter of which were CEOs, company presidents or managing directors. Ninety-three percent of surveyed executives are expecting further changes to at least one aspect of their business model over the next three years. Further, around 38 percent of the surveyed executives cited the emergence of new technologies as an issue that would necessitate major revisions of their business models [Lofhouse 2006]. In addition, new technologies have enabled new organizational arrangements among firms, suppliers, partners, and customers [Geoffrion and Krishnan 2003]. Value creation through new technologies has been highlighted a long time ago by the pioneering work of Schumpeter [1934]. According to the Schumpeterian theory, innovation-based competition is rooted on the premise that new technologies and innovations can create disequilibrium in the market, setting the stage for new value creation opportunities. One of these technologies is Radio Frequency Identification (RFID).

RFID is an auto identification technology that extends the commonly used bar code identification system to provide organizations with unprecedented improved visibility and tracing to items throughout their journey in the value chain. Supply chain visibility enables organizations to deliver the right products to the right place and at the right time . As an enabling technology, RFID promises to improve inventory management and operations, reduce labor and logistic costs, enrich customer services, stimulate further knowledge-sharing, and enhance security. The combination of RFID with sensor and GPS technologies, in addition to the ongoing decline in the price of RFID tags, are enabling innovative business models beyond value chain management.

RFID is not a new technology. It originated back in the 1940s when it was used for aircraft identification during World War II. New technological advancements however have facilitated the wider adoption of RFID. Today RFID is leading the way toward the "Internet of Things," a vision of an ubiquitous network society that will unleash collaboration and communication between people and things, and among things themselves.

The proliferation of RFID deployments in the market place is further accentuated by tagging mandates from major players. For instance, large retailers such as Wal-Mart, Target, Albertson's and Best Buy mandated that their top suppliers start implementing RFID tags on pallets and cases by early 2005. The U.S. Department of Defense (DoD) made similar directives to its suppliers, requesting RFID tagging of pallets and cases by January 2005. Driven by other factors, such as new regulatory mandates, a "me too" approach or the fear from being left behind, many organizations are also experimenting with RFID. However not all organizations will benefit from this technology. In fact, businesses are increasingly becoming aware that simply investing in RFID does not constitute a recipe for increased efficiency. Only those organizations with viable RFID business models will be in position to create business value from the technology.

Motivation and Research Relevance

There is so much talk about the benefits, applications, and key success factors of RFID, but there is no in-depth discussions on how RFID will impact existing business models or create new ones. Understanding the potential effects of RFID on business models is the first step toward innovative and adaptive business modeling. Such modeling can enable organizations make the best use of RFID in order to achieve superior value creation and sustain competitive advantage. History teaches us how some organizations developed disruptive technologies, yet failed to capitalize on them because of poor business models. The most famous case is perhaps that of Xerox, which gained very little from the innovations of its Palo Alto Research Center (PARC) [Kijl, et. al. 2005]. Another example is Netscape, which despite its first-mover advantage, lost the Web browser war against Microsoft. The loss

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is partially attributed to the vulnerability of Netscape business model (giving away its browser but selling server software), which Microsoft took advantage of to attack Netscape's revenue sources. On the other hand, the success of many companies like Dell, eBay, FedEx, and Amazon is often attributed to the way they exploited new technologies to innovate their business models, rather than to enhance operational efficiencies. As a result, and to be successful, enabling technologies require as much business model innovation and adaptation as innovation in products, services, or operations [The Economist Intelligence Unit Report 2005]. RFID is not an exception.

The need to explore the many facets of RFID business models is also fueled by the practical use of the business modeling approach in (1) supplying several business entities with a holistic and universal perspective that a shortsighted strategy cannot deliver [Eriksson and Magnus 2000]; (2) conveying business rules needed for successful strategy; (3) providing an adequate methodology and foundation for managers to understand new opportunities offered by RFID and react in an increasingly dynamic environment [Osterwalder, Ben Lagha and Pigneur 2002]; and (4) facilitating organizational transformation through a holistic view of the firm's inter- and intra-organizational processes and boundaries [Papakiriakopoulos, Poylumenakou and Doukidis 2001].

Research Methodologies

Our methodology for RFID business model innovation is partially inspired from the design science framework outlined by March and Smith [1995], as well as the work of Plavia et.al [2003]. For a comprehensive summary of these two contributions, the reader is referred to Osterwalder [2004]. Accordingly, this research makes use of five main methodologies,

Frameworks and Conceptual Models

As the backbone of this research, frameworks have been used as conceptual models to guide toward understanding the impact of RFID on business model components. Our approach is inspired by the business process analysis and modeling approach of McKibben and Pacatte [2003]. We basically apply a combination of a top-down and a bottom-up approach. In the top-down approach, we start with the main value proposition of RFID; that is the capability to quickly and automatically identify objects together with their properties. We then explore how this core capability can be used to improve existing business models or create new ones. In the bottom-up approach, we start with the basic components of a business model in mind, and then identify potential "pain points" within these components. We then explore how RFID data can address these pain points.

Conceptual research, in the form of RFID business model taxonomies and dynamic business models, has also been used. In doing so, we also made use of the literature analysis methodology, drawing on earlier findings from e-business modeling research.

Speculation/Commentary

Given some of the ambiguity surrounding RFID business case and its future applications, analogy, inference, and speculations have occasionally been used to initiate discussions on RFID business model innovation and taxonomies. Though these speculations are not backed by empirical evidence, they played a role in constructing some of the conceptual RFID models in this research.

Library Research/Literature Analysis

Key findings related to past research on business model innovation are highlighted in this paper. The paper also draws extensively on earlier research contributions in business modeling, particularly within the domains of e-business, strategic management, and high-tech innovations. By extending the cumulative knowledge on business models, as captured in the existing literature, we were able to move one step forward and establish a new base for RFID business modeling.

Secondary Data

This work makes use of financial data and statistics, derived from company Web sites, published case studies, and consulting reports. These are used to illustrate some of the claims in the paper.

Case Study and Interviews

This research uses a case study to test the practical and theoretical relevance of the conceptual models and frameworks of the paper. The case study is based on desk research (involving gathering data which is already available from internal sources, the Internet, newspapers and annual reports) and interviews with some managers at DP World who have been involved in some recent RFID initiatives. The interviews are based on a mix of open-ended and closed-ended structured questions.

Research Goals and Contributions

This research is the first step in trying to understand how RFID would revamp traditional business models or create new ones. The main goals of the paper are to:

- Draw on existing research contributions to propose an analytical framework to define the required components of an RFID business model and the external factors influencing it.
- Demonstrate how RFID can adapt traditional business models or develop new ones.
- Articulate how an RFID business model can define a framework for creating new value chains for customers, suppliers, partners, and other stakeholders.
- Outline the major dynamic phases of RFID evolution and their corresponding impacts on business models.
- Describe a taxonomy of specific RFID business models, which reflects the wide spectrum of the value-creation capabilities of the technology.

Structure of the Paper

The remainder of this paper is organized as follows: We present in the next section an overview of the business model and its role; after which we sketch our business model framework. We then briefly review the major components of an RFID system. With this background information in hand, we are ready to demonstrate how RFID can reshape existing business models or create new ones. We also identify the dynamic phases of RFID adoption. This is followed by a categorization of RFID business models into a number of typologies. We finally present a case-study to validate our conceptual models and conclude with a discussion of the main findings of the paper and implications for future research.

II. THE BUSINESS MODEL AND ITS ROLE

What Is a Business Model?

The term "business model" has gained popularity in the business press and then in the academic literature, with the rise of the dot.com in the late 1990s [Osterwalder, Pigneur and Tucci 2005]. Having the right business model became a key factor in understanding how organizations can compete in the digital economy and how e-business start-ups can raise funds [Seddon et al. 2004; Nagle and Golden 2007]. Some e-business models were even patented, such is the case of the *one-click* purchase model of Amazon.com or the *name your price* reverse auction model of Priceline.com.

Although there have been many earlier interpretations and loose definitions of what a business model is, there is a general consensus that the term describes the business *logic* a company or network of companies use to generate revenue and create customer and network *value* [Faber et al. 2003]. As such, a business model becomes the blueprint of the way a business creates and captures value from new services, products, or innovations. The concept also defines how a firm interacts and transacts with customers, partners, and suppliers. As shown in Figure 1, a business model converts technological characteristics and potentials to economic outputs, thus directing technology investments towards profitable and sustainable economic value creation [Chesbrough and Rosenbloom 2002]. The success of a well-planned business model is, however, not guaranteed until the model is properly run and managed.

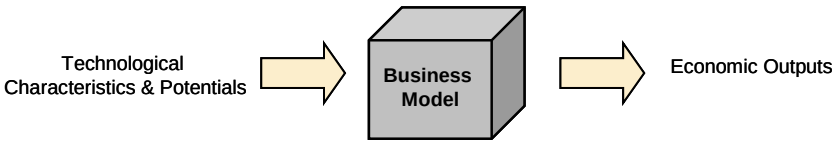

Figure 1. The Role of the Business Model

It is also important to distinguish between a business model and the concept of strategy, though the term has been misused many times in the press to infer strategy or even business process. In fact, a business model focus on the logic (the *what*) of value creation, while the details on *how* to achieve this value creation to gain competitiveness in the market is the task of strategy [Keen and Qureshi 2006]. The interplay between business model and strategy is perhaps best articulated by Keen and Qureshi [2006] who recognized that an effective business model must be first supported by strategy and over time becomes embedded in the strategy.

Osterwalder and Peigneur [2002] provide a different conception for the relationship between a business model and strategy. As shown in Figure 2, they view a business model as the conceptual and architectural implementation (blueprint) of strategy, that establishes the missing link between the concepts of technology, business processes, and strategy.

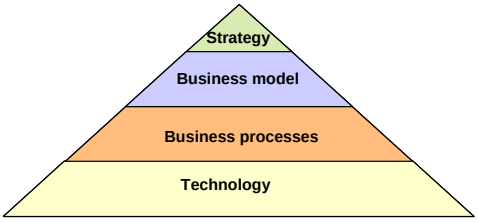

Figure 2. The Business Model and Its Relationship with Strategy, Business Processes, and Technology

Over the past few years, the growing body of business model research has developed into six main subdomains [Pateli and Giaglis 2003] :

1. **Business model definition**: exploring meaning, scope, purpose of a business model and its relationship with strategy, value chain, market positioning, and business process
2. **Business model components**: focusing on decomposing a business model into a set of key constructs
3. **Business model change methodologies**: aiming toward the establishment of frameworks to guide in adapting business models in response to new innovations
4. **Business model evaluation**: identifying criteria to assess the viability of a business model or evaluating a business logic against alternatives or best practices
5. **Business model taxonomies**: trying to categorize typical business models into various typologies, based on well-defined criteria
6. **Business model representations**: Describing tools to visualize business model components and their interrelationships

While the focus of this paper is highly geared toward subdomain 3, we will also build on recent research contributions pertaining to subdomains (1-5) to synthesize new findings and hypotheses. These will provide guidance in rethinking the business model, given the new RFID opportunities and mandates.

The Use of the Business Model

Studying business models serves many purposes, as it helps to (1) identify and understand the relevant elements in a specific domain and the relationships among them; (2) communicate and share the understanding of business model among stakeholders; (3) facilitate change; (4) identify relevant performance measures for an organization; (5) experiment with and assess new business models; and (6) enhance the current way of doing business [De Reuver, Haaker, and Bouwman 2007; Osterwalder and Pigneur 2002].

Dynamic Business Model

Though most earlier studies have focused on a static (snapshot-based) view of the business model, recent research has emphasized the importance of taking into the account the dynamic aspects of business models. In fact, various dynamic business model frameworks have been proposed in recent years to reflect the fact that business models do evolve and adapt to changing technologies, market conditions, and regulatory environments [see for example Afuah and Tucci 2003; Bouwman and MacInnes 2006; De Reuver, Haaker, and Bouwman 2007, and the references cited therein]. In particular, the identification of new business models and the adaptation of existing ones in response to new innovations is an intricate task in technology management research. This requires a high degree of risk and uncertainty and a deep understanding of not only the technology, but also the organization's business, market, economic, regulatory, and competitive environments.

Business Model Framework

The first step to understand how an enabling technology like RFID will impact the business logic of the firm is to identify a framework that describes the basic building blocks of a business model and the surrounding external forces. Many authors have attempted to define the business model components, with different views regarding the logic, scope, details, number of components, and rigor of conceptualization [see for example Linder and Cantrell 2000; Hamel 2000; Chesbrough and Rosenbloom 2000; Mahadevan 2000; Weill and Vitale 2001; Stähler 2002; Afyuah and Tucci 2003; Osterwalder 2004, and the references cited therein for more details].

Based on extensive literature review of past research, we synthesize and propose in Figure 3 our conceptual business model framework, which encompasses the key elements of a business model and its relation to external factors. The inner box depicts the business model and its main four domains, which are value proposition, value creation system, value deliverance, and value capture model. Our framework of dissecting the business model into these four specific value-driven constructs is motivated by the inherent use of the business model in conceptualizing

the value creation and money earning logic of the organization. Further, each of these four domains is further divided into subcomponents, as described in Appendix 1.

From Figure 3, we see that the business model acts as a blending agent, bringing together business strategy, business processes, and technology (outer box). This is in line with Osterwalder and Peigneur [2002] conceptualization, previously depicted in Figure 2. All together, these four domains are influenced by external environmental forces, including economic, legal, regulatory, competitive, social, technological, and changing customer demand factors. In response to changes in these external factors, prevailing business models might need to be adapted and new ones might be created. Though the business model components in the inner box of Figure 3, reflect a *static* view, the outer boundaries add a *dynamic* view by highlighting the fact that business model design and adaptation cannot be performed in isolation from the external forces.

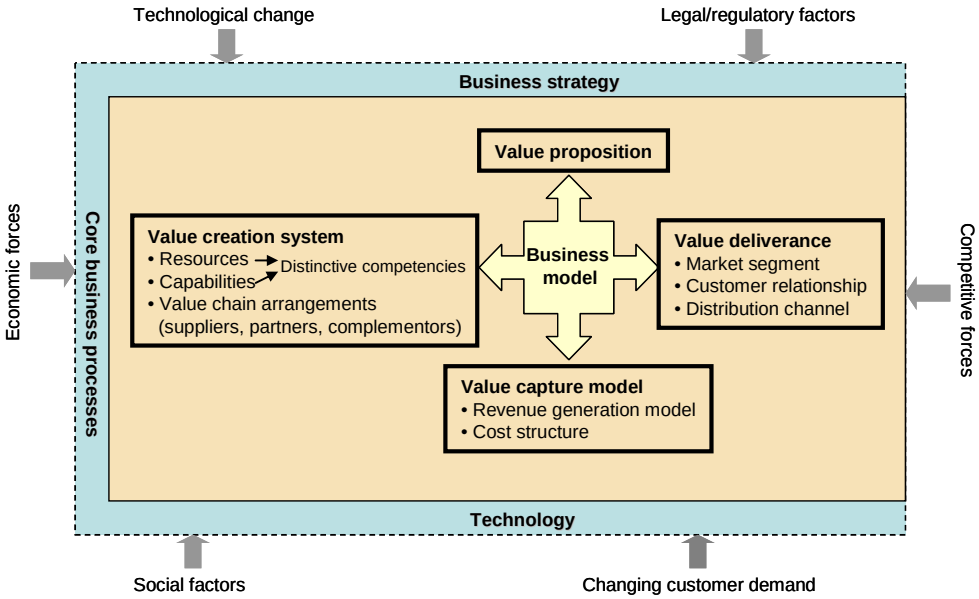

Figure 3. The Business Model Framework

III. RFID: AN ENABLING TECHNOLOGY FOR INNOVATION

Radio Frequency Identification (RFID) is an automatic identification (Auto-ID) technology, sometime referred to as next-generation barcode. It enables an electronic devise to use safe radio frequency to identify a tagged item. As illustrated in Figure 4, an RFID system typically consists of five main components:

1. **RFID tag** (transponder): The identification device attached to the tracked item. A tag is programmed with a unique identification and a descriptive information that can be read at distances ranging from one inch to approximately hundred feet. There are two types of RFID tags. Passive tags require no internal power source. They are typically very small and have relatively short read ranges. Active tags have their own internal power supply, provide read-write access, and are used in environments that need longer and more reliable read ranges.
2. **A reader** (transceiver): Handles radio communication through the antenna to detect the presence of RFID tags and read the information stored in them. The reader can then pass the tag information to another system, running an RFID middleware.
3. **An antenna:** a device attached to the reader to communicate with the RFID tag
4. **RFID middleware:** Software used to consolidate, aggregate, process, and filter raw RFID data received from multiple readers to generate useful information for end-users. The middleware can also pass the processed data to back-end Enterprise applications.
5. **Back-end RFID Enterprise service:** Receives filtered RFID data from the middleware and uses Application Programming Interfaces (APIs) to integrate these with existing enterprise applications, such as POS, SCM, ERP, and CRM systems.

RFID outperforms other Auto-ID technologies, such as bar codes and contact memories in many aspects. First, RFID tags can store substantial amount of data and some tags can be reprogrammed with new information throughout the items' life cycle. Second, RFID tags do not require direct contact or line-of-sight and many tags can be scanned simultaneously with high accuracy. Third, since tags do not require human intervention, human-induced errors are reduced. Fourth, each tag can carry a distinctive 96-bit identifier, which allows billions of items to be

uniquely identified. Finally, RFID tags come in various shapes and sizes and can better withstand harsh environments.

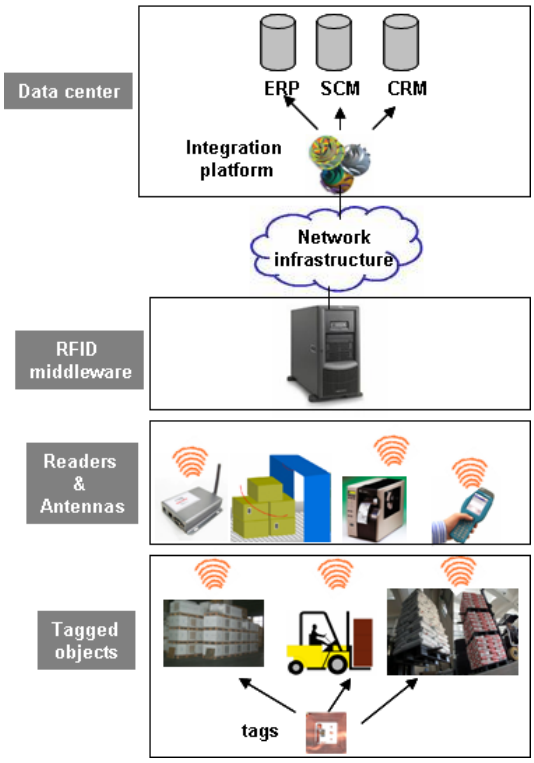

Figure 4. Typical RFID System Components

RFID is identified as an enabling technology since the technology does not provide much value on its own. It rather provides organizations with opportunities to develop data collection applications that can create value. RFID has also been recognized as a "disruptive" technology since it created a more efficient and less costly approach to track items than traditional Electronic Product Codes (EPCs). Firms that are unprepared to adapt their business model to accommodate this technological disruption might be left at a competitive disadvantage. Though there is no “one size fits all” RFID solution, value creation with RFID strongly depends on two main factors, namely the identification of a viable business model and the depth of RFID assimilation. Hardgrave, Armstrong and Riemenschneider [2007] identified a three-level hierarchy of RFID assimilation (extent of use), as shown in Figure 5.

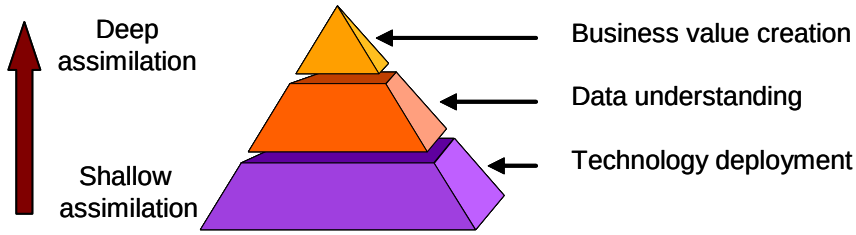

Figure 5. RFID Assimilation Hierarchy

Organizations at the bottom layer of the hierarchy have limited opportunity to extract real business value. At this level, RFID assimilation is weakest. Driven by compliance mandates from major customers, organizations simply place RFID tags on products (cases and/or pallets) before shipping them. Understanding the RFID data and getting payback from the technology are very limited at this stage, albeit compliance to RFID mandates from major customers will keep business moving forward.

Organizations at the middle layer of the hierarchy are in a better position to create business value by acquiring the capability to collect and understand the potentially overwhelming data generated from RFID systems. At this stage, data understanding will enhance supply chain visibility and will prepare organizations to reap business value benefits.

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Moving to the top of the hierarchy, organizations process the collected data and convert them into valuable information which can help them create real business value in at least three main areas [Hardgrave, Armstrong and Riemenschneider 2007]:

1. Identifying problems in the supply chain and reacting upon them accordingly, without changing existing processes
2. Enhancing the efficiency or effectiveness of existing processes via incremental process change
3. Creating new RFID-enabled business processes

RFID is particularly well positioned in applications that require fast and accurate data collection, or when many data collection points are required [The Business Value of Radio Frequency Identification (RFID), 2006]. The technology is being experimented with and deployed in many sectors, including supply chain, logistics, manufacturing, defense, healthcare, retail, transportation, and customs. Recent forecasts for global sales of RFID tags show a dramatic increase in pallet/case tagging between 2005 and 2010, with item-level tagging dominating the sales figures between 2010-2015 [Harrop and Das 2006]. Currently, item-level tagging is currently limited to expensive items, and this is expected to change as the cost of tagging is declining thanks to anticipated economies of scale and better manufacturing processes. As shown in Figure 6, the opportunity to scale from pallet, to case and then to item-level tagging is setting the stage for unprecedented real-time tracking and visibility capabilities. This also enables RFID value propositions to unfold from currently dominated warehouse applications toward retail floor and other applications. In fact, the ultimate goal is to eventually get the ongoing decline in RFID tags' prices to reach a level that will economically allow to tag everything in the consumer package goods ["Progress with Item-Level," 2004]. Already, pilot trials to tag items such as library books, laundry clothes, retail drugs, postal packages, car tires, pets, DVDs, mass transit tickets, and airline luggage are underway.

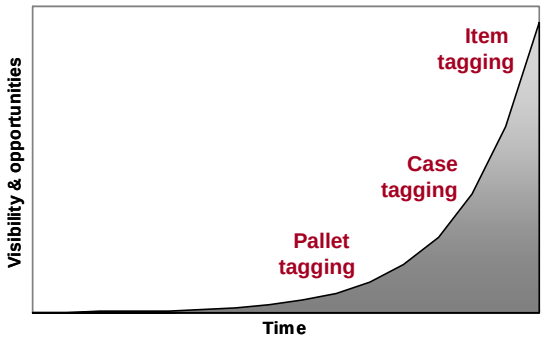

Figure 6. Enhanced Real-Time Visibility with RFID Tag Scaling

A key factor in deciding whether to deploy RFID for a given application is to quantify the corresponding return on investment (ROI). This makes a cost-benefit analysis a valuable tool in the decision-making process. Figure 7 illustrates the major cost components and main benefits of a typical RFID deployment.

IV. RETHINKING THE BUSINESS MODEL WITH RFID

The set of business model components as well as the external factors, depicted in Figure 3, provide a starting point to explore how RFID can enable new business models or reshape existing ones.

RFID and Value Proposition

Like ICT, CRM, and ERP, RFID technology is a resource by itself which draws on other resources (such as financial, physical, human cognition, and organizational resources) to generate new value creation opportunities to customer segments and/or to enhance the efficiency of existing value offerings. These two capabilities give rise to what Zott and Amit [2006] refer to as *novelty-centered* business model and *efficiency-centered* business model, respectively. These two models are neither orthogonal, nor mutually exclusive, and can coexist within the same business model.

In a novelty-centered business model, RFID can be used to offer a target customer-segment a new or customized value proposition. This redefined value proposition can enable firms to penetrate new market segments that they were not able to explore before. In fact, organizations today are struggling with some commoditized value propositions and are looking for ways to revitalize them to create unique value for stakeholders. For example, International Paper (IP), the world's largest paper and forest products company, moved a few years ago to a wholly automated RFID warehouse system. After years of experimentation with the technology, IP has accumulated invaluable experience and know-how to effectively deploy RFID in harsh warehouse environments. As a result, IP has redefined its value proposition to include the offering of RFID consultancy and system integration services. This

also enables IP to generate new revenue streams. Mead-Wesvaco, another paper and packaging company, has developed, through its systems division, an RFID networking technology to enable one RFID reader to control hundreds of antennas. Some organizations in the logistics industry, such as *Menlo Worldwide Logistics* , found in the RFID compliance mandates an excellent opportunity to expand their value proposition and offer RFID compliance services to many suppliers, who lack expertise in this area.

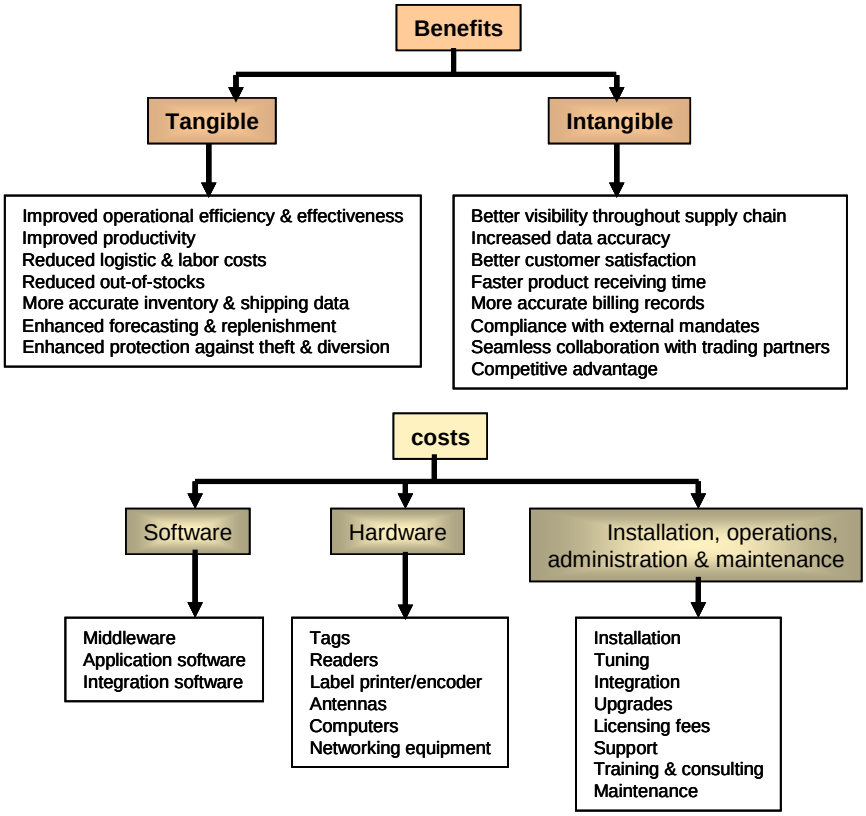

Figure 7. Main RFID Cost and Benefit Components

An RFID-enabled and novelty-centered model can also allow a firm to find new ways of conducting economic transactions among various stakeholders, such as linking transaction participants in new and intelligent ways. For example, TrenStar, a global provider of mobile asset management solutions, is using RFID tracking technology to create a new "pay-per-use" business model for its brewing trading partners. Under this model, TrenStar acquired 4.5 million beer kegs from leading breweries and is managing and maintaining these assets, while invoicing customers each time a keg is filled. Since all the breweries trading partners share kegs, they benefit from economies of scale. TrenStar is using RFID to provide a new value proposition to its trading partners by helping them reduce purchasing, storage, and maintenance costs, while eliminating losses due to stock thefts.

An RFID-enabled and novelty-centered business model can also enable a firm to offer superior customer service levels, thus further enriching the value of its product offering. For instance, leading global retailer Metro is experimenting with RFID-enabled smart shelves and smart dressing rooms to further differentiate its offerings by providing customers with superior shopping experience. Under this model, an RFID-enabled store allows shoppers to find the correct size, color, and additional information about a displayed garment at the touch of a screen. An RFID-enabled digital trolley, equipped with smart Personal Shopping Assistant (PSA), provides Metro's future store shoppers with customized promotion advertisement, real-time display of trolley content and cost, on-demand product information and guided routes [Weber 2003].

In an efficiency-centered business model, RFID can be used to achieve transaction efficiencies by reducing transaction costs for all participants. Cost reduction is mainly enabled from labor reduction, reduced coordinated costs and information asymmetry, and enhanced transaction transparency. The benefits from cost savings will spill over customers in the form of aggressively lower prices. As an example, instead of manually scanning each individual case, Gillette is using RFID to automatically scan pallets' contents at the receiving door. This enabled Gillette to reduce pallet receiving time from 12 seconds to 5 seconds, thus making the receiving process more efficient [Katz 2006].

RFID and Value Creation

Resources and Capabilities

To successfully create value with RFID, certain resources and capabilities need to be acquired, developed, and maintained. For example, budget must be allocated, supporting organizational structure should be identified, and suitable RFID infrastructure must be procured. IT personnel with the proper training, know-how, and skills to use the technology correctly and efficiently must be available internally, or their services should be outsourced. Budget for business process change must equally be secured to maximize return on investment. Trust with various trading partners must be secured as seamless information sharing is needed for optimum decision making. Organizations also need to acquire and develop new capabilities to operate and manage their RFID systems. These include the following:

- Provision of end-to-end integration from the tagged-item level to the backend ERP/CRM resources and legacy systems
- Ability to filter and interpret potential overwhelming data generated by the readers to enhance existing knowledge base and enable intelligent decision making
- Ability to deal with erroneous tag reads due to noisy environments, scanning area overlaps, data redundancy or damaged tags
- Managing other technological challenges, such as reader and tag collision, signal interference and noise, inconsistent data and data synchronization issues
- Remote monitoring and configuration of RFID devices for proactive management of the RFID infrastructure

Lessons learned from the early days of Internet-based competition suggest that if organizations will rely on commercial, off-the-shelf (COTS) RFID solutions to achieve further operational effectiveness, the resulting improvements can easily be shared among rivals. That is, it is unlikely that firms will sustain competitive advantage from "out of the box" RFID solutions because the acquired capabilities can be easily imitated. This constraint might push organizations to rethink their RFID deployment strategy and consider the option to develop customized RFID solutions that best fit their distinctive strategic positioning. Similarly, instead of focusing on just meeting RFID mandates or increasing efficiency in isolated areas, organizations should rather focus on outlining an RFID vision that is aligned with their corporate and business strategies.

In addition, and according to the resource-based theory, a firm's unique RFID resources and capabilities can give a company the potential for competitive advantage. The Value, Rarity, Imitability and Organization (VRIO) framework [Barney and Hesterly 2005] can be used as an "acid test" to determine the competitive potential of a firm's RFID resources and capabilities.

RFID must be aligned and embedded with other resources, activities, as well as with the organizational structure of the firm. As a result, managers will have to deal with a new range of cognitive and cultural constraints [Hedman and Kalling 2001]. These include:

- Knowledge about the interrelation between RFID and a firm's business processes and strategy
- Potential changes and reengineering in workflow process, triggered by the migration from manual or bar-code scanning toward automated RFID tracking of goods
- Redefinition of job responsibilities
- Risk of eliminating some jobs and the need to create new ones
- Positive attitude among employees towards the new technology and their commitment to change

Value Chain Arrangements

Although existing technologies and services enabled by EDI, third-party logistic providers, supply-chain modeling, and CRM have already helped streamlining the supply chain, supply-chain management (especially for fast-moving consumer goods) is a real pain for many organizations. This is mainly due to the prevailing inefficiencies in cooperating with trading partners to optimize the replenishment process and reduce out-of-stock situations [Kourouthanassis et. al. 2001]. Some of these "pain-points" are shown in Figure 8.

Retailers and suppliers can take advantage of RFID automatic product identification capabilities to address some of the above paint-points. With RFID, the movement of goods from the store's back door to the point of purchase can be tracked in real-time, leading to better inventory visibility. Shipments from the distribution centers can be cross-checked to improve accuracy and reduce misshipment and shrinkage scenarios. RFID can further strengthen the collaboration between retailers and suppliers, enabling the suppliers to optimize production and replenishment scheduling, based on real-time demand [Schwartz and Putta 2006].

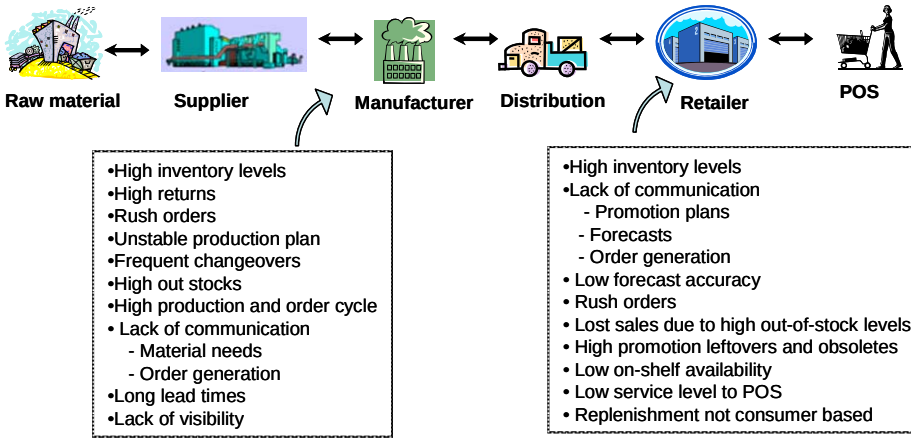

Figure 8. Common Supply Chain Inefficiencies [Adapted from Kourouthanassis, et al. 2001]

RFID is not meant to replace the existing SCM-ERP-CRM model but rather makes it more efficient. The technology can be used in conjunction with these enterprise applications to streamline transactions between a focal firm and its ecosystem of partners, suppliers, and consumers. In particular, the technology provides firms with information processing capabilities, which need to be exploited to enable further cost savings. These can be achieved through work-flow optimization and reengineering, allowing value chain activities to be conducted swifter and more efficiently, while reducing the cost of misshipment and shrinkage. Wal-Mart has been in the forefront when it comes to exploiting information management technologies to improve the management of its supply chain. Wall-Mart was able to reduce out-of-stocks by 16 percent by using RFID data to optimize the effectiveness of its shelf-replenishment process [Hardgrave, Waller, and Miller 2005]. Metro reported a reduction in out-of-stocks by 11 percent [Johnson 2005].

RFID has also given rise to new strategic networks in the value creation process. Strategic networks are defined as "stable interorganizational ties which are strategically important to participating firms. They may take the form of strategic alliances, joint-ventures, long-term buyer-supplier partnerships and other ties" [Gulati, Nohria, and Zaheer 2000]. In fact, since RFID can help trading companies share information related to supply chain events, improved information flow, and collaboration can take place. This collaboration can be the basis for strategic networks to form, enabling participating partners to benefit from new opportunities, such as demand-driven ordering and collaborative promotion planning. The RFID-enabled pay-per-use business model is an example that is leading to new strategic networks. Under this model, trading partners use the pooled mobile assets from a third-party firm and are charged on a per-use basis. The third-party firm uses RFID devices to track the location of the mobile assets on behalf of the trading partners, who also have online access to inventory movement.

Recent RFID mandates from major retailers will most likely raise their bargaining power over their suppliers. At the same time, RFID can be a direct threat for wholesaler and distributors if manufacturers can exploit this technology to improve product visibility, get closer to end customers and grab a dominant position in the value network. This scenario can eventually lead to the disintermediation of wholesalers and distributors [Higginbottom and Gholson 2005].

Similarly, under urgent pressures to adopt RFID, some organizations might solicit the external services of RFID value chain service providers or integrators. These organizations can potentially witness the deconstruction of their existing value chain, with new players handling some of their value chain activities. Value chain deconstruction can thaw the "information glue" that previously held the value chain activities together and can destabilize a firm's value creation system. As a result, organizations need to carefully manage the changes induced by value chain deconstruction through careful rethinking of their business models and value creation systems.

RFID and Value Deliverance

A key value proposition of RFID lies in its ability to forge the link between the front-end (customer facing) and back-end systems to successfully automate a firm's operations. This way, the resources of all value chain partners can be managed more efficiently. Because RFID can easily track the movement of goods within a facility, common issues related to inaccurate and incorrect outgoing shipments can be resolved.

RFID can assist organizations strengthen customer relationship by fostering more personalized relations with customers. Gathered customer information from RFID scanned items can further enhance customer relationship through profiling and personalized services. When RFID is combined with other business intelligence and data

mining technologies, valuable insights about consumer behavior can be captured and then used to create what Hamel [2000] calls the positive feedback effect [Osterwalder, Ben Lagha, and Pigneur 2002]. In Europe, specialty clothing retailers such as Zara and Prada are experimenting with RFID to enhance their responsiveness to consumer preferences. This is particularly important in the disposable high-end fashion industry, as some displayed items need to be changed almost on a weekly basis. RFID also supports promotion management by ensuring that products are displayed on-time on the sales floor in order to meet demand. These insights can help firms enhance their products, services. and marketing strategies.

Since RFID can increase shipping accuracy and reduce mismatches between invoices and receipts [The Business Value of Radio Frequency Identification (RFID), 2006], customer service level can be enhanced. Customer satisfaction can also be increased as RFID systems have the potential to enhance a store's inventory management. For instance a customer can know whether a particular garment (matching his style, size, and color requirements) is in the store and if so, the store's clerk can precisely locate this item for him (whether on the sales floor or in the backroom). If the item is out of stock, an RFID-enabled system can recommend the nearest branch where this particular item is available. These added-value customer services cannot be achieved with today's bar codes and POS solutions [Schwartz and Putta 2006].

RFID can assist firms optimizing the way value proposition is delivered to the market by enabling the delivery of the right quantities of the right product/service available at the right place, at the right time and to the right people. These are the main objectives of a successful channel strategy [Pitt, Berthon, and Watson 1999].

Once item-level tagging becomes a reality, RFID will have a ground-breaking impact on customers' shopping experiences via the concept of "contactless checkout" [Hardgrave, Armstrong, and Riemenschneider 2007]. Under this model, RFID-tagged items, placed in the shopping cart, are automatically scanned by an RFID reader at the checkout counter. The reader will also enable the automatic billing of customers, using their RFID-enabled credit cards. The success of this model is tied not only to technological developments, but also to other important factors such as privacy and security assurance. In fact, consumers' willingness to share personal information depends not only on the personalized services they expect back, but also on their loyalty and trust in the RFID privacy and security measures put in place.

RFID and Value Capture

Revenue Model

New opportunities enabled by RFID can be used to generate additional revenue streams or maximize existing revenues. The previously cited example of International Paper showed how an organization, operating in paper-thin margins and highly competitive markets, diversified into the RFID consultancy and system integration business to generate new revenues. In the future, makers of storage displays can also own RFID-enabled smart shelves and sell the collected data to retailers and manufacturers.

The deployment of RFID-enabled smart shopping carts is expected to enhance customer relationship through better shopping experiences. This can help retailers strengthen customer loyalty and increase revenue.

Total supply chain visibility, enabled by RFID, can prevent out-of-stock situations, thus enhancing the firm's revenue stream. For instance, stock management of seasonal garments and equipments is very important for retailers. Out-of-stock situations translate into loss of revenues, while stocks that are not sold by the end of the season are often sold at very discounted prices. This has immediate negative impact on a retailer's profit margins. Existing technologies at the POS are unable to pinpoint whether a particular item/garment (with specific color, model, or size) is available in the store, nor can they track the exact location (backroom, sales floor, or fitting room) of a given item in the store [Schwartz and Putta 2006].

Counterfeit products for electronic equipments, DVDs, pharmaceutical, and spare car parts are becoming a real threat to the revenue model of many manufacturers. RFID systems can be used to protect against counterfeits. For example, GlaxoSmithKline is using RFID-tags on its HIV drug *Trizivir*, which is among the most susceptible drugs to counterfeiting and theft.

Cost Model

The proper use of RFID in value chain optimization opens up new opportunities to lower cost. When RFID is used to enhance supply chain visibility, inventory level, diversion, theft, shrinkage, and safety stock level are reduced. These benefits will lower operational and carrying costs. Several studies have shown that RFID can bring substantial cost reduction and operational improvements to the distribution center. These are reflected for instance in reduced labor

requirements, automatic processing of loading, unloading and cross docking, faster product retrieval, and fewer order errors ["Business Benefits from," 2007].
Additional RFID-enabled cost-savings can also be achieved from reduced manual checks, inventory stock levels, inventory handling costs and better asset utilization. According to a study by Accenture [Chappell et al. 2003], manufacturers who are implementing EPC/RFID tagging programs to satisfy customer requests are realizing the following cost reduction benefits:

- Decreased cost of goods sold of 1 percent to 5 percent from improved overall equipment effectiveness
- Reduced working capital of 2 percent to 8 percent from reducing raw materials, work-in-process and finished goods inventories
- Reduced fixed assets of 1 percent to 5 percent from better maintenance and utilization of plant equipment

Nevertheless, it will be hard for many manufacturers to justify investment in RFID technology just to comply with new RFID mandates from major retailers, as these manufacturers have to incur the bulk of the cost. This is particularly the case for Chinese manufacturers who have been operating in environments characterized by mass production, thin profit margins, access to cheap labor, and low-technology infrastructure. For these manufacturers, there are no compelling reasons to adopt RFID, as the Total Cost of Ownership (TCO) of a full-scale RFID system is significant. Further, most of these manufacturers would make up for shrinkage by simply overproducing [Wong 2005]. The main issue here is whether the revenues generated from trading with major retailers will cover the RFID TCO. Many of these manufacturers would avoid investing in an RFID infrastructure, and would opt instead for a shallow deployment with a third-party slap-and-chip[1] services. Though a slap-and-chip strategy provides the quickest way to fulfill compliance mandate without losing key partners, it does not enable manufacturers to benefit from the integration of RFID information back to the supply chain. Another alternative would be to establish cost-sharing agreements among large retailers and manufacturers [A.T. Kearney Report 2003]; after all the benefits would eventually spread over the entire value chain.

External Influences

In the context of RFID business model, not all the external environmental factors, depicted in Figure 3, are relevant. However, RFID technological development, competitive forces, and legal/regulatory issues will definitely be the main external factors that will have most impact on RFID business models.

New laws and regulations can have drastic effects on an RFID business model, especially when it comes to privacy issues. RFID has created some never-seen-before privacy concerns by making possible to capture detailed personal profiling data. Today, many privacy advocates such as the Electronic Frontier Foundation (EFF) and the Consumers Against Supermarket Privacy Invasion and Numbering (CASPIAN) are protesting against RFID violation of consumer privacy and are bringing this issue to the public. These groups are also calling for the boycott of firms which use RFID, while demanding tougher legislations to regulate RFID use [Hunt, Puglia, and Puglia 2007, p. 98]. In response, EPCglobal, a major RFID standardization body, has established a public policy steering committee to look at ways to create a balance between RFID capabilities and consumer privacy concerns. EPCglobal has also issued a privacy recommendation to make it possible to “kill” (i.e. remotely disable) the tags at the point of sale and to inform the public about this situation.

Several states in the U.S. have been introducing new legislations against the use of RFID tagging in some applications, such as public schools, libraries, vehicle identification, and drivers' licenses. As a result, RFID industry players need to constantly monitor and address consumer privacy concerns. These can be tackled on multiple fronts, including: (1) informing consumers about the presence of RFID tags; (2) giving consumers the choice to accept, discard, disable or remove the tag; and (3) educating consumers about the technology and its applications.

RFID can and has already intensified the rivalry among providers of third-party logistics (3PL) and physical delivery services. These players are now pressured to follow early RFID adopters or lose their market share because of competitive threats.

In addition to major retailers and governmental agencies, numerous regulatory bodies have also prescribed strict new requirements related to product labeling, tracking and tracing. These include the US food and Drug Administration (FDA), the EU and U.S. food safety associations (such as FSA, FDA, USDA), the U.S. Tread Act, and the TSA/C-TPAT (Customer-Trade Partnership Against Terrorism). Manufacturers, wholesalers, and distributed affected by these regulations will be forced to comply or lose business opportunities and face penalty charges.

[1] The term refers to the practice of slapping RFID tags on the cases at the distribution center (just before chipping to customers) rather than on the manufacturing floor.

V. THE THREE-PHASE DYNAMIC RFID BUSINESS MODEL

To identify the dynamic phases of the RFID business model, we need to better understand the role of RFID technology, and the associated competitive, legal/regulatory, and socio-economic forces on business model dynamics. For this purpose, on draw on earlier contributions in business model dynamics, as well as on RFID literature to sketch a multistage migration path for RFID technology adoption, diffusion, and value creation.

Several models have been developed in the literature to identify the dynamic evolution of a general business model. These include Roger's [1962] classic diffusion and innovation model, Mason and Rohner's [2002] venturing dynamic model, technology-related models and innovation management dynamic models [Bouwman and MacInnes, 2006]. Although different phases have been identified in the literature to describe business model dynamics, there are at least three common phases which are applicable to RFID. These are RFID proof of concept, rollout, and commercialization. Following Kijl et. al [2005] , we use these three phases to describe the dynamic evolution of an RFID business model. As shown in Figure 9, these phases follow a linear sequential model with inner and outer feedback loops reflecting the dynamic iterative behavior and "imperfections" in the incarnation of RFID from R&D to full commercialization. It is important that technology managers understand that RFID adoption is a journey, involving different stages and that different objectives and values can be realized at each stage. Failure to do so will result in short-cut approaches that are doomed to failure.

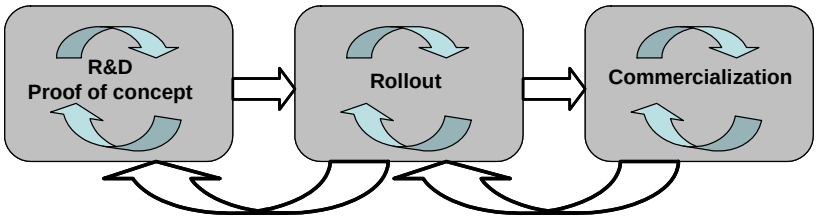

Figure 9. Dynamic Phases of RFID Adoption

R&D and Proof of Concept

At this first stage, technology and R&D play a dominant role and drive the development of new business models. Priorities are centered on technology, investment, applications, and collaboration with RFID technology partners. Technological challenges, environmental constraints, hardware and software compatibility issues, and implementation gaps are identified and potential solutions are provided. Better insights as how to integrate RFID information with legacy systems and interface to ERP and other operations support systems are acquired at this stage. RFID hardware manufacturers, middleware providers and data integrators are collaborating at this stage to secure an end-to-end functionality as a proof of concept. Standardized protocols outlining how RFID devices communicate with higher-level systems are still evolving at this stage. Customized and proprietary solutions will be available in the interim. Financial feasibility studies based on cost-benefit analysis (Figure 7) are undertaken. RFID-based opportunities are assessed from a strategic aligning/impacting perspective, as the technology needs to be eventually embedded within the strategic directions of the firm. Only a few leading actors, also known as *nodal companies* or *orchestrators* [Maitland et al. 2005] are adopting RFID as the total cost of ownership is still high at this stage. These nodal companies will also define where the center of gravity lies in their respective value network. The rate of RFID adoption at this stage is relatively low but increases once new adopters join in. This phase sets the stages for field experiments and small scale, alpha trials, with special focus on controlled "proof of concepts" and initial introduction. A multidisciplinary team is given the task to conduct this early experimentation. The goal of the "proof of concept" experimentation is to gain practical lessons-learned that can be used to further justify investment and broaden rollout.

Organizational issues related to the usage of the technology are explored. This stage provides a excellent opportunity to engage workers to work with the RFID system and monitor their interaction with the equipment. An RFID site survey is conducted at this stage to identify potential blind spots and areas of high RF interference. Testing is typically conducted within the organization's premises or at a third-party testing lab. Many decision variables related to the pilot study can be tested and refined in a lab environment, saving time and efforts, once the pilot system is put in place. Yet, at this stage one cannot rule out the possibility of refinements and reconfigurations in the RFID architecture (including tag and reader placement) as the underpinning implementation details are not completely understood.

The RFID diffusion process, at this stage, is fueled by the interdependencies between the major players in the industry, including competitors, suppliers, and distributors. Some firms will incrementally adapt their business models while others will create new ones with RFID. Some suppliers such as Procter & Gamble, Pacific Coast

Producers, Hewlett-Packard, and Kimberly-Clark will be adopting RFID because of mandates from major retailers such as Wal-Mart, Target, and Alberstson's. For these suppliers, the guidelines received from their major customers will form the basis of their RFID project's functional and nonfunctional requirements.

Rollout

Issues related to performance, scalability, device interoperability, regulation, and security are mostly resolved. During this phase, cost reductions in RFID hardware (tags, readers) and middleware software prevail. Beta trials take place and the results are used to secure funding for large scale deployment. At this stage, RFID becomes more embedded within the organizational operations and this is an excellent opportunity for firms to test their business model and manage organizational changes, as well. The technology is not yet fully mature and is still subjected to further refinement and cost reductions. New RFID applications will start to emerge, which can trigger additional privacy concerns.

Commercialization

Adoption of RFID gradually spreads. Incremental releases will emerge to add new functionalities or to address existing bugs, deficiencies or limitations. RFID deployments will still be subjected to regulatory surveillance and monitoring to ensure compliance. Priorities will shift to incremental developments, upgrades, reconfigurations, and maintenance activities. The transition from pallet/case tagging to item-level tagging will lead RFID market adoption at this stage. This will open up new business opportunities for RFID beyond supply chain optimization.

VI. A TAXONOMY OF RFID BUSINESS MODELS

In this section, we build on earlier contributions in business model taxonomy research to identify and categorize RFID business models into a number of typologies. Various criteria for classifying business models have been proposed in the literature [see for example Ostrerwalder 2004; Timmers 1998; Linder and Cantrell 2000; Mahadevan 2000; Applegate 2001; and Rappa 2002]. Some taxonomies are based on marketing concepts or product types, while others are based on value creation and new opportunities offered by the technology [Bouwman and MacInnes 2006]. Following the latter approach, we have identified and categorized RFID business models into twelve main typologies, whereby business models within the same category share some common characteristics related to their value-creation capabilities. This framework has been developed based on current RFID deployments, as well as on experimental RFID trials. The commercial viability of some of the identified RFID business models is still being questioned, given the current status of the technology. As a result, we observe that not all of these models are being implemented. The identification of these RFID business models, however, can provide directions for the future evolution of the technology. It should also be noted that our classification is intended to be neither exhaustive nor complete. As the technology matures, and our understanding of its value-creation capabilities improves, more types of RFID-enabled business models will emerge. The 12 main categories of RFID business models are listed and briefly described in Table 1.

Table 1. Taxonomy of RFID Business Models

Type of RFID business model	Description
RFID infrastructure merchant	Wholesaler , retailer or distributor of RFID infrastructure-related products (example: A.C.C. Systems Inc, Mighty Card Co, Arskey, NextPoint Solutions, Dynasys, Encore Graphics)
RFID infrastructure and management services provider	Provider of RFID infrastructure-related products and solutions, including RFID tags, readers, sensors, printers, application platforms, data integration services, management services, APIs and middleware. (example: Microsoft, IBM, Motorola, Sun, ODIN technologies, Rafsec, TagSense, Alien Technology, ThingMagic, OAT Systems, Impinj, Savi Technology, Creative Systems, Cleritec Systems Corporation, Grupo Hasar, GlobeRanger, Provia, Zebra, Intermec, RFID Inc, Checkpoint Systems, Cleritec Systems Co, Reva Systems, HighJump Software, GlobeRanger Co)
RFID community business model	A community of programmers who develop and freely share a suite of open-source RFID software that conforms to the EPCglobal's RFID standards. Funding is often generated from monetary donations by a consortium of organizations that support the project. (example: RadioActive Foundation (http://www.radioactivehq.org/)
Value chain integrator	A firm that uses RFID to further integrate value chain activities and add value (ex: Wal-Mart, Tesco, Best Buy,Marks & Spencer). This also includes firms which provide business integration solutions to help

Table 1. Taxonomy of RFID Business Models	
Type of RFID business model	Description
	integrate RFID information with existing applications such as POS, SCM and ERP systems (example: IBM, ABIresearch, RFID Business Intelligence, Cougaar Software Inc)
Information and business intelligence agent	A firm uses RFID to offer new information-based services. It can act as information intermediary by independently analyzing the extensive data collected from RFID systems and incorporating business rules. This can assist firms better understand the effectiveness of their product and service offerings as well as marketing/promotion campaigns. This model also makes use of data mining techniques to analyze RFID information and provide business intelligence solutions. (example: SAS, Business Objects, Cognos, Data Brokers, Oat Systems and RFID Business Intelligence consulting).
Seller of RFID data	A firm, such as a maker of storage displays, can own RFID-enabled smart shelves in stores and sells the collected data to retailers and manufacturers.
RFID-enabled “pay-per-use” business model	A firm which pools a huge number of assets in a given industry and uses RFID devices, located throughout the supply chain, to track them on behalf of trading partners. In this model, customers benefit from the economies of scale and are charged on a “per-use” basis. Trading partners have on-line access to inventory movement in order to track the location of their mobile assets. The partners’ ERP systems are also connected to the firm’s RFID system for seamless information sharing and transactions. This enables a “pay-per-use” business model, whereas partners use the pooled assets for better cost predictability, lower operating, maintenance and storage costs, as well as reduced labor cost and 3PL charges. (example: TrenStar).
RFID-enabled "pay-per-scan" business model	A firm uses RFID to enable pay-per-scan as a new method of inventory [Sarma, 2006]. Under this model, the retailer will not pay the supplier until the product is sold, as reported by the RFID reader at the checkout counter.
RFID-based security provider	A firm which provides RFID-based tracking solutions for the purpose of authentication, brand protection, security and to combat diversion, tampering, counterfeiting and theft. Clients, include casinos, customs, transport authorities, hospitals, and pharmaceutical companies. (example: TransCore, Verisign, Siemens, OpSec, ASK, TagSys, Innovision group, Aramark Healthcare)
RFID services consultant	A firm which provides consultancy services, including RFID strategy development, business case study, prototyping, readiness assessment, education, demos and training. Some software integrators and strategic consultants have also adopted this model. (example: RFID solutions, Inc, Serviant Corporation, Enterprise Information Systems, Tompkins Associates, Traxus Technologies)
"Smart" appliances manufacturer	A firm specializing in making RFID-equipped appliances (ex: fridge or microwave), shelves and cabinets that can communicate with smart tagged items for optimum settings or to generate alerts for specific events. (example: MeadWestvaco)
RFID services broker	A firm that minimizes cost for customers by providing the best RFID deals from several offers, taking into account customer requirements, uncertainty and risk factors. (example: Scan Solutions, Inc)

Following a similar approach as in [Timmers 1998], we can qualitatively map the 12 RFID business models along two dimensions, namely the degree of innovation and the extent of functional integration. This is illustrated in Figure 10. As may be seen, the degree of innovation varies from a very weak level, reflected in traditional trading and brokerage of RFID systems, to high levels, reflected in new innovative applications such as value chain integration and new collaborative arrangement models that did not exist before. The extent of functional integration varies from single function (such as distribution function) to multiple and highly integrated functions (such as value chain integration). In the bottom-left quadrant of Figure 10 are basic RFID services trading models, including merchants

and consultants. On the top-right quadrant are powerful models, which promise to unleash most of RFID acclaimed value propositions by combining high innovation with multiple integrated functions.

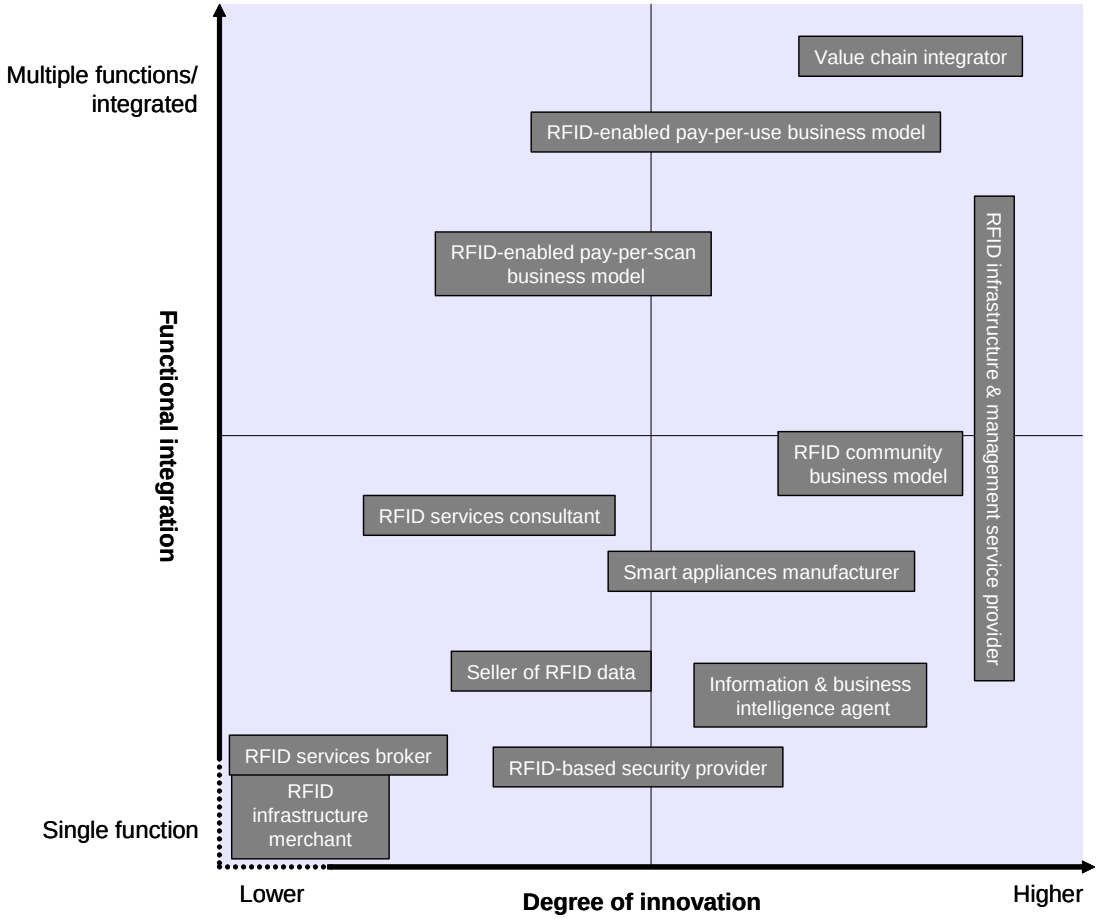

Figure 10. Classification of RFID Business Models

These models include value chain integrators and pay-per-use players. In between these two extremes are business models that are simply adding RFID functionality to existing processes and services. These include RFID-based security providers, smart appliances manufacturers and business intelligence agents. It is also expected to see a gradual shift of some business models toward the upper-right quadrant, as the business case and financial returns of higher functional integration and increased information flow are most appealing.

VII. DISCUSSION

The validity of the proposed RFID business model framework can be assessed using different criteria, such as the integration of the model (logical coherence), its practical and theoretical relevance, and relative explanatory power [Hedman and Kalling 2001; Glaser 1978].

As previously discussed, our framework integrates value-based business components (value proposition, creation, deliverance, and capture) with external factors (such as technology, regulations,1 and competitive forces) to assess the potential impact of RFID on a firm's business model and strategic position. The framework draws on earlier contributions in strategic management and e-business research to reiterate the need to align and integrate RFID technology with the firm resources, capabilities, organizational factors, and value chain activities. Another important aspect of our framework is that it integrates the RFID business model view with the time factor by incorporating a longitudinal dimension of RFID business model evolution. This is very important because different phases of the business model have different priorities and managerial implications.

To test the practical and theoretical relevance of our proposed approach, we conducted an illustrative case study related to Dubai Ports World (DP World). This is summarized in the next section.

Communications of the Association for Information Systems

VIII. CASE STUDY: THE RFID EXPERIENCE AT DP WORLD

Background Information

DP World is the fourth-largest global marine terminal operator in the world, running 42 container terminals at major ports in more than 25 countries. It is owned by Ports & Free Zone World, a company that is a subsidiary of Dubai World, one of the largest holding companies in the world, with investments in diverse industry sectors, including real estate development, e-commerce, hospitality, transportation and logistics. DP World is wholly owned by the government of Dubai, one of seven city states that make the United Arab Emirates (UAE). The company came under national spotlight in the U.S., following the controversial vote of the Congress in early March 2006 to block a deal that would have allowed DP World to take over six major ports in New York, New Jersey, Philadelphia, Baltimore, New Orleans, and Miami, as well as operations in 16 other U.S. ports. The opposition of the deal came under concerns over the potential negative impact the deal would have on U.S. port security.

DP World has developed an integrated port management approach, bringing together terminals, other cargoes, free zones and infrastructure development. The company strives to enhance customers' supply chain efficiency by providing quality services to effectively manage container, bulk and other terminal cargo. DP World also uses its own experience to provide logistics, infrastructure development, and consultancy services.

DP World has been experimenting with RFID technology for the past few years. Very recently, the company launched the RFID-enabled "automatic gate" project (named "Asraa") at the Jebel Ali port terminals 1 and 2. Automatic gates are equipped with Optical Character Readers (OCRs) and RFID readers to recognize trucks entering and exiting the terminals. Accordingly, each truck, scanned at the gate stand, is automatically supplied with the appropriate information related to the lane it should proceed to for container loading and unloading . The trucks need to be equipped with active RFID tags, which are supplied and installed by DP World at a one-time nominal fee. DP World is offering permanently fixed tags for regular tracks, as well as temporary tags for non-regular trucks. In the latter case, companies will be charged a small fee for a temporary tag, in addition to a security deposit which is refunded upon return of the tag. RFID permanent or temporary tags will be compulsory for all trucks operating at the Jebel Ali Port terminals, effective May 1, 2008.

Our discussions with DP World management revealed that in addition to technological issues related to RFID readers, tags, and middleware, many people issues have also surfaced. Among these are the nonfamiliarity of truck drivers with the new automatic gate system and the changes it brought to the regular gate entrance and exit processes. Another issue relates to the resistance of many companies to pay for the tag fee, despite all the advantages the automatic gate system will provide them. The Asraa project is currently in the early rollout phase, with limited deployment at two port terminals. The plan is to extend the deployment to other terminals, once all technical and nontechnical issues related to the current small-scale deployment are circumvented.

The Interview Process

We conducted interviews with managers at DP World, who were selected based on their past involvement with RFID initiatives. We organized the interviews according to the following structure: (1) introduction; (2) general exploratory discussion, including first impressions about our proposed RFID business model framework; and (3) more detailed discussions based on a mix of open-ended and closed-ended structured questions.

According to the interviewed managers, our proposed RFID business model framework proved to be very helpful in assisting organizations rethink their current business model and capitalize on RFID to enrich the way value is created. We were also able to relate many aspects of DP World RFID experience to some of the conceptual frameworks discussed in this paper. Certainly, there are plenty of future opportunities for DP World to make further use of RFID to innovate its business model. For instance, RFID applications geared toward tracking individual containers and increasing security are been investigated.

Based on the interviews, as well as the analysis of publicly available documents, we were able to apply our proposed framework to the DP World case, as highlighted below.

RFID Business Model Framework at DP World

Value Proposition

Offering: providing customers with cost effective marine terminal services of high quality and unparalleled efficiency and safety around the world.

The most recent RFID-enabled automatic gate project has recently enabled DP World to reinforce the above value proposition by enhancing customers' supply chain efficiency.

Value Creation System

Resources

DP World pioneers the use of world-class facilities and technology, including the largest quayside cranes in the world. The company heavily invests in state-of-the-art equipment and advanced technologies and automated terminal systems to maximize terminals' efficiency. Special arrangements with the Jebel Ali Free Zone provide incentives for Foreign Direct Investment (FDI), transshipment and re-export activities, as the Free Zone offers full foreign share ownership, tax-free and duty-free operations and 100 percent repatriation of capital and profits [Jacobs and Hall 2007].

With the distinctive capital and financial resources available at DP World, financial barriers that might impede investment in expensive RFID infrastructure are circumvented.

Capabilities

DP World has been successful in enhancing container terminal capacity utilization via improved productivity and efficiency. Various IT solutions are being deployed to help customers manage effectively their supply chains. These solutions include electronic customs release of cargo, Electronic Data Interchange (EDI) reporting, Security Management System, and Internet-based information services. In 2007, the company launched the "e-token" electronic system, aimed at facilitating work-flow efficiency and movement. The new system enables customers to log on to the DP World portal and book in advance the delivery and receipts of containers to and from the terminal. "Token slips" generated online are accepted at all ports' entry points. The company invests heavily on training and on upgrading the skills of its workforce. DP World is also using its large financial resources to acquire the lease concession of nearby ports and the takeover of other strategic (including competing) container ports, thus increasing the barriers to entry.

For the automatic gate project, DP World is working closely with its RFID vendor, in charge of the project, to transfer some of the required capabilities to operate and maintain the system to its staff. This is achieved by direct involvement of some of staff in the project, as well by special training workshops.

Value Chain Arrangements

DP World provides services to help customers streamline their supply chains and reduce logistic costs, either directly or indirectly through third-party logistic providers. The company seeks to insert itself in supply chains by providing financial incentives, leasing concessions, and setting up ports around the world. Further, DP World strives to integrate activities within the supply chain to reduce uncertainty, transaction and transportation costs, and enhance operating efficiency. The company has also pursued an aggressive global acquisition strategy to gain control over a larger part of the logistical chain through vertical and horizontal integrations.

The recent installation of the RFID-enabled "automated gates" will ease trucks flow in the terminals and eliminate manual inspection at gates, therefore adding value to the overall supply chain.

Value Capture Model

Revenue Generation Model

At DP World, a significant majority (76 percent) of the throughput traffic is Origin & Destination (O&D), with transshipment volume at 24 percent. O&D (import/export) traffic is more profitable, generating more revenue per quay crane lift. Customers are charged for delivery as well as ancillary services. Other sources of revenue include management fees and terminal tariffs.

By easing traffic flow, the RFID "automatic-gate" project also aims to increase the handling throughput at the ports, while enhancing service offering to customers. These will have direct impact on bottom-line results.

Cost Structure

DP World management keeps tight cost control policy. Cost of sales includes costs incurred in connection with the operation, maintenance and security of DP World facilities and other costs attributable to services provided by DP World, including terminal concession fees, stevedoring, and marine labor costs. Capital expenditures in infrastructure, superstructure, terminal expansions, facilities' modernization, and new development projects are major components of DP World cost structure. For low-level jobs, DP World benefits from its easy access to cheap labor from neighboring countries such as India, Pakistan, and Bangladesh. DP World focuses on controlling two major cost drivers: increasing traffic volume to leverage fixed capital cost and reducing operating costs.

RFID enable DP World to increase traffic volume, as trucks will no longer need to stop to finalize entry or exit transactions and obtain gate passes, thus reducing traffic congestion at the port entry points. RFID can potentially reduce transaction costs for port users, as manual inspections at gates are now completely eliminated.

Value Deliverance

DP World strives to provide outstanding customer services, with more than 30,000 employees helping customers manage global supply chains. The newly launched automatic gate system will further enable DP World to meet the increasing demands for its customers by eliminating lengthy paper transactions and by providing smoother and more efficient operations and movements of containers at terminal gates. By speeding up truck turn-around time, DP World will not only increase port productivity but will also increase customer satisfaction.

IX. CONCLUSION AND FUTURE RESEARCH

In a business environment characterized by rapid changes, RFID technology has emerged among the latest innovations that promise to redefine the business models of many organizations. However, RFID on its own does not guarantee value creation and competitive advantage, but can act as catalyst for business model innovation. As discussed here, technology managers must take a holistic approach to RFID business model innovation. The ultimate goal is to look to RFID adoption not just as a means to comply with new mandates but also as an enabler for business process innovation and business model transformation.

Based on an extensive investigation and integration of different theories related to E-business models, external environmental factors, value networks, transaction cost economics, and dynamic models, we outlined a framework for RFID business model redesign and innovation. We also presented a taxonomy of RFID business models, which reflected the wide spectrum of potential directions and applications of the technology. Based on interviews conducted with managers at DP World, our proposed framework proved to be valuable, both conceptually and practically.

Our research highlights the need for organizations to examine their business model and their external environmental factors before embarking on an RFID project. In fact, there is no single formula for RFID business model success. The economic value creation and appropriation from RFID is mainly driven by the ability of the firm to integrate, diffuse and align RFID with its resources, capabilities, and activities.

Like other qualitative empirical studies, this work is not without its limitations. We tested the validity of our conceptual models with a single illustrative case study, consisting of a desk research, and interviews with managers at DP World. This can be improved by conducting comparative/longitudinal case studies. This contribution can also initiate other research directions, as some of the main findings of this work can be treated as hypotheses for further refinement, validation and empirical testing.

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APPENDIX 1

Table 2. Business Model Components

Business model component	Description
Value proposition	The unique added value an organization offers customers via a bundle of product and services
Value creation system	
Resources	Unique and valuable resources (financial, physical, human, technological and organizational) needed to execute the business model and deliver the proposed value
Capabilities	Skills and repeatable patterns of actions needed to coordinate the resources and putting them to execute the business model and deliver the proposed value. Unique resources and capabilities are major sources of a firm's distinctive competency.
Value chain arrangement	The structure of the value chain required to procure, produce, market, and distribute the offering, as well as the position of the firm within the value network. This includes the inter-linked activities and alliances of the firm with suppliers, partners, distributors, and complementors that are needed to execute the business model and deliver the proposed value.
Value deliverance	
Market segment	The group of customers and geographic markets an organization wants to target to deliver the proposed value. Different segments might have different needs, thus requiring a different value proposition and different products and services.
Customer relationship	The kind of link the firm establishes with its customers
Distribution channel	The way a firm reaches its customers to deliver products and services.
Value capture model	
Revenue generation model	The source of revenue flow and the way the income is generated. The model also needs to assess the margin and market share for each revenue source.
Cost structure	The aggregate tangible cost (fixed and variable) required to execute the business model and deliver the proposed value. The effect of the difference between the cost structure and revenue model yields the profit model.

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