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Stages in Adoption of RFID Innovations by Organizations: Identifying Facilitators and Inhibitors

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ABSTRACT

Radio Frequency IDentification (RFID) innovations have gained considerable attention in the last several years and attracted the attention of organizations across different industries. RFID technologies have found applications in diverse areas such as package tracking, inventory management, baggage handling, school attendance, and logistics. Prior literature on RFID innovations offers insights into the major benefits and challenges of RFID; the technological, organizational, and environmental factors that influence organizational adoption of RFID; and the experiences of specific companies. However, there is a lack of understanding of the processes by which organizations actually adopt and implement RFID technologies over time. We develop a stage model of RFID adoption, empirically examine it using multiple case studies, and identify the facilitators and inhibitors of RFID adoption over time.

Keywords

Radio Frequency IDentification, RFID, Innovation, Adoption, Stage Model, Facilitators, Inhibitors.

INTRODUCTION

Radio Frequency IDentification (RFID) innovations have attained prominence over the last several years and attracted organizations competing in several different industries (e.g. Loebbecke and Palmer 2006; Vijayaraman and Osyk 2006; Janz, Pitts and Otondo 2005). Organizations use RFID technologies for a variety of purposes including access control, package tracking, inventory management, baggage handling, fraud prevention, school attendance, tagging parts, logistics, marketing, sales, and after-sales service (e.g. Brown and Russell 2007; Asif 2005; Curtin, Kauffman and Riggins 2007).

Prior research has examined RFID innovations from different perspectives. Some studies have provided an understanding of the benefits and challenges in adopting and implementing RFID technologies (e.g. Jones et al. 2005; Li et al. 2006). Other studies have developed models for examining RFID innovations: for instance, Curtin et al. (2007) proposed an agenda that included the dimensions of adoption, usage, and impact; Brown and Russell (2007) examined a model with technological, organizational, and environmental contexts; Ranganathan and Jha (2005) included institutional, organizational, and supply chain factors; and Sharma and Citurs (2005) examined technological, inter-organizational, organizational, and environmental factors. Yet other studies have reported on specific cases (e.g. Loebbecke and Palmer 2006).

Despite the considerable attention, prior literature does not offer explanations on the processes by which organizations adopt and implement RFID innovations over time. We develop a stage model of adoption of RFID innovations for organizations and empirically examine the model through a series of case studies of real-world organizations. Based on insights gained from a preliminary analysis of the empirical cases, we identify various facilitators that persuade as well as inhibitors that dissuade organizations to move through the different stages of adoption of RFID innovations.

STAGE MODEL OF RFID ADOPTION

Organizations pursuing innovations are known to progress through various stages of adoption over time (e.g. Rogers 1995). At the very fundamental level, it is possible to recognize two distinct phases of adoption: a) the phase prior to the adoption decision, and b) the phase following the adoption decision. Whereas the former deals with activities that lead to the adoption decision by an organization, the latter deals more with the ways in which or the extent to which the organization may exploit

the innovation. Prior literature is replete with a variety of models that attempt to delineate the different stages within the two phases.

Ettlie and Vellenga (1979), employed six different stages of adoption: awareness, interest, evaluation, trial, adoption, and implementation. Fichman and Kemerer (1997) and Fichman (2001), following up on Ettlie and Vellenga (1979), also suggested six stages of adoption: awareness, interest, evaluation/ trial, commitment, limited deployment, and general deployment; however, the evaluation and trial stages were combined into a single stage whereas the implementation stage was split into two distinct stages as limited deployment and general deployment. Awareness refers to the key decision makers being conscious of the innovation; interest represents the organization's commitment to learn more about the innovation; evaluation/ trial denotes the organization's acquisition of the innovation and initiation of evaluation and trial; commitment indicates that the organization is dedicated to implementing the innovation in some respect; limited deployment represents the organization's established procedures for some use of the innovation; and general deployment represents the organization's substantial use of the innovation.

Kwon and Zmud (1987), Cooper and Zmud (1990), and Gallivan (2001) argued for six stages of adoption as well: initiation, adoption, adaptation, acceptance, routinization, and infusion. Initiation refers to the selection of the innovation for the organization; adoption is concerned with the securing of resources and support for the innovation within the organization; adaptation deals with the processes of making the innovation available to all individuals within the organization; acceptance involves the mechanisms of convincing the individuals to use the innovation; routinization refers to the integration of the innovation into the normal everyday activities of the organization; and infusion deals with the use of the innovation by individuals to its full potential. In this conceptualization, the first three stages have generally been regarded as the initiation/ implementation stages whereas the last three stages have been considered as the levels of implementation.

Rogers (1995) introduced five different stages of adoption for organizations: agenda-setting, matching, redefining/ restructuring, clarifying, and routinizing. Agenda-setting refers to the processes by which the adoption decision was made by the organization; matching deals with the ways in which the needs of the organization were matched to the capabilities of the innovation; redefining/ restructuring describes the mechanisms by which the innovation was fit to the organization, including changes in organization structure and operations; clarifying deals with the reinvention of the innovation for the organization; and routinizing describes whether the innovation was assimilated into the everyday operations of the organization.

These stage models exhibit certain differences (e.g. the number of stages proposed by the various models is different, some models deal only with implementation whereas others deal with levels of implementation, the stages in some models deal only with behaviors while others deal with both perceptions and behaviors, etc.) as well as similarities (e.g. evaluation and trial are generally common to several models, implementation and deployment are common to different models, acquisition is generally found in stage models, etc.). The similarities in behaviors across the various models may be used to construct a general stage model of innovation adoption.

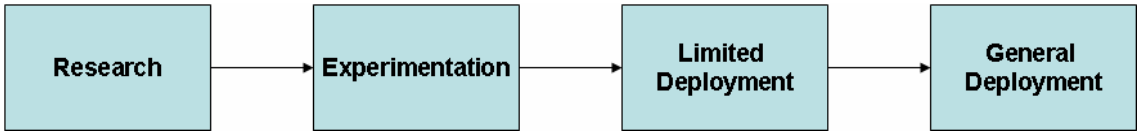

Figure 1. Stages in Adoption of RFID Innovations

We formulate a four-stage model of RFID adoption by organizations: **research**, **experimentation**, **limited deployment**, and **general deployment** (Figure 1). Research refers to the organization's awareness of the innovation and its efforts to obtain more information about the innovation and understand the extent to which the innovation may be appropriate for its strategy and operations. This is consistent with awareness (Fichman 2001) and agenda-setting (Rogers 1995) stages in other models. Experimentation represents the organization's evaluation and trial of the innovation to gain an understanding of the extent to which the innovation can be implemented or the ease with which it can be customized to its needs. This is consistent with experimentation and evaluation/ trial (Fichman 2001) stages in other models. Limited deployment deals with the organization's initial efforts at implementing the innovation, typically for a limited set of operations that requires only a limited set of features of the innovation. This is consistent with limited deployment (Fichman 2001) and partial adoption in other models. General deployment encompasses the organization's continued efforts at implementing the innovation, typically for a more complete set of operations that dictates the predominant use of several, if not all, features of the innovation. This is consistent with general deployment (Fichman 2001) and full adoption in other models of innovation adoption.

RESEARCH METHOD

The research method employed in our study involved the identification of organizations in the mid-western region of the United States and the conduct of a series of interviews with different individuals in each organization. The organizations were identified from a variety of sources such as personal contacts, an advisory board at our university comprising several organizations, and published reports. At each organization, we requested access to those individuals who were directly involved with the introduction of RFID technologies. Such individuals have been from different functional areas within the organizations, including information systems, manufacturing, etc. and performing different roles such as managers, project managers, etc. These individuals participated in interviews conducted by the researchers at the research sites and reported on their experiences with the RFID research, experimentation, or deployment. In addition to the interviews, the researchers also participated in a tour of the organization's facilities, which also provided useful information. The researchers also gathered additional information from secondary sources such as the organizations' web sites, white papers and technical reports, and industry reports and magazine articles.

EMPIRICAL CASES

The subsections below describe the experiences of different organizations in various stages of RFID adoption, including research, experimentation, limited deployment, and general deployment.

Research Stage: ORG-A

ORG-A is a $200 million manufacturing operation located in a small town in mid-western United States. The operation focuses on screen printing or decorative work on several different products such as control panels (for washers and dryers), bumpers, door handles, ceramic signs, burner bowls, etc. ORG-A deals with two major suppliers providing raw materials (one of which provides about 90% of the raw materials) and with only a handful of buyers.

The manufacturing operation is housed in a large area and spans several stages, including stations for receiving materials, cutting and pressing, screen printing, packaging finished goods, shipping, etc. The existing systems rely heavily on barcode technologies for tracking everything – this includes the homegrown barcode system for keeping track of work-in-process materials as well as the barcodes used for tracking raw materials received and shipping finished goods.

The basic unit tracked by the barcode systems differs through various stages of the production function. For instance, at the receiving end, the unit is typically the big rolls of steel that will be eventually cut, pressed, and printed, whereas through various work-in-progress stations, the unit is typically the individually-cut pieces. At this time, however, ORG-A does not track individual pieces, but is more interested in the batches of individual pieces. This is true even when they store the pieces (in specially designed containers) between different stations. [At each of these designated stations, ORG-A currently uses a rudimentary inventory-tracking mechanism that is a combination of barcodes and hand-written index cards which provides an indication of how many pieces arrived at the station and how many are still remaining at the station.] Similarly, at the very end of the production process, when the finished goods are ready for shipment, the individual pieces are packaged in large containers, some holding as many as 50 pieces. These large containers (mostly cardboard sides and plastic tops and bottoms) are typically reusable and contain a mass of barcode labels – some of which are created by ORG-A while the others are generated by its buyers. These containers are gathered at specially designated floor locations (also identified by unique barcodes) from where they are loaded on the transport vehicles.

ORG-A is entrenched in a technology culture that makes it more prone to adopting innovations. Key managers at ORG-A are very much technology-focused and generally scan the environment for news of breakthrough technologies: they believe in taking advantage of technology when and where possible. Recently, several technology implementations have been implemented, including barcode technology for work-in-progress materials, Materials Requirements Planning (MRP) systems, and Enterprise Resource Planning (ERP) systems. Decisions regarding the adoption or acquisition of technologies can happen at various levels at ORG-A depending on the extent to which such systems support the production function, the cost of deploying the technology (including human resources, training, etc.), and the extent to which there is a business case for the new technologies. Key managers have some discretionary budget that allows them to explore and implement newer technologies which may benefit the production function. Approvals for new technologies involving capital expenditure are typically obtained from higher level management and in consultation with the finance department.

Currently, ORG-A is engaged in researching the potential of RFID technologies for their operations. Key managers are particularly excited about the potential of RFID technologies and express an active interest in adopting them for their internal and, quite possibly, external operations. Several different business reasons (such as tracking units being different, the need to focus more on batches and not individual pieces, the recent introduction of barcode-based technologies for tracking work-in-

progress inventory, the cardboard- or plastic- based containers for packing finished goods, etc..) contribute to ORG-A's decisions regarding for RFID technologies. Key managers believe that the greatest potential for RFID technologies surrounds the finished goods and shipping to customers – which would tie well with the emphasis placed on customer-focused efforts. [This also addresses some of the limitations or cost considerations associated to RFID technologies – for instance, ORG-A uses metal-based materials, which may not be suitable for use with the relatively inexpensive passive tags.] ORG-A is looking for other organizations who have already adopted RFID and can help understand the power of RFID technologies, while also researching on the new equipment (such as a RFID-capable printer to print info as well as encode RFID info, readers, etc.) that would be required for implementing RFID technologies.

Experimentation Stage: ORG-B

ORG-B is a state academic institution located in mid-western United States and is home to about 3,000 faculty/staff and 15,000 students, a large proportion of who are regular commuters to the campus. Even though the primary function is higher education, ORG-B focuses a lot on the efficient management of basic operations, such as parking, identification cards, pharmacy services, etc. required for faculty/staff and students on its premises.

The current method of parking uses unrestricted surface parking lots, which tend to get crowded during the peak hours, leading to inconvenience for faculty/staff and students alike in getting to their destinations on time. There are 20 parking lots, out of which two are designated for student parking only, three for faculty parking only, and the rest are shared, with spaces distinctly marked for faculty/staff and students. Some of the parking lots are at an inconvenient distance from the campus, and the organization uses shuttles to allow students to go into the campus from these parking lots.

The university procures parking hangtags from a national hangtag manufacturing company. Each hangtag has a unique identification number that is printed in both numeric and barcode formats. New hangtags are procured every year and all faculty/staff and students must obtain a new hangtag to continue parking in campus. Parking enforcement is currently performed visually. Parking enforcement officers use golf carts and small pickup trucks to move around the parking lots ensuring there are no violations. This is done visually by ensuring every car has a hangtag with the proper color and design that is used for the year; however, if the visual process fails, then the parking enforcement officers have to physically go near the vehicles to complete the inspection. The inspectors have access to barcode readers and Bluetooth-enabled portable printers for printing parking tickets for violations. However, the large number of parking lots and a relatively small number of inspectors means that zone violations sometimes go undetected.

ORG-B has a technology culture that allows it to be flexible regarding innovations. For instance, ORG-B has implemented controlled access to two faculty-only parking lots. These parking lots are equipped with gates and require the patrons to swipe their university identification cards in the card readers installed by the gates to obtain entry. Recently, ORG-B also experimented with magnetic proximity cards in place of the swipe cards. [Thus, the connectivity required for validating the swipe or proximity cards is already available at ORG-B in those controlled-access parking lots.]

When ORG-B became aware of RFID technologies over a year ago, it set up a small research and development laboratory to look into different applications of the RFID technology within the domain of campus management, vehicle tracking, and emergency response issues. This lab conducted independent research that showed how the implementation of RFID in parking operations can lead to a positive return on investment (although much of the returns in a non-profit academic setting as ORG-B would initially be non-tangible returns such as savings in time). However, the research also showed that a full implementation of RFID across all parking lots will definitely allow ORG-B to better manage its parking resources, while breaking even on the tangible returns on the investment.

Recently, ORG-B engaged in a pilot study by implementing RFID-based controlled-access in one of the faculty parking lots, with favorable results. In this pilot, approximately 50 users were issued with RFID tags (i.e. passive RFID tags were attached to their regular parking hangtags). An RFID portal specifically designed for parking control was temporarily installed at the gate to monitor the vehicles entering the lot. When vehicles with a valid RFID tag were detected, the reader opened the gate by sending a signal to the gate controller. This study was performed for two days in different weather conditions (sunny, windy and light drizzle) and the RFID reader reported a 98% read rate (i.e. only one vehicle reported problems with proper detection). Currently, ORG-B is planning additional pilots relating to RFID technologies.

Limited Deployment Stage: ORG-C

ORG-C is an automobile manufacturing organization located in mid-western United States. It supplies fully-assembled vehicles as well as engines and parts for customers in the commercial, federal, and military sectors. The manufacturing

facility is segregated into two main areas: one that deals with non-military products and the other that deals with military products, and ORG-C follows different processes in the two areas.

ORG-C set up this RFID operation in response to a mandate issued by one of its major clients. This mandate required the organization to devise a mechanism by which the client's products can be identified at various levels, including the item, product, pallet, and container levels. This client also required ORG-C to demonstrate a proof-of-concept of the required implementation; and ORG-C did not have a whole lot of time to set up an operational system to conform to the stipulations of the mandate. Hence, ORG-C went about directly setting up a passive-tag RFID system for the various levels of tracking required by the client. The client actually visited International's site to verify the proof-of-concept system developed by ORG-C and to ensure that it was consistent with needs and expectations.

The current RFID-based system implemented by ORG-C was done to satisfy the requirements of the mandate issued by its client and nothing more. ORG-C realizes that it can benefit a lot more from the RFID implementation if it focuses on other aspects such as operations efficiency and process reengineering; however, ORG-C does not have the need to pursue those pieces now (since only this one client in the supply chain has mandated the RFID tags and the remaining clients in the supply chain do not require this particular capability at this time).

ORG-C also believes that it does not have the slack resources (including human and technical resources) necessary to pursue operations efficiency and process reengineering. For instance, ORG-C only engages in a "slap-and-ship" operation (i.e. slap on the passive RFID tag to the item, product, pallet, or container as needed) to comply with the mandate; it does not track the tags with the intent of improving its internal operations related to the client – which may actually allow ORG-C to review its operations and processes. Moreover, ORG-C anticipates integration issues between the business and enterprise layers of its information systems while viewing the RFID tags as an implementation of the data layer.

General Deployment Stage: ORG-D

ORG-D is located in mid-western United States and we are currently in the process of data collection relating to their RFID implementation. We will present findings on this organization at the conference.

DISCUSSION

The empirical cases above serve to validate the stages of adoption formulated in Figure 1. ORG-A is currently in the research stage of RFID adoption, ORG-B in the experimentation stage, and ORG-C in the limited deployment stage. From these cases, it is also seen that ORG-B moved through the research and experimentation stages whereas ORG-C moved through the experimentation and limited deployment stages. [ORG-C did not experience the research stage prior to the experimentation and limited deployment stages due to the way in which it initiated the RFID implementation effort, i.e., through a mandate that also involved a proof-of-concept test.]

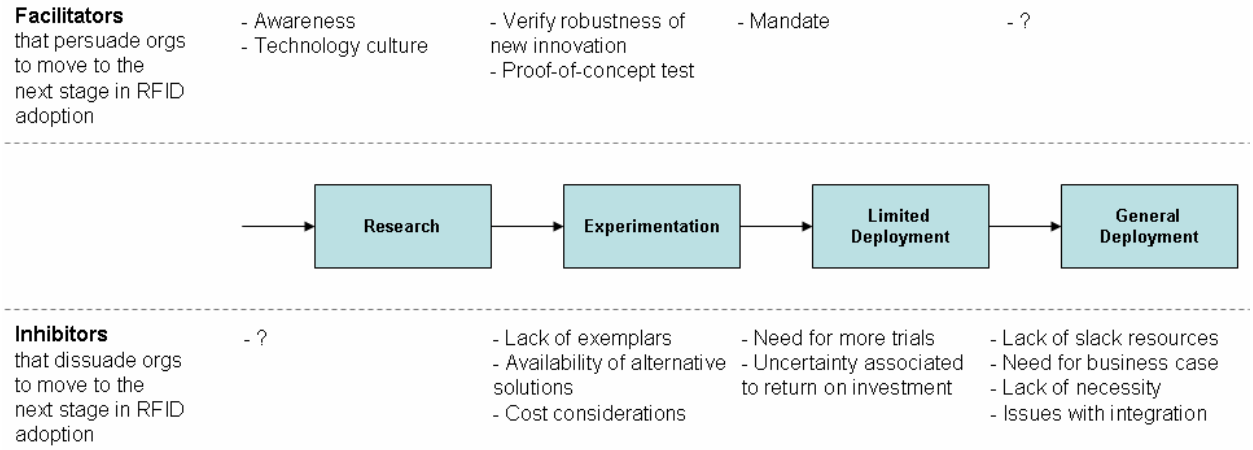

Figure 2. Facilitators and Inhibitors in the Stages of Adoption of RFID Innovations

The empirical cases were also used to identify the **facilitators** that persuade organizations to move to the next stage in the adoption of RFID innovations as well as the **inhibitors** that dissuade organizations to move to the next stage in the adoption of RFID innovations (Figure 2).

Facilitators. The experiences of ORG-A and ORG-B show that an awareness of the RFID innovation and a technology culture are essential for organizations to move to the research stage. The behaviors of ORG-B and ORG-C reveal that the need to verify the robustness of the RFID innovation and to develop a proof-of-concept involving the RFID innovation is critical in moving organizations from the research stage to the experimentation stage. The events at ORG-C demonstrate that an external mandate is one way by which organizations move from the experimentation stage to the limited deployment stage. [The facilitators for moving to the general deployment stage have not yet been extracted.]

Inhibitors. The reports by ORG-A and ORG-B reveal that the availability of alternative technological solutions and the lack of exemplars of successful RFID implementations inhibit organizations from moving to the experimentation stage from the research stage. The experiences of ORG-B show that the uncertainty associated with the potential returns on investment as well as the need to conduct more trials prevent organizations from moving to the limited deployment stage from the experimentation stage. The issues faced by ORG-C such as the lack of slack resources to dedicate to RFID innovations and implementations, the lack of necessity, and also integration restrain organizations from moving to the general deployment stage from the limited deployment stage.

These are preliminary results extracted from a handful of empirical cases described earlier. Research on other organizations is currently being conducted.

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