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Selecting RFID Technology in the Manufacturing Industry Sector: A Decision Criteria Proposal

Puja Sahni, Carleton University, psahni@gmail.com

Gerald M. Grant, Eric Sprott School of Business, Carlton University, 1125 Colonel By Drive, Ottawa, Ontario, Canada, K1S 5BG, gerald_grant@carleton.ca

ABSTRACT

While RFID has received significant coverage in the popular and IT press it is evident that managers, particularly those in the manufacturing industry, have limited knowledge about RFID with regards to its adoption and use. With the dearth of academic papers on the topic, a common occurrence whenever any new technology is in an emergent state, there appears to be a need for work that would fill the gap in knowledge as well as provide a basis for future research on RFID adoption in manufacturing settings. Drawing on the limited academic literature, white papers, and scholarly websites, this paper first discusses what RFID is and the issues affecting its adoption by organizations. It then goes on to propose a set of decision criteria that could inform managerial decisions to adopt RFID by manufacturing organizations.

INTRODUCTION

Radio Frequency Identification (RFID) is currently regarded as one of the *'hot'* new information technologies. It is widely presumed that organizations, particularly those in the Manufacturing Industry, can benefit greatly from using RFID in plant operations as well as in the entire supply chain. Practical use of RFID in the manufacturing industry has been very recent (within the last decade). The need for manufacturers to upgrade their information systems to handle RFID has stemmed from the shift in manufacturing from being more material based to more information based. Some have suggested that "as the material component of manufacturing shrinks relative to the information component, integration and electronic markets have appeared on the agendas of manufacturers large and small" (IBM Global Services - Executive Tek Report, 2003, p.1). Two organizations have been prime forces behind companies in North America adopting RFID: Wal-Mart and the U.S. Department of National Defence (DoD). Both Wal-Mart and DoD have created mandates requiring their major suppliers to be RFID compliant by 2005 (Roberti, 2003; RFID Journal, 2003). Some well-known manufacturing companies that have adopted RFID are Coca-Cola, Johnson & Johnson, Kraft, Pfizer, Proctor & Gamble, and Unilever (Datex Corporation, 2004).

While the adoption of RFID seems desirable given its many well-touted properties, the decision to adopt is not as easy as it first appears. There are both benefits and constraints to adoption that must be identified and addressed. We seek to do that in this paper. We begin with a brief introduction to RFID followed by a discussion of the benefits and constraints of RFID adoption as identified in the literature. We then discuss key manufacturing plant and supply chain processes relevant to RFID adoption. A set of evaluation criteria for RFID adoption is then outlined along with a decision tree to guide managers in making the adoption decision. Conclusions are drawn.

WHAT IS RFID?

RFID stands for Radio Frequency Identification and can be defined as "The range or frequencies between 10 kilocycles per second to 300,000 megacycles per second in which radio waves can be transmitted" (tech-encyclopedia.com, 2004). RFID uses wireless radio transmissions with a "variety of ranges and material penetration characteristics" (Datex Corporation, 2003). RFID has become known as the next generation of barcoding, but is much more powerful because it is a wireless technology that does not require line-of-sight scanning. The hardware components that make up RFID hardware are RFID tags and RFID readers.

RFID tags and readers work in the following manner: moving a tag near a reader causes a read event to occur. The reader then picks up the data embedded in the radio waves from the tag, and converts the data into a digital format creating an electronic product code (EPC). There is a layer of software between the tag and reader that allows data to be presented as meaningful information for end users. RFID tags can be classified as either read-only or read-write, the latter allowing more flexibility for information sharing. In the article, *Integrating the Supply Chain with RFID: a Technical and Business Analysis*, appearing in Communications of the Association of Information Systems, Asif and Mandviwalla (2005) provide an in-depth description of RFID and applications of the technology.

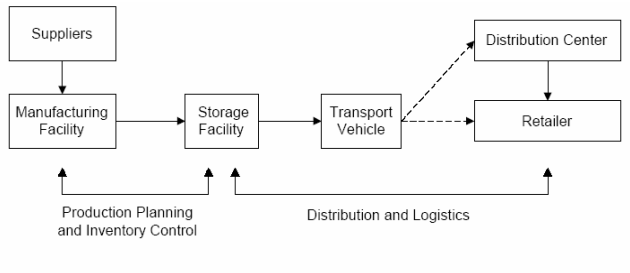
MANUFACTURING PLANT AND SUPPLY CHAIN PROCESSES

Before discussing the benefits and constraints of RFID adoption in a manufacturing setting, we first outline some of the key features of plant operations and supply chain processes relevant to this setting. We use a model proposed by Beamon (1998) to define general process elements of a manufacturing plant and its supply chain. Although manufacturing processes will vary across different industries, the common goal of all manufacturers is to "…minimize cycle times and costs while maximizing the quality of the manufactured product" (Scherr, 1993, p.81). Some detailed examples of manufacturing processes are shipping, receiving, packaging, material handling (heat treatment, welding, etc.), information handling (scanning received items), and assembly.

A Model of the Supply Chain Process

Beamon (1998) defines a supply chain as "an integrated manufacturing process wherein raw materials are converted into final products, then delivered to customers. At its highest level, a supply chain is comprised of two basic, integrated processes: (1) the Production Planning and Inventory Control Process, and (2) the Distribution and Logistics Process" (Beamon, 1998, p.2). Figure 1 below is a diagram by Beamon (1998) that outlines the supply chain process.

Figure 1. Supply chain process



Source: Beamon, 1998

Beamon (1998) describes component parts of the supply chain as follows:

"The Production Planning and Inventory Control Process *encompasses the manufacturing and storage sub-processes, and their interface(s). More specifically, production planning describes the design and management of the entire manufacturing process (including raw material scheduling and acquisition, manufacturing process design and scheduling, and material handling design and control). Inventory control describes the design and management of the storage policies and procedures for raw materials, work-in-process inventories, and usually, final products" (Beamon, 1998, p.3).*

"The Distribution and Logistics Process *determines how products are retrieved and transported from the warehouse to retailers. These products may be transported to retailers directly, or may first be moved to distribution facilities, which, in turn, transport products to retailers. This process includes the management of inventory retrieval, transportation, and final product delivery" (Beamon, 1998, p.3).*

"These processes interact with one another to produce an integrated supply chain. The design and management of these processes determine the extent to which the supply chain works as a unit to meet required performance objectives" (Beamon, 1998, p.3).

BENEFITS OF RFID FOR THE MANUFACTURING INDUSTRY

RFID benefits accrue in two main areas for manufacturers: Plant operations and the supply chain. Although there are numerous suggested benefits of RFID, the main benefits of RFID for manufacturers can be summarized as follows:

1) Increased visibility within the plant and the supply chain
2) Access to real-time information
3) Increased information sharing within the plant and among supply chain members
4) Cost savings

Plant Operations

With RFID, manufacturers can make unloading time quicker and reduce inventory shrinkage. Because RFID doesn't require line-of-sight scanning, a significant amount of time can be saved when pallets are unloaded from a truck. All the contents can immediately be verified and information for real-time visibility can be provided by embedded RFID tags (Intermec, 2004). Within plant operations, inventory shrinkage is usually inevitable. Shrinkage can occur from inventory disappearing as they travel through the Third Party Logistics (3PLs) processes, or just from employees misplacing assets. Oftentimes, employees sometimes purposely keep assets / tools accessible in convenient places. They may then appear to be missing from inventory, leading replacement purchases. Using RFID, it becomes easier and more effective to know where assets are located. The amount of time spent looking for them and money spent replacing them is greatly reduced, producing significant savings (Werb and Sereiko, 2002).

With RFID not requiring line-of-sight scanning as barcodes do, many costs are eliminated. These include portions of salaries paid to employees involved in physically scanning items as well as the costs associated with human data entry errors.

The Supply Chain

The use of RFID in the supply chain enhances the overall benefits of RFID. For example, it provides better visibility of goods as it passes from manufacturer to retailer. Visibility within the supply chain is greatly increased when the RFID system used within the manufacturing plant is integrated with RFID systems used in the supply chain. RFID tagging allows for the exact location of products to be known in any cross section of time. This enhances product availability. The impetus for partners in a supply chain to adopt RFID sometimes comes from a key buyer or seller. For example, a large retailer, such as Walmart, may force members of the supply chain to use RFID in order to reduce costs and make business processes more efficient (Roberti, 2003).

One of the greatest benefits of RFID use in the supply chain is the increased information sharing between members, especially when read-write tags are used. These RFID tags have a programmable memory, which permit process data to be directly stored on the host. This feature allows the tags to be used in a "… closed networked database and can also be used with a stand-alone reader to transfer data throughout the supply chain" (Monette, 2001, p.4). With information being conveniently accessible, much time is saved when gathering information for decision making or executing processes.

Because so much information can be stored on an RFID tag, over time it is also possible to identify "… trends in which pick/pack and shipping routings are more efficient, which machines work better, which 3PL performs better, which common mistakes are being made in terms of retail orders fulfillment" (Johnson, 2004, p.22). This will also contribute towards overall cost savings resulting from more efficient and effective inventory management made possible by the increased information availability.

Improved decision making and business processes will undoubtedly have a positive impact on manufacturers' logistics partners as well. According to Bear, Stearns & Co, Inc., 3PLs have acknowledged that using RFID at their distribution centres and warehouses can greatly reduce check-in and check-out time, unloading time, time needed to record inventory, and the amount of human error due to reduced human labour (Bear, Stearns & Co. Inc., 2003). Most of the time, benefits of RFID are evaluated in terms of ROI. However, non-monetary benefits of RFID such as improved business decisions are not always recognized immediately – especially when doing an ROI analysis. Evidence exist that suggests that RFID, because of more accurate, real-time information and data availability, improves decision-making regarding replenishment and customer service −(Lee, Cheng, and Leung, 2004).

BARRIERS AND CONSTRAINTS TO RFID ADOPTION

The main barriers to RFID adoption are the cost of RFID tags and lack of RFID standards. Barcodes cost less than one cent each, but RFID tags can cost anywhere between 20¢ and tens of dollars US. Moreover, RFID standards are still being developed. Much work still needs to be done to formulate internationally acceptable standards. Asif and Mandviwalla (2005) cite standards, interoperability, costs, forward compatibility, and lack of familiarity as initial barriers against widespread adoption of RFID.

The availability of resources such as money, employees, and time plays a critical role in the adoption of any technology. According to Milind Patil of Patni Computer Systems Ltd, "The scope of RFID technology adoption is limited to Organizational Resources Control. Broadly

speaking, these resources can be of five types: people, material, time, knowledge, brand equity" (Patil, 2005). Material, time and knowledge are obviously necessary resources, but people resources are important as well. For example choosing the right person(s) to lead the RFID project initiative is crucial. Such persons need to possess the requisite managerial competences to orchestrate and deliver a successful project. Among the competences required is the ability to effectively communicate the vision to others. If those leadership abilities are not present, it will be difficult to keep others motivated when encountering the challenges that inevitably must be faced along the way.

Cost is one of the main barriers of RFID adoption. It is therefore crucial that effective Return on Investment (ROI) analyses of resources are performed and that the RFID project implementation plan are followed as closely as possible.

A PROPOSED EVALUATION CRITERIA FOR RFID ADOPTION

Determining whether, when, and how to invest in technologies such as RFID is a central responsibility for managers in organizations. Given the relative infancy of the RFID phenomena, it is not surprising that managers are not readily conversant with all the issues that affect decisions to adopt the technology. In reviewing the literature and in informal discussion with managers in manufacturing organizations it is clear that a set of decision criteria would be valuable in helping managers with decisions as to whether or not to adopt RFID. Drawing on the relatively small amount of scholarly literature on the subject we present a proposed set of evaluation criteria.

Three criteria are proposed. Criterion one arises from the information relating to the benefits of RFID in the manufacturing industry. Criterion two draws on information that addresses manufacturing plant and supply chain processes, and criterion three focuses on the constraints affecting RFID adoption. Each criterion is expressed in the form of a question. All three criteria have two root issues, which are used in the decision tree to give manufacturing managers an efficient way of determining whether or not adopting RFID could improve business processes. The decision criteria and issues are described in Table 1. Figure 2 displays the proposed decision tree.

Criteria 1 - Can business processes be improved and/or costs be reduced using RFID?

This criterion needs to be determined first because if the answer is 'no', then no more time or money should be wasted on an RFID solution. The issues in this criterion arise from the literature review, which identified the main benefits of RFID for manufacturers.

Criteria 2 – Where can business processes and/or costs be improved: in plant operations, in the supply chain, or both?

Once it has been determined that RFID may improve business processes, the next logical step would be to determine where business processes could be improved. The questions have been separated to apply to either plant operations (Criteria 2a) or the supply chain (Criteria 2b) in order to determine the scope of a possible RFID solution.

If the answers to the questions is 'yes', then it is evident that both manufacturing plant and supply chain processes can benefit from RFID. If most 'yes' answers were in Criteria 2a), then it can be assumed that the scope of the problem is more prevalent in the manufacturing plant. If most 'yes' answers were in Criteria 2b), the scope of the problem is more prevalent in the supply chain. The next step is to determine a feasible scope of an RFID solution.

Criteria 3 - Are sufficient resources available to complete the project and ensure a positive return on investment (ROI)?

The ultimate benefit of RFID is realized when it is implemented both in the manufacturing plant and in the supply chain. If RFID is needed in both the manufacturing plant and the supply chain, but cannot feasibly be implemented in both areas immediately, the manufacturing company can consider implementing RFID in-house first and eventually take on the bigger scope after some ROI has accumulated. Therefore, an RFID system implementation could occur in phases by starting in plant operations, and then expanding into the supply chain over time. It is assumed an ROI analysis will be performed to determine a feasible RFID solution given the constraint of resources.

Scarcity of resources (especially financial resources) is one of the main reasons why returns on investments are not realized. The benefit of implementing a technology usually occurs only when all components of the system have been implemented and are working together as a whole. Often, during the middle or end stages of a project, resources become scarce for various reasons, and the project is either put on hold or not completed at all. The result is a waste of the resources allocated at the beginning, because the benefits of the initial investments are never realized. Extra resources (especially time and money) should be allocated to encounter unexpected challenges during the project to help ensure the completion of a project.

Criteria 1	**Can business processes be improved and/or costs be reduced using RFID?**	
	Issue 1 Do the core activities of your business processes involve the identification/tracking of items?	**Issue 2** Are labour costs related to product identification/tracking high?
Criteria 2	**Where can business processes and/or costs be improved: in plant operations, in the supply chain, or both?**	
Criteria 2a	**Can business processes and/or costs within the manufacturing plant be improved?**	
	Issue 3 Are information sharing methods during shipping and receiving inefficient?	**Issue 4** Is it difficult to keep a track of asset loss?
Criteria 2b	**Can business processes within the supply chain be improved?**	
	Issue 5 Is there potential for better communication with supply chain members?	**Issue 6** If your company had more visibility of inventory in transit, would substantial cost savings be realized?
Criteria 3	**Are sufficient resources available to complete the project and ensure a positive return on investment (ROI)?**	
Issues	**Issue 7** Is there sufficient funding available to implement RFID in the plant and supply chain simultaneously	**Issue 8** Is there sufficient project management and technical skills to implement the RFID program?

DECISION TREE FOR RFID ADOPTION

We translate the following criteria into a decision tree (Figure 2) that may provide a useful entrée for managers charged with making decisions about adopting RFID into their organizations. Since the elements of the decision tree are based on issues generated from the available literature, the validity of the proposal will need to be empirically tested in actual practice. Consequently, this proposal embodies a set of propositions that should provide a foundation for future research.

CONCLUSION

The purpose of this paper was to use existing literature to 1) fill an information gap on the potential of RFID technology in the manufacturing industry, and 2) develop a set of criteria for RFID adoption, which may be tested in a future research initiative. The decision tree purposely includes broad questions (the root questions) to allow manufacturing managers to quickly identify if RFID can solve business problems. If after following the decision tree managers are not clear if RFID is the optimal solution, or have clearly decided about RFID adoption but are still interested in more evaluation criteria, then detailed questions may be developed under the root questions, which may help to make the decision to adopt RFID clearer.

This study is limited by the relatively small amount of academic literature on RFID adoption. Further research is required to test the proposed evaluation criteria to help determine their validity. We

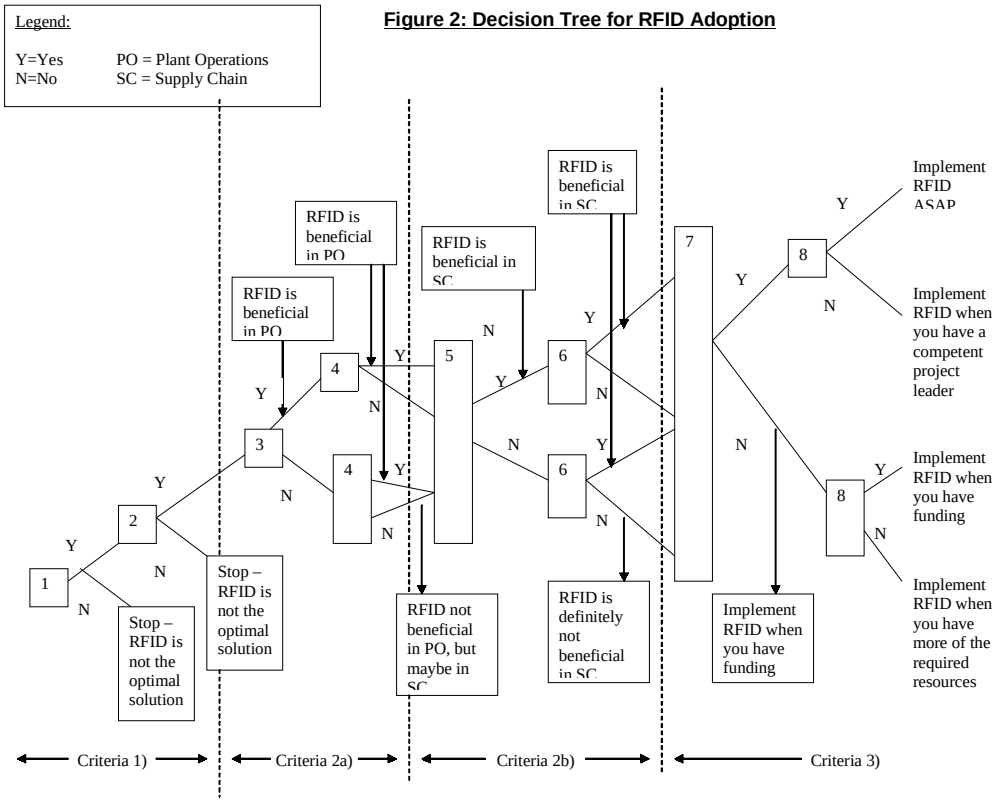


Figure 2: Decision Tree for RFID Adoption

envisage a cross-sectional case study design involving manufacturing managers of different organizations. A validated instrument would provide a tool that manufacturing managers can apply when faced with RFID adoption decisions.

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