Journal of Information Technology Management

ISSN #1042-1319

A Publication of the Association of Management

IMPORTANCE- PERFORMANCE ANALYSIS FOR THE ADOPTION OF RADIO FREQUENCY IDENTIFICATION TECHNOLOGY

YUH-WEN CHIU
FAR EAST UNIVERSITY
Jessica@cc.feu.edu.tw

DAVID C. YEN
MIAMI UNIVERSITY
yendc@muohio.edu

DONG-HER SHIH
NATIONAL YUNLIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
shihdh@yuntech.edu.tw

ABSTRACT

Radio frequency identification (RFID), an automatic identification mechanism via radio waves, is a very promising means of replacing the traditional barcode technology. With increasingly fierce competition, organizations within the retailing and logistics sectors have been forced to adopt RFID technologies as a means of maintaining relative competitive advantage. Even as the RFID technology or systems becomes more and more popular, the following questions and concerns remain an important issue for the potential adopters: (1) what are the real benefits of the adoption and/or implementation of RFID system, and (2) how far and fast should companies change in order to embrace this technology?

Importance-performance Analysis (IPA) is a simple and effective management analysis tool that has been successfully applied in the marketing field for many years. However, few researchers use IPA in the MIS/IT area, and this paper argues for the use of the aforementioned tool to study RFID system implementation.

From a manufacturing company core competence perspective, this empirical investigation (n=134) found that warehouse management likely has a special need for focusing continuously on performance improvement. In essence, I-P grids prove to be an attractive analysis tool in determining how well RFID meets user's important concerns.

Keywords: RFID (Radio frequency identification), Importance, Performance, Importance-performance Analysis (IPA).

INTRODUCTION

Radio Frequency Identification (RFID) is a promising wireless system technology, which can be used to help retailers, manufacturers and other users reduce supply chain costs while speeding up the production process and flow of goods. A typical RFID system contains a tag, reader, and some sort of data processing equipment, such as a computer. The tag is actually composed of a small integrated circuit that is connected to an antenna. Further, the tag is placed on an object for identification purposes. The tag component transmits identified information back to the reader, which then forwards this information to the data processing unit where additional information may be stored [1].

Global market demand for RFID is projected to reach US $25 billion by 2015. This forecast represents a major potential business opportunity. Forecasts by territorial region show that by 2010, 48% of RFID tags will be sold in East Asia, followed by 32% to North America. In 2006, almost three times the volume of RFID tags were sold than over the previous 60 years since their invention. This exponential growth is expected to continue, and by 2015, the value of sales of RFID tags will be increased by thirteen times over the 2005 figures [2].

Keen and Mackintosh [3] consider RFID technologies to be part of a 'universal infrastructure' that will support mobile commerce technology. The applications of RFID are wide-ranging and include the manufacturing and distribution of physical goods such as automobiles and transmission assembly [4], shipping and port operations [5, 6], and pharmaceutical packaging [7], among others.

However, the situations for utilizing RFID do not always create a simple task. In spite of RFID's advantages, a significant barrier in its use is the cost. Individual tags currently range from US$ 0.25 - 0.35 per unit. Therefore, primary applications for RFID systems have been limited to instances where the cost of the tag is not an issue [8]. Only 30% of Wal-Mart's suppliers possessed the capability to execute the RFID project in 2005[9]. Adding to the complexity, the standards of RFID are not yet fully established. These factors will most likely hinder industries as they move to adopt/implement RFID. Ferguson [10] also argues that RFID growth in 2006 was slow and 2007 figures promise to be similar. It turns out that 2006 wasn't the banner year for RFID adoption as some analysts had predicted, particularly in the retail and consumer packaged goods sectors, where fast growth was expected. In addition, it looks like in 2007 the situation didn't appear much different.

Roberti [11] suggests that the reasons that RFID didn't achieve a large-scale adoption in the retail/consumer-packaged goods supply chain in 2006 were due to factors such as the costs of tags, and the return on investment of RFID adoption. Angeles [12] articulates that the guidelines for IT and business managers to proactively implement RFID technologies in the first stage make the ROI cases for the slow movement of RFID. Managers, therefore, face a dilemma in which the contribution of RFID technology as a means to strive for the competitive advantages is pitted against uncertainties as to its actual business value. This has led to a clear need to track the success of RFID investments. There is an obvious need for a tool which is simple enough for easy management adoption, sufficiently powerful for diagnosing these areas of weakness, and easy enough to facilitate the feedback necessary for continuous re-alignment and improvement processes.

The purpose of this paper is to advocate for I–P maps as a strategic management tool, and to help compare immediate courses of action from a manufacturing core competency perspective. The following research questions were addressed in our investigation:

RQ1: Does IPA method expand the utility in the IS field like RFID?

RQ2: What is the realistic value of RFID from manager's perspective?

LITERATURE REVIEW

Introduction to RFID Technology

RFID is a generic technological concept that refers to the use of radio waves to identify objects [13]. It's considered a significant improvement over the traditional barcode, which needs to be read by scanners in a "line-of-sight" fashion and can be stripped away if the paper product label is ripped or damaged. The RFID system is typically comprised of the following components: an RFID device (tag); a tag reader with an antenna and transceiver; and a host system or connection to an enterprise system.

The tag contains unique identification information of the objects to which it is attached. The reader emits and receives radio waves as a means to read the information stored in the tag and the data-processing equipment processes all the collected data. This equipment can be as simple as a personal computer or as complex as an entire networked enterprise management information system. Current RFID tags can be active, passive or semi-passive. An RFID device that actively transmits data to a reader is referred to as an active tag, while the un-powered devices are referred to as ''passive tags''. Active tags are typically read/write devices, while passive tags are generally read only. Active tags are larger and more expensive than passive tags. There are also semi-passive tags where the battery runs the chip's circuitry, but the device communicates by drawing power from the reader.

The chip in the tag can incorporate read only memory (ROM), volatile read/write random access memory (RAM), or write once/read many memory (WORM). ROM is used to store secure data and hence has a unique device identifier and operating system instructions. RAM is used for data storage during transponder interrogation and response.

Costs of tags are currently an important issue and are proving to be one of the main barriers to RFID system adoption. RFID tags' cost, however, is continuing to drop, which may encourage wider scale adoption [1, 12]. The goal is to bring down the cost to about 5 cents per tag or lower. If this reduction of costs can be achieved, it will make RFID a viable alternative to the traditional barcode.

RFID readers communicate with tags trough the method of inductive coupling. Passive tags draw their power from the transmission of the reader through inductive coupling and then respond to the enquiry. Active tags usually communicate through propagation coupling and respond to the reader's transmission, drawing on internal power to transmit [14]. There are differences in terms of frequencies allocated for RFID applications although standardization through international Standards Organization (ISO) and other similar organizations are assisting to provide improved compatibility [1].

Importance-Performance Analysis (IPA)

In the formulation of operations strategy, a critical stage is the derivation of a ranked list of competitive factors like cost, efficiency, quality, flexibility, etc. These factors are used either to infer an appropriate set of strategic operations decisions or alternatively are used in conjunction with an independently derived list of the organization's performance in order to prioritize each of the competitive factors. Martilla and James [15] take the latter approach to derive an importance-performance matrix [16].

Martilla and James [15] first proposed IPA as a tool to develop firms' management strategies. IPA has continued to be a popular management tool among researchers in the areas of service quality [17], travel and tourism [18,19], leisure and recreation [20,21], education [22,23], healthcare marketing [24,25], new product success [26], and diagnosing IS success [27].

IPA is a matrix-based technique that combines the measures of attribute importance and performance into a two-dimensional grid [15]. IPA begins with the generation of a set of key attributes of a target product and then ranks each attribute for its importance in terms of a purchasing decision. These attributes, which are critical for analysis, are generally obtained from literature or interviews from which survey instruments are developed. Finally, the importance and performance of the identified elements are plotted against each other, allowing for comparisons to be made. Figure 1 summarizes the steps to conduct an IPA grid.

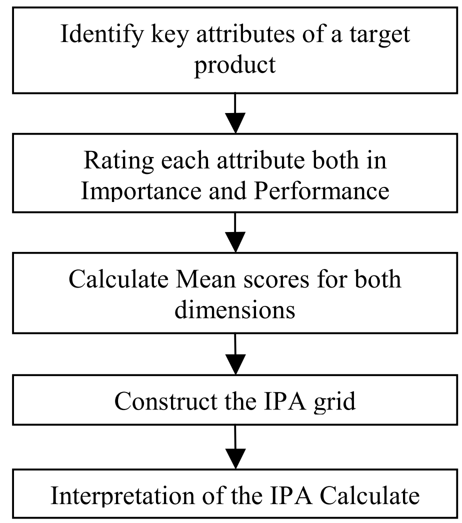

Figure 1: Steps of Constructing IPA Grid

This method defines a two dimensional grid - with the horizontal axis pertaining to the judged performance of a product, rated from 'fair' to 'excellent', and with the vertical axis indicating the importance of the attribute rated, ranging from 'slightly' to 'extremely' important. The means of importance and performance for each attribute provided supplies the coordinates for placement in this two-dimensional matrix. The crosshairs are located at the mean of the results. From the discussion above, an importance-performance grid can be formed with four quadrants yielding prescriptions for appropriate actions [15]. Figure 2 shows a standard IPA grid.

The 'Keep up the Good Work (high importance/high performance)' quadrant indicates that an advantage should be maintained. The 'Concentrate Here (high importance/low performance)' quadrant designates the areas that should be given top priority for improvement, as these attributes are indicative of critical weaknesses. The attributes in 'Low Priority (low importance/low performance)' quadrant are indicative of low salience and require no additional or immediate resources. Finally, the 'Possible Overkill (low importance/ high performance)' quadrant points out overly used resources and un-needed performance perceived by prospective customers. These classifications can help a manager to identify the directions and priorities to improve a target's performance, and increase customers' satisfaction. The list of ranked or scaled competitive factors can be used to determine improvement priorities among the competitive factors.

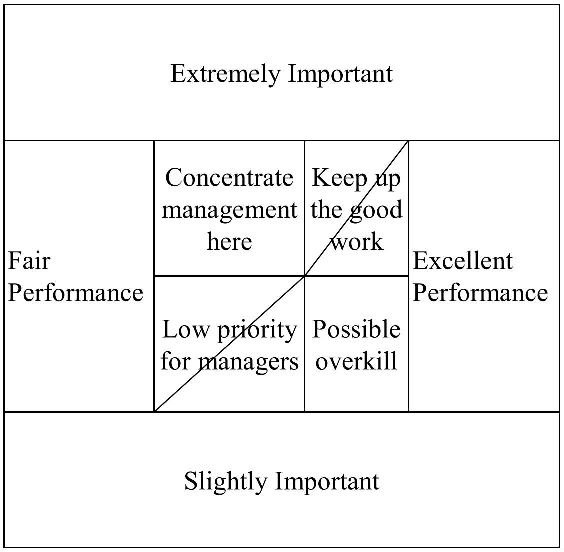

Figure 2: A Standard Importance-Performance Grid.

The use of a diagonal line from the origin, along which performance equals importance, or lines to separate regions of differing priorities has also been used in several studies (e.g. [16,25]). All points above the line represent points where importance exceeds performance, and may represent high priorities for improvement (or 'market opportunities': [25]). Points below this line represent the opposite (or 'satiated needs': ibid.).

This approach typically involves comparing the importance rating of each competitive factor with some perception of its required performance. From what is presented here, it would appear that by using a very simple survey and preparing a graph based on averages, you could identify what you should be putting effort into as a means to improve the dining experience.

There have been few publications on IPA in IS field journals. The study of Skok et al. [16] argues that IPA are an example of a portfolio based matrix, and demonstrates the use of both importance and performance dimensions within IS evaluation via I–P maps. They conclude that the strengths of IPA could be considered to be both simplistic and powerful in setting priorities and suggesting areas of improvement [16].

APPLYING IPA IN RFID'S ADOPTION DECISION

To date, RFID technology is still developing, standards are still converging, and costs are slowly dropping as a means to drive adoption. Despite the promising applications of RFID, a number of challenges have hampered the adoption of RFID. These challenges include technological application, standards, patents, costs, infrastructure, return on investment (ROI), and barcode to RFID migration challenges [1].

ROI is one of the important considerations in assessing RFID investments. Expectations of RFID benefits are difficult to calculate, because true returns estimates are based on limited benefits information from pilot projects in segmented RFID system installations [1]. Its full impact is not yet foreseeable and there is still much promise for the future. However, there is a strong managerial need to assess the value of RFID in facilitating new IT system investment. Following the methodology showed in Figure1, IPA was developed and interpreted as a means for diagnosing the importance of RFID system adoption.

Identify Key Attributes of RFID System Adoption

The main purpose of this manuscript is to use the IPA as a tool to identify RFID adoption strengths and weaknesses as perceived by users. To accomplish this, literature regarding the perceived performance (benefit) and priority importance of RFID system implementation were reviewed.

Few publications on RFID research and applications have shown up in academic journals until now. Karkkainen [28] concludes that RFID could provide quick amortization of capital by offering a range of operational benefits in the supply chain for products with a short shelf life. Kourouthanassis and Roussos [29] designed and implemented a prototype system --- a second-generation pervasive retailing system, catering to consumers. Ruff and Hession-Kunz [30] conducted a test of the systems and subsequently developed a custom RFID system that can be used for both surface and underground mining equipment. Hengst and Sol [31] presented a framework that shows the direction in which inter-organizational structures of coordination will change under the impact of e-commence.

Angeles [12] argued that RFID had the potential to liberate considerable human labor from certain workflows and also facilitate the possibility of making information visible to all participants throughout the value chain. These specific RFID-enabled capabilities are provided for two major business processes: distribution processes (receiving and check-in, put away and replenishment, order filling, and shipping) and transportation process (product and asset tracking).

Accenture proposed a RFID Strategy Matrix to assist companies in determining where they are today and where they should be in the future in terms of the adoption of this technology. They also argued that by adopting RFID, a company can improve its strategic advantage with capabilities like finished goods inventory visibility, production visibility, asset visibility, and safe and secure supply chain and supply chain planning [32]. Based on the aforementioned literature, the capabilities of RFID applications are summarized in table 1.

Table 1: Capabilities Delivered through RFID Applications

Capabilities	Description
Finished goods inventory visibility	Enhanced performance levels in shipping and receiving, labor productivity, order accuracy, and returns processing.
Production visibility	Elevated visibility into the accuracy of raw material receipts, work-in-process inventory management, and receiving-labor productivity.
Asset visibility	Enhanced asset utilization through better tracking of vehicles, reusable containers, and other high-value assets.
Safe and secure supply chain	Improvements in recall management, lot track and trace, expiration date management, and reductions in shrink.
Supply chain planning	Reduction in inventory and working capital, improved revenue through reduction in out-of-stocks, reduced expediting costs

The manufacturing industry has been the key driving force for Taiwan's economic development. Through the efforts of both the government and the private sector in creating a stable and attractive environment for investment and prosperous business development, the manufacturing industry has become very competitive. Due to the economic structure of Taiwan, there are legitimate reasons to study the benefits of RFID system application from a manufacturing point of view. Accordingly, ten specific attributes about core manufacturing logistics requirements were operationalized from previous survey instruments. Table 2 presents the complete list of attributes and items used to develop the instrument.

Table 2: Questionnaire Elements

	Benefit item	Description
1	Track and trace	Improved lot track and trace
2	Warehouse management	Better receiving labor productivity
3	Transport and logistics	Better shipping and receiving productivity
4	Inventory management	Better WIP inventory management
5	Order fulfillment management	Increased order accuracy
6	Demand planning	Reduced expediting costs
7	Out-of-stocks	Improved revenue through reduction in out-of-stocks
8	Asset tracking	Better asset use and visibility of high-value assets through tracking of vehicles
9	Manufacturing/quality control	Reduction in inventory and working capital
10	Theft/shrink management	Reductions in shrink and expiration date management

Importance and Performance Ratings Generated for Each Attributes

Seven point numerical scales were developed to measure the importance and performance of these elements. These points were categorized as ‘critical’ or ‘not that important’ when measuring the importance of the elements, and categorized as ‘poor’ or ‘excellent’ for the performance of the elements. The purpose of the survey was described, and respondents were asked to answer demographics questions about their organization and personal characteristics (including gender, age, levels of formal education, and years of experience with the business).

Data used in this survey was collected via a Convenience sampling method to select respondents. The sample for this study was taken from ten class sections of EMBA (Executive Master of Business Administration) of a major university in middle Taiwan. The subjects were enrolled in RFID related classes and voluntarily engaged in this study. Further, all had considerable work experience before participating, and most are now at the middle management level in the business domain or IT domain. A total of 500 surveys were distributed and 134 valid responses were returned with a 26.8 % response rate, which appears to be consistent with other mail surveys [33]. The demographics information of the respondents is provided in Table 3.

Slightly less than three-quarters (71.6%) of respondents were male, which outnumbered the number of females by a ratio of nearly three-to-one. The respondents were mostly 30-40 years old (67.1%), and four-fifths of the respondents had worked more than six years and almost one-third (31.1%) had worked more than eleven years. In terms of their educational background, almost one-half of the respondents were Bachelor of Science (50.7%) and more than one-third with a graduate degree (38.8%).

Table 3: Demographics Information of Survey Sample (n=134)

		Frequency	Percent
Gender	Male	96	71.6
	Female	38	28.4
Age	Less than 30	25	18.7
	30-40	90	67.1
	40-50	18	13.2
	50 or more	1	0.7
Educational	High school	1	0.7
	College	13	9.7
	University (Bachelor)	68	50.7
	Graduate	52	38.8
Work years	Less than 2	2	1.5
	3-5	27	20.1
	6-8	38	28.4
	9-11	25	18.7
	11 or more	42	31.3
Number of	Less than 100	32	23.9
	101-250	26	19.4
	251-500	18	13.4
	501-1000	28	20.9
	1000 or more	30	22.4

Obtaining Mean Values Using Importance-Performance Grid

The level of importance and performance for each attribute provided the coordinates for placement in a two-dimensional matrix. The crosshairs were located at the mean of the results, (5.336 and 5.457). Table 4 presents the mean values and difference by attributes. Figure 3, which is based on Table 4, provides the I-P grid information for RFID adoption.

Table 4: Importance and Performance Means for RFID Adoption

	Benefit item	Description	I	P	D
1	Track and trace	Improved lot track and trace	5.54	5.89	0.35
2	Warehouse management	Better receiving labor productivity	6.01	4.66	1.35
3	Transport and logistics	Better shipping and receiving productivity	5.82	5.54	0.28
4	Inventory management	Better WIP inventory management	5.91	5.51	0.4
5	Order fulfillment management	Increased order accuracy	4.94	5.48	0.54
6	Demand planning	Reduced expediting costs	4.79	5.25	0.46
7	Out-of-stocks	Improved revenue through reduction in out-of-stocks	5.01	5.55	0.54
8	Asset tracking	Better asset use through tracking of vehicles	5.40	5.71	0.31
9	Manufacturing/quality control	Reduction in inventory and working capital	4.86	5.38	0.52
10	Theft/shrink management	Improvements in shrink	5.08	5.48	0.4
			5.336	5.445	

Note: I: Importance, P: Performance

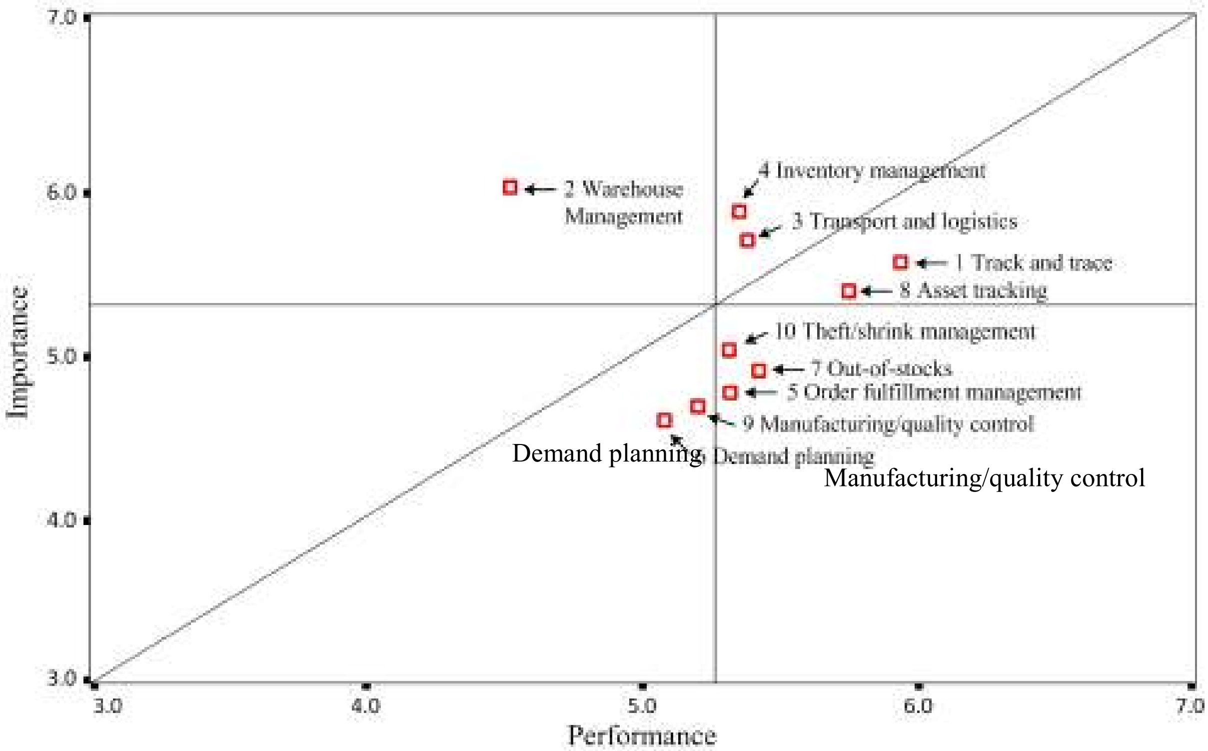

Figure 3: Importance- Performance Grid for RFID Adoption

Four attributes were situated in the Keep up the Good Work quadrant, and these attributes were rated as both important and performs highly. These items were "Improved lot track and trace", "Better asset use through tracking of vehicles", "Better shipping and receiving productivity" and "Better WIP inventory management".

RFID uses radio waves to automatically identify people or objects, with the most common use being to store a serial number that identifies a person, object, or information, on a microchip that is attached to an antenna (the chip and the antenna together are called an RFID transponder or an RFID tag). The antenna enables the chip to transmit the identification information to a reader. The reader converts the radio waves reflected back from the RFID tag into digital information that can then be passed on to computers that can make use of the data.

When RFID tags are applied to objects, radio readers give complete visibility of WIP inventory, finished goods, and assets. The readers can track their whereabouts automatically. Manufacturers that move large numbers of items every day and need the tools to track and locate them cheaply have improved supply chain efficiency through a number of initiatives from ISO 9000 to Six Sigma and lean management in last two decades. Now, with the advent of RFID technology, manufacturers may eventually be able to extend their effective supply chains to include service and maintenance of their products.

The two attributes loaded in the Low Priority quadrant were "Demand planning" and "Manufacturing/quality control." Although these attributes performed below average, they were not considered very important to the respondents. "Demand planning" and Manufacturing/quality control" fall in the area of supply chain planning, which can be regarded as a long-term benefit of applying RFID technology. Similar to responses in the U.S., earlier surveys by Accenture taken in Europe and the Asia Pacific [34, 35] supported the notion that most participants were focused on the short-term benefits of RFID and gave low marks to the supply chain-planning category.

Three attributes were identified in the "Possible Overkill" quadrant that was rated as having low importance and high performance. These attributes were "Order fulfillment management," "Out-of-stocks," and "Theft/shrink management." RFID tags on products are able to indicate when products are stolen, as well as employ a homing device to report their exact location and contents. However, most respondents thought that these attributes are not important now, even though RFID technology is doing well. Accenture [34] argues that the highest potential for benefits in RFID implementation are “Track and trace”, “Warehouse management”, “Transport and logistics” and “Inventory management”. Similar results were found in our study. Concentrating on the 45° line, three attributes above the diagonal iso-rating line represent points where importance exceeds performance: “Warehouse management”, “Inventory management” and “Transport and logistics”. Seven points fall into “Satiated Need” where performance exceeds importance.

While opportunities for improvement to all of these attributes are available, it is noted that a company may be better off by placing significant investment focus toward the top-left guardant of the I-P grid. Only one attribute, “Warehouse management,” was identified in the “Concentrate Here” quadrant which is perceived to be important, but performed poorly.

One important characteristic of RFID is providing a unique identifier to an object. An RFID tag has higher data capacity than a bar code. Depending on the type of chips, RFID tags can store more than identification information, and the information stored can also be rewritten by the users. Given these characteristics, RFID could provide more advanced record keeping and retrieval capabilities at the individual level by enabling closed-loop tracking. Closed-loop tracking can be applied in many ways. For manufacturers, RFID could better track production, quality control, and supply and production continuity. For distributors or providers, space utilization and asset management can be realized as benefits from RFID implementation [36]. RFID technology has the potential to provide freedoms to manufacturers that will liberate considerable human labor from the receiving and check-in processes within the distribution centers. It can be used to read tags and automatically update inventory quantities as tagged cases and pallets enter the warehouse, rapidly reducing time and effort at these locations. In addition, intensive manual labor required in the quantity check-in and receiving of products will no longer be needed.

However, the cost of RFID tags is one of the main barriers to the immediate implementation of this technology. Respondents of our survey agree that “Warehouse management” could achieve better receiving labor productivity with today’s tag price, under the assumption that all products got the tag on their label. As it stands currently, the efficient management of product warehousing has not been achieved as quickly as expected. It is the authors’ belief that once all goods are attached with RFID tags, radio readers will be able to track their whereabouts automatically, giving supply chain managers complete inventory visibility and improved warehouse management efficacy.

Finally, another characteristic of RFID is the ability to trace and track objects, which can produce many benefits in supply chain management [32, 34]. However, these benefits are typically considered long-term benefits of RFID because realization of visibility requires the mass adoption of RFID, trading partner collaboration, and establishment of technology infrastructure for information sharing [36]. Hence, “Track and trace”, the most potential benefit area from Accenture [34] did not go above the diagonal iso-rating line represents points.

RESEARCH CONTRIBUTION

At present, a gap exists between the actual and potential value of RFID technology in industry. In recent years, academic researchers have recognized the importance of closing this gap, but existing studies have not yet dealt explicitly with the strategic value of RFID. Our goal was to describe and explore the importance of the factors affecting RFID system adoption decisions by using IPA.

As with any new technology, the full application scope of RFID is extremely difficult to gauge until it is more widely used. There is significant potential for great benefits and misuses, particularly in the area of supply chain management. But before the widespread adoption of RFID can be observed, tag prices will have to fall significantly, clear benefits will have to be demonstrated, and consumers will have to embrace the technology. IPA provides detailed insights into RFID adoption

First, this study expands the utility of IPA in the IS field. Skok et al. [26] noted that “IPA is an example of a portfolio-based matrix, which have already been discusses within the IS discipline and found to be extremely useful, if simplistic [37, 38]. However, no direct reference to IPA could be found”. Bacon [39] stated that the effectiveness of IPA by industry remains an important area for future research. Oh [40] also argued that IPA needs more empirical reports on its actual contribution.

We put forward a case for using IPA in the adoption of RFID system and found IPA could provide managers with a simple graphical representation of how user(customer) feel about he product(or system),some direction for improvement of the business, and an indirection of why customers want particular improvements.

Second, we focus on the management perspective of RFID and provide insight into management decisions. The majority of RFID research has been in the engineering field and focuses on technology standard and development.

Research in the management field was not active until after 2003 and most of these publications provide a general overview of RFID [36]. Our study was motivated by the research question: What is the realistic value of RFID? We approached this question with the use of surveys to find out the general perception of industry insider.

CONCLUSIONS

Summary

The framework developed here generated several important findings that help to explain the recent evolution of RFID technology and current RFID system market. This paper makes a modest contribution to the ability to evaluate implementation options in RFID's adoption. Several additional findings from this analysis will be included at the end of this section.

First, there is a clear need to prioritize areas of concern such as warehouse management, around hands-free data entry, and efficient receiving and shipping. In other word, how do you improve labor productivity through those aforementioned processes? According an IBM survey, RFID could reduce picking errors and labor costs by 36 percent, and reduce labor costs associated with receiving and checking goods into the distribution center by 60 percent to 93 percent [41]. Taiwan is world-renowned for its excellence in manufacturing technology. Products manufactured by Taiwanese companies include semiconductors, optoelectronic products, and IT hardware and communications equipment. From a manufacturing point of view, the value of using RFID in warehouse management systems is clear. RFID enables tracking of raw materials, work-in-process inventory, finished goods, and even assembly status during production. RFID could also be used to ensure quality control during production by improving material tracking through the manufacturing process, ensuring continuity in production and supply availability [36]. Unfortunately, companies won't realize the value of integrating RFID within a warehouse environment until they start tagging objects.

Second, I-P grids have proven to be a powerful mechanism to highlight managerial needs for tracking the adoption decision of RFID technology. For administrators, I-P grids were simple and easy to interpret. With costs and time pressure being an important issue, development of I-P grids was a relatively quick and an inexpensive tool to help highlight user perceptions about this new technology.

Research Limitation

The purpose of this study was to explore the factors affecting the RFID adoption decision using I-P grids. Even though our findings seem to be consistent with prior research literature, the dynamic nature of IT could change the order of importance in the future. Furthermore, a number of issues still remain to be addressed. First, the investigation of RFID adoption is relatively new to IS researchers. The discussed findings and their implications were obtained from one single study that examined a particular technology and targeted a specific user group in Taiwan. Thus, continued research is certainly needed as a means to generalize our findings and discussion to include other groups.

Second, our study is cross-sectional. In other words, it measures perceptions at a single point across time and perceptions do change over time as individuals gain experience. These changes have certainly created implications for researchers and practitioners who are interested in predicting/analyzing trends of RFID adoption over time.

Future implications

Provided importance judgments are an antecedent of performance perceptions in consumer decision-making, direct predictions of performance, as well as other criterion variables which are feasible based on importance ratings. This direct causal modeling of importance within prevailing consumer models, such as those on service quality and consumer satisfaction, may offer a fresh opportunity to explain and understand consumer behavior. Ryan [42] argued that importance be used as a normative standard of performance. Use of importance either as a weighting variable or as a stand-alone construct in a causal model is an issue to be considered in future studies.

Future research is needed to assess the utilities of absolute versus relative importance. Relative importance is a crucial concept in the highly competitive industry. The concept of relative importance is likely to be multidimensional; for example, it can be modeled across a set of attributes under study (a) within the focal product and (b) across different market offerings in the same target market. Neslin [43] illustrated methods of deriving relative importance. The two-dimensional IPA framework also needs to be developed further to encompass relative importance in its grid.

REFFERENCES

[1] Wu, N.C., Nystrom, M.A., Lin, T.R. and Yu, H.C., Challenges to global RFID adoption, Technovation, Volume 26, 2006, pp.1317-1323.

[2] Peter, H., and Raghu, D., "RFID Forecasts", *Players and Opportunities 2005-2015*, IDTechEx, 2005.

[3] Keen, P., and Mackintosh, R., *The freedom Economy: Gaining the M-commerce Edge in the era of the wireless Internet*, McGraw-Hill, New York, 2001.

[4] Mintchell, G., "Its automatic: automation shifts transmission assembly into high gear", *Control Engineering*, Volume 49, Number 6, 2002, pp.12.

[5] D'Amico, E., "Steering clear of new costs", *Chemical Week*, Volume 64, Number 36, 2002, pp.30-32.

[6] Dornheim, M.A., "Port Security", *Aviation Week and Space Technology*, Volume 157, Number 7, 2002, pp.17.

[7] Forcinio, H., "Packaging advances showcases", *Pharmaceutical Technology North America*, Volume 26, Number 8, 2002, pp.22-30.

[8] ITRI, "CAST to Lead RFID Development in Taiwan", **http://www.rtc.itri.org.tw/eng/news/spotlight-show.jsp?path=f-20040702.dcr**, 2006.

[9] Swedberg C., "Wal-Mart's On Track to Hit Target. ", *RFID Journal*, 2010.

[10] Ferguson, R.B., "RFID Adoption is lagging", **http://www.eweek.com/c/a/Finance-IT/RFID-Adoption-Is-Lagging**, January 2007.

[11] Roberti, M. "What's Holding Up Rapid Adoption of RFID?", **http://www.rfidjournal.com/article/article-view/2899/1/2/**, 2006.

[12] Angeles, R. "RFID Technologies: Supply-Chain Applications and Implementation Issues", *Information Systems Management*, Volume 22, Number 1, 2005, pp.51-65.

[13] Auto-ID Center, "Technology Guide", **http://www.autoidcenter.org**, 2002.

[14] Roberts, C.M. "Radio frequency identification (RFID) ", *Computers and Security*, Volume 22, 2006, pp.18-26.

[15] Martilla, J.A. and James, J.C. "Importance–performance analysis", *Journal of Marketing January*, 1977, pp.77–79.

[16] Slack, N. "The importance-performance matrix as a determinant of improvement priority", *International Journal of Operations and Production Management*, Volume 14, Number 5, 1994, pp.59-75.

[17] Ennew, C.T., Reed, G.V. and Binks, M.R. "Importance–performance analysis and the measurement of service quality", *European Journal of Marketing*, Volume 27, Number 2, 1993, pp.59-70.

[18] Evans, M.R. and Chon, K. "Formulating and evaluating tourism policy using importance–performance analysis", *Hospitality Education and Research Journal*, Volume 13, Number 3, 1989, pp.203-213.

[19] Go, F. and Zhang W. "Applying importance–performance analysis to Beijing as an international meeting destination", J*ournal of Travel Research Spring*, 1997, pp.42-49.

[20] Guadagnolo, F. "The importance–performance analysis: an evaluation and marketing tool", *Journal of Park and Recreation Administration*, Volume 2, 1985, pp.13-22.

[21] Hollenhorst S., Olson D. and Fortney R., "Use of importance–performance analysis to evaluate state park cabins: the case of the West Virginia state park system," *Journal of Park and Recreation Administration*, Volume 10, Number 1, 1992, pp.1-11.

[22] Alberty S. and Mihalik B., "The use of importance–performance analysis as an evaluative technique in adult education," *Evaluation Review,* Volume 13, Number 1, 1989, pp. 33-44.

[23] Ortinau D.J., Bush A.J. and Bush R.P., and Twible J.L., "The use of importance–performance analysis for improving the quality of marketing education: interpreting faculty-course evaluations," *Journal of Marketing Education Summer*, Volume 11, Number 2, 1989, pp.78-86.

[24] Dolinsky, A. L. and Caputo, R. K., "Adding a competitive dimension to importance–performance analysis: an application to traditional health care systems," *Health Care Marketing Quarterly,* Volume 8, Number3, 1991, pp.61-79.

[25] Hawes J.M. and Rao C.P., "Using importance–performance analysis to develop health care marketing strategies," *Journal of Health Care Marketing,* Volume 5, Number 4, 1985, pp.19-25.

[26] Duke C.R. and Mount A.S., "Rediscovering performance-importance analysis of products," *Journal of Product and Brand Management*, Volume 5, Number 2, 1996, pp.43-54.

[27] Skok, W., Kophamel, A., and Richardson, I., "Diagnosing information systems success: importance–performance maps in the health club industry," *Information and Management,* Volume 38, Number 7, 2001, pp.409-419.

[28] Mikko Kärkkäinen, "Increasing efficiency in the supply chain for short shelf life goods using RFID tagging," *International Journal of Retail and Distribution Management,* Volume 31, Number 10, 2003, pp.529-536.

[29] Kourouthanassis, P. and Roussos, G., "Developing consumer-friendly pervasive retail systems," *IEEE*

Pervasive Computing, Volume 2, Number 2, 2003, pp.32-39.
[30] Ruff, T. M. and Hession-Kunz, D. “Application of radio-frequency identification systems to collision avoidance in metal/nonmetal mines,” *IEEE Transactions on Industry Applications*, Volume 37, Number 1, 2001, pp.112-116.
[31] Hengst, M.D. and Sol, H.G. "The impact of electronic commerce on interorganizational coordination: a framework from theory applied to the container-transport," *International Journal of Electronic Commerce*, Volume 6, Number 4, 2002, pp.73-91.
[32] Accenture "High Performance Delivered from Compliance to Competitive Impact through Radio Frequency Identification", **http://www.accenture.com/xd/xd.asp?it=enwebandxd=services\rfid\insights**, May 2004.
[33] Rai, A., Lang, S.S. and Welker, R. "Assessing the Validity of IS Success Models: An Empirical Test and Theoretical Analysis, " *Information Systems Research*, Volume 13, Number 1, 2002, pp.50-69.
[34] Accenture "High Performance Enabled through Radio Frequency Identification Accenture research on Manufacturer Perspectives”, **http://www.accenture.com/xd/xd.asp?it=enwebandxd=services\rfid\insights**, May 2004.
[35] Accenture "High Performance Enabled Through Radio Frequency Identification-Accenture research on Asia Pacific Perspectives", **http://www.accenture.com/xd/xd.asp?it=enwebandxd=services\rfid\insights**, May 2004.
[36] Tajima, M. "Strategic value of RFID in supply chain management," *Journal of purchasing and supply management*, Volume 13, 2007, pp.261-273.
[37] Ward, J. "Information systems and technology application portfolio management: an assessment of matrix-based analyses," *Journal of Information Technology*, Volume 3, Number 3, 1988, pp.205-215.
[38] Ward, J. "A portfolio approach to evaluating information systems investments and setting priorities," *Journal of Information Technology*, Volume 5, 1990, pp.222-231.
[39] Bacon, D.R. "A comparison of approaches to Importance-Performance Analysis," *International Journal of Market Research*, Volume 45, Number 1, 2003, pp.55-71.
[40] Oh, H. "Revisiting importance–performance analysis," *Tourism Management*, Volume 22, Number 6, 2001, pp.617-627.
[41] O'Connor, M.C. "Warehouse Management Systems That Handle RFID Data," *RFID Journal,* 2009.
[42] Ryan, C., *From the psychometrics of SERVQUAL to sex-measurements of tourist satisfaction*, in: A. Pizam, Y. Mansfeld, (Eds.), Consumer behavior in travel and tourism, Binghamton, Haworth Press, New York, 1999, pp.267-286.
[43] Neslin, S. A. "Linking product features to perceptions: self-sated versus statistically revealed importance weights, " *Journal of Marketing Research*, Volume 18, 1981, pp.80-86.

ACKNOWLEDGEMENTS

The authors want to thank National Science Council from Taiwan for their support on this research under grant NSC 98-2410-H-224-011-MY2 and NSC95-2221-E-224-049-MY2.

AUTHOR BIOGRAPHIES

Yuh-Wen Chiu received the Ph.D. degree in information management from the National Yunlin University of Science and Technology, Douliu, Taiwan, in 2009. She is currently an Associate Professor in the Department of Information Management, Far East University, Tainan, Taiwan. She is currently studying customer value in e-commerce.

David C. Yen is currently a Raymond E. Glos Professor in Business and a Professor of MIS of the Department of Decision Sciences and Management Information Systems at Miami University. Professor Yen is active in research and has published books and articles which have appeared in ***Communications of the ACM, Decision Support Systems, Information & Management, Information Sciences, Computer Standards and Interfaces, Government Information Quarterly, Information Society, Omega, International Journal of Organizational Computing and Electronic Commerce, and Communications of AIS*** among others. Professor Yen’s research interests include data communications, electronic/mobile commerce, database, and systems analysis and design.

Dong-Her Shih received the Ph.D. degree in electrical engineering from the National Cheng Kung University, Tainan, Taiwan, in 1986. He is currently a Senior Professor in the Department of Information Management, National Yunlin University of Science and Technology, Douliu, Taiwan. Dr. Shih is the Associate Editor of the *International Journal of Mobile communication* and published over 50 journal articles. His current research interests include machine learning, data mining, security, ontology, and wireless network.