FACTORS INHIBITING THE ADOPTION OF RFID TECHNOLOGY: A CASE OF THAILAND

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Abstract

Radio Frequency Identification, known as RFID, is a technology utilizing a tag to identify items using radio frequency. RFID becomes popular in many countries such as USA and most countries in Europe in order to track and trace the origin or identify the product. However, this new technology is relatively costly and currently does not have a mandatory, unified standard. Companies may also encounter privacy and technical issues. Even though the technology is gradually being accepted in other countries, most of the industries in Thailand decided not to implement RFID technology. Therefore, this study attempts to understand the factors that inhibit the adoption of RFID technology in Thailand by utilizing the Technology Acceptance Model Theory (TAM). This study is one of the first in-depth analyses into RFID adoption intention in Thailand. The result shows that External Variables, Perceived Usefulness, Perceived Ease of Use, and Adoption Intention are factors that caused an inhibition in the adoption of RFID technology in Thailand. Price, Compatibility, and Efficiency are the significant values which affect the adoption intention. The findings suggest that because of RFID price and potential incompatibility leads to the inhibition of its adoption in Thai industries.

Keywords: RFID, Inhibition, Thai Industries, Adoption Intention

1. INTRODUCTION

In the past, the technology which dominates the industries, and is still being used currently in terms of automatic identification and data capture, is the barcode technology. Barcode is ubiquitous in today's world, very cheap to use, and is implemented on many applications worldwide (Anonymous, 2012).

While barcode is cheap and widely used, the system itself also has its flaws (Adaptalift, 2012). Therefore, industries had started to search for alternatives which can yield better productivity, more accuracy, and less operational expense. One of the recent technologies that are coming into play is the Radio-frequency identification (RFID), a technology which uses a tag to identify and track products using radio waves. These tags have greater capabilities and resilience, and promised many benefits once firms implemented it in long-term.

The use of RFID starts to become widespread in retailing operations in 2003. However, the technology is still relatively young at the time. Because of its immense implementation cost, compatibility problems, and privacy concerns, many industries were doubtful and reluctant to adopt

such technology. Therefore, the main objective of this study is to explore the reasons behind inhibition of RFID adoption.

2. LITERATURE REVIEW

This section reviews and discusses about the Radio Frequency Identification (RFID) technology. RFID is a major technological step-forward for many industries throughout the world, especially in business management, supply chain management, and assets management specialization.

2.1 RADIO FREQUENCY IDENTIFICATION (RFID)

This technology is evolving as a major technology for identifying and tracking goods, increasing productivity, product visibility, accuracy, increasing utilization and reducing transaction errors. It is being implemented and is becoming a fixture in many industries in various countries. RFID refers to small electronic devices that consisted of integrated circuits and an antenna. In fact, RFID system has three component parts which are tag, reader, and host computer. The tags are also known as "electronic labels", "transponders", or "code plates". The tags are typically unnoticeable due to its small size, and can be placed on many types of objects. Next, the reader can be called an "interrogator" or "scanner". It sends and receives radio frequency data to and from the tag via antennas. For host computer, it acquires the data from the readers, which runs on a specialized RFID software or middleware to filter the data and route it to the correct application, to be processed into useful information.

The perspective of RFID in supply chain was completely changed after the introduction of this RFID tags for products. Instead of a stand-alone data stored in a single tag, RFID became a globally linked technology which could be accessed online. Suppliers could now let their business partners know when the shipments are being delivered from the factory or the warehouse, and retailers could inform the suppliers when the goods arrived.

2.2 RFID IN THAILAND

RFID implementation in Thailand is dominating in access control, cattle, and farm management markets. From 2007-2008, RFID technology began to spread into commercial stores, supply chain management, logistical operations, and manufacturing industries. The forecast from RFID Institute of Thailand determined that the technology will be used in transportation and finance in the upcoming future (RFID Institution of Thailand, 2009a).

RFID Institute of Thailand is intensely promoting the use of RFID in agricultural industries, as sponsored by Chulalongkorn University and National Electronics and Computer Technology Center (NECTEC), an affiliated institution of National Science and Technology Development Agency of Thailand (NSTDA). The promotion came as a result of rising fixed costs associated with cattle and livestock farming (RFID Institution of Thailand, 2009b; RFID Institution of Thailand, 2009c).

Further RFID usage in the livestock are as follows: record-keeping of animal medical history, including weight, breed, illness, treatment records, classification and grouping animals based on their productivity, such as the amount of milk yield given by a particular cow.

2.3 TECHNOLOGY ADOPTION THEORIES

This study explores various methods and adoption theories for use in inhibition of RFID adoption cases. Technology Acceptance Model (TAM) is a widely used framework in proving the

user's acceptance or declination on a particular technology. However, there are also some more theories in question and these theories are listed and explained below.

Social Cognitive Theory

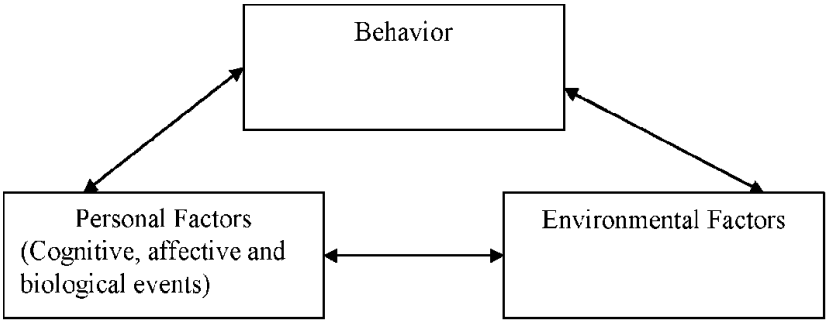

Figure 1: Social Cognitive Theory

Social cognitive theory provides a framework for understanding, predicting, and changing human behavior. The theory identifies human behavior as an interaction of personal factors, behavior, and the environment.

In the model, the interaction between the person and behavior involves the influences of a person's thoughts and actions. The interaction between the person and the environment involves human beliefs and cognitive competencies that are developed and modified by social influences and structures within the environment. The third interaction, between the environment and behavior, involves a person's behavior determining the aspects of their environment and in turn their behavior is modified by that environment. Social cognitive theory is helpful for understanding and forecasting both individual and group behavior. As a result, we can identify approaches in which can modify or change behavior.

Theory of Planned Behavior (TPB)

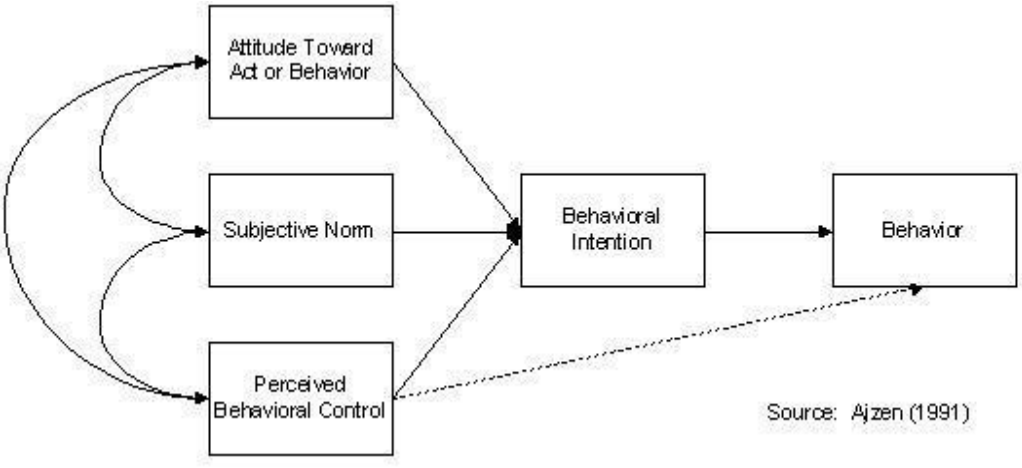

Figure 2: Theory of Planned Behavior

TPB posits that individual behavior is driven by behavioral intentions where behavioral intentions are a function of an individual's attitude toward the behavior, the subjective norms surrounding the performance of the behavior, and the individual's perception of the ease with which the behavior can be performed (behavioral control) (Ajzen, 1991).

Attitude toward the behavior is defined as the individual's positive or negative feelings about performing such a behavior. It is determined through an assessment of one's beliefs regarding the consequences arising from individual behavior and an evaluation of the desirability of these consequences. Formally, overall attitude can be assessed as the sum of the individual consequence times desirability assessments for all expected consequences of the behavior.

Subjective norm is defined as an individual's perception of whether someone can cause the others to think one's behavior should be performed. The contribution of the opinion of any given referent is weighted by the motivation that an individual has to comply with the wishes of that referent. Hence, overall subjective norm can be expressed as the sum of the individual perception times motivation assessments for all relevant referents.

Perceived Behavioral Control is defined as one's perception of the difficulty to perform such a behavior. TPB views the control that people have over their behavior lie on a continuum from behaviors that are easily performed.

Behavioral Intention Although, there is not a perfect relationship between behavioral intention and actual behavior, intention can be used as a proxy measure of behavior. This observation is one of the most important contributions of the TPB model.

This theory is also implies that interventions are designed to change individual behavior. The target behavior should be defined carefully in terms of its Target, Action and Time.

Unified Theory of Acceptance and Use of Technology (UTAUT)

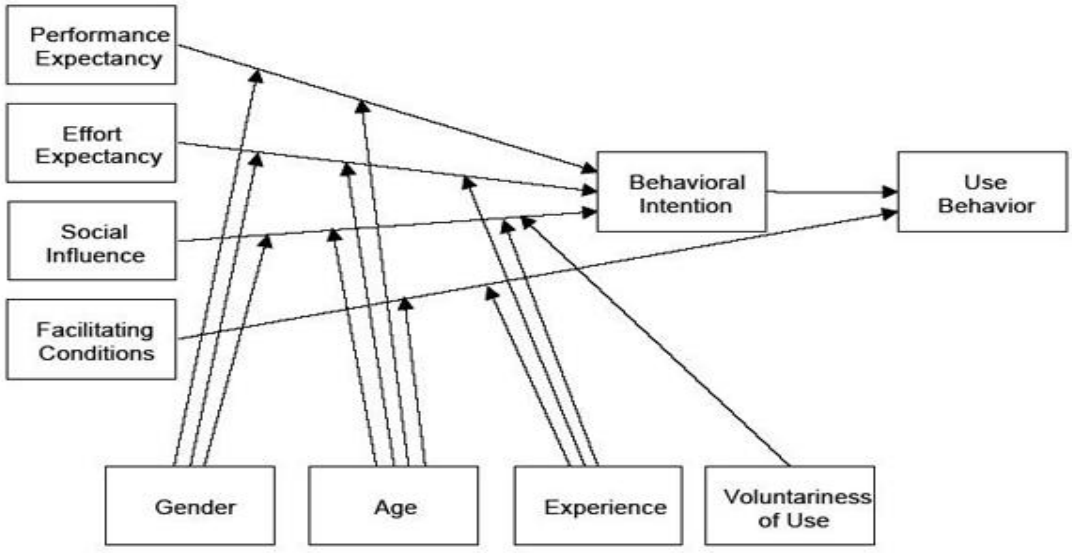

Figure 3: Unified Theory of Acceptance and Use of Technology

Unified theory of acceptance and use of technology (UTAUT) aims to explain user intentions to use an information system and subsequent usage behavior. The theory holds that four key constructs, which are: performance expectancy, effort expectancy, social influence, and facilitating conditions (Venkatesh and Morris, 2000).

Performance Expectancy is the degree to which and individual believes that using system will help them to improve their job performance. The influence of performance expectancy on behavior

intention together with factors like gender and age would be stronger for men, particularly younger workers.

Effort Expectancy is the degree of ease associated with the use of system. The construct is significant in both voluntary and mandatory. The influence of effort expectancy on behavior intentions together with factors like gender, age, and experience would be stronger for young women and older workers at early stages of experience.

Social Influence is the degree to which an individual perceives that it is important when others believe they should use the new system. It is insignificant when the usage is voluntary while it becomes significant when the usage is mandatory. The influence of social influences on behavior intentions together with factors like gender, age, voluntariness, and experience would be stronger for woman, particularly in mandatory settings in the early stages of experience.

Facilitating Conditions is the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system. It usually significant in both voluntary and mandatory during the initial usage period but when both performance expectancy and effort expectancy constructs are present, facilitating conditions become insignificant. The influence of facilitating conditions on usage together with factors like age and experience would be stronger for older workers, particularly with increased experience.

Technology Acceptance Model (TAM)

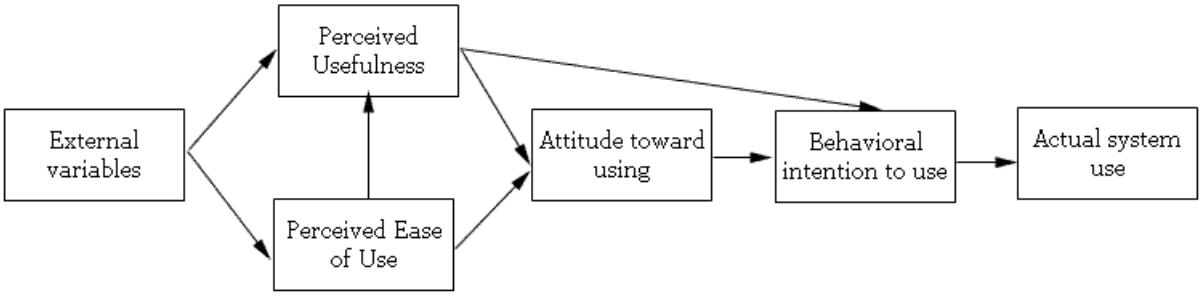

Figure 4: Technology Acceptance Model

TAM is an adaptation of the Theory of Reasoned Action (TRA) to the field of IS. TAM posits that perceived usefulness and perceived ease of use determine an individual's intention to use a system with intention to use serving as a mediator of actual system usage. Perceived usefulness is also seen as being directly impacted by perceived ease of use. Attempts to extend TAM have generally taken one of these following three approaches: by introducing factors from related models, by introducing additional or alternative belief factors, and by examining antecedents and moderators of perceived usefulness and perceived ease of use.

Reasons behind the Inhibition of RFID Adoption

There are various external factors which affect companies' decision to adopt RFID technology, such as economic crisis, government regulations and environmental conditions. Since RFID technology is a costly asset, subject to tight telecommunication regulations from Thailand National Broadcasting and Telecommunications Commission (NBTC) (Blognone, 2012), and difficult to relocate and reinstall, companies may be very reluctant to adopt such technology.

Based on the RFID technology, and adoption theories above, this project will use Technology Acceptance Model (TAM) to determine the factors which inhibit the RFID adoption. The model analyzes the influence of external variables, perceived ease of use, perceived usefulness, behavioral intention to use, and the employee knowledge on the technology, to determine whether these factors have an effect on adoption inhibition. Each of the sections presents both the concept and hypothesis.

The perceived usefulness is defined as the degree to which the company sees that the adoption of RFID technology will give an increased work performance based on the company's expectations.

The perceived ease of use is defined as the perception of the company that RFID can work and be used without exerting much effort. Because of wide variety of RFID regulatory standards and products, existing degree of knowledge, and the employee' skills to adapt to the technology, companies might be skeptical on the terms of ease of use.

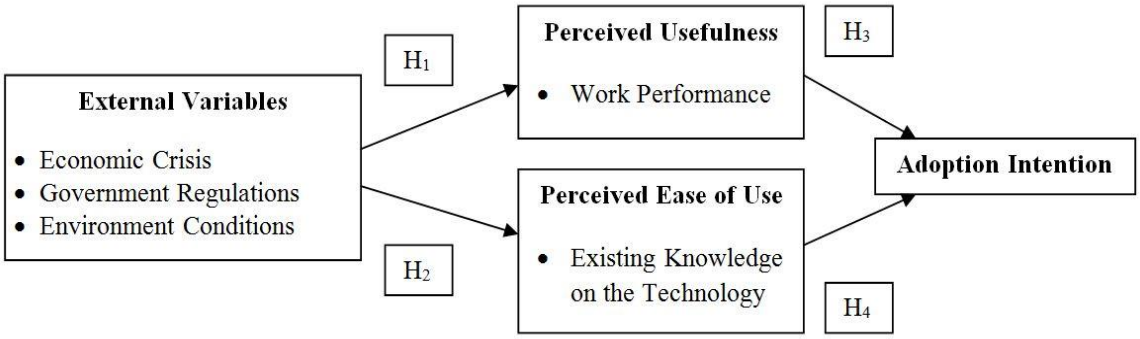

Figure 5: The Conceptual Model

Hypothesis 1: External Variables will affect perceived usefulness.

Hypothesis 2: External Variables will affect perceived ease of use.

Hypothesis 3: Perceived Usefulness will affect adoption intention.

Hypothesis 4: Perceived Ease of Use will affect adoption intention.

3. RESEARCH METHODOLOGY

As a part of this project, this study has conducted a survey to companies in various industries. The data was collected from the correspondents including managers and personnel who may have prior experiences with RFID technology. The focus industries would be concentrated on agriculture, manufacturing, retail, and logistics.

A survey instrument was implemented to empirically test the model. The instrument items used to operationalize the construct in Table 1 were derived from past research questions used a 1 to 5 scale where 1 meant "strongly disagree" and 5 meant "strongly agree".

Table 1: Questionnaire Questions

Question Number	Construct	Number of Items
1-5	General Information	5
6-8	External Factors	3
9-14	Perceived Usefulness	6
15-20	Perceived Ease of Use	6

To implement the survey, random samplings of 200 companies were selected. The majority of our samples were companies and factories located in Industrial Estates in various regions in Thailand. The sampling source was the Industrial Estate Authority of Thailand (IEAT) (Industrial Estate Authority of Thailand, 2012).

4. DATA ANALYSIS

The data were analyzed to identify relevant factors. The results of the analysis are shown and explained in this section.

4.1 DESCRIPTIVE ANALYSIS

By applying the Descriptive statistical analysis approach, the detailed composition of the analysis is described below.

Table 2: Descriptive Statistic Results

Descriptive Statistic Results					
		N	**Frequency**	**SD**	**Std. Error Mean**
Correspondents	First-line	37	12	.475	.078
	Middle	37	14	.492	.081
	Top	37	4	.315	.052
	Others	37	7	.397	.065
Industries	Agriculture	37	0	.000	.000
	Manufacturing	37	25	.475	.078
	Retail	37	1	.164	.027
	Logistics	37	4	.315	.052
	Others	37	7	.397	.065

Workforce Size	Mini	37	2	.229	.038
	Small	37	7	.397	.065
	Medium	37	13	.484	.080
	Large	37	15	.498	.082

The final sample size of 37 is illustrated in Table 2. The industries are composed of manufacturing firms, which represented the majority of the sample at 67.6%; Retail at 2.7%; Logistics at 10.8%; and other industries at 18.9%. The sizes of the sample are composed with 5.4% of micro enterprise, 18.9% of small enterprise, 35.1% of medium enterprise, and 40.5% of large enterprise. Most of the correspondents are composed of 32% first-line managers, 38% middle managers, and 11% top managers. 19% are responded with other ranks besides managers.

4.2 REGRESSION OUTPUT

Regression analysis is a statistics tool utilized for evaluating relationship between our dependent variable and independent variables. The details of the models are outlined below:

Table 3: ANOVA

ANOVA						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	2.116	3	0.705	6.282	0.006
	Residual	1.684	15	0.112		
	Total	3.799	18			
2	Regression	0.722	2	0.361	5.276	0.016
	Residual	1.231	18	0.068		
	Total	1.952	20			
3	Regression	2.837	9	0.315	3.175	0.023
	Residual	1.489	15	0.099		
	Total	4.327	24			
4	Regression	4.129	6	0.688	3.603	0.008
	Residual	5.730	30	0.191		
	Total	9.859	36			

Table 4: Coefficients and Summary

Coefficients						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	**Std. Error**	**Beta**		
1	Compatibility	0.088	0.083	0.205	1.067	0.303
	Pricing	0.269	0.096	0.489	2.800	0.013*
	Regulations	0.209	0.109	0.374	1.916	0.075
2	Compatibility	-0.143	0.056	-0.478	-2.540	0.021*
	Pricing	-0.119	0.068	-0.329	-1.746	0.098
3	Efficiency	0.158	0.069	0.437	2.294	0.037*
	Security	0.118	0.150	0.193	0.787	0.443
	Track-and-trace	0.013	0.102	0.031	0.130	0.898
	AssetMgmt	-0.062	0.151	-0.123	-0.409	0.688
	Visible/Auth	-0.007	0.109	-0.016	-0.065	0.949
	CustRequire	0.174	0.173	0.491	1.002	0.332
	SuppBiz	-0.117	0.241	-0.265	-0.486	0.634
	Regulations	0.129	0.129	0.251	1.002	0.332
	CRM	0.137	0.111	0.294	1.233	0.236
4	LossCompetitive	-0.127	0.109	-0.216	-1.157	0.256
	UnauthModify	-0.162	0.140	-0.230	-1.161	0.255
	FakeProduct	-0.040	0.116	-0.069	-0.347	0.731
	TagDamage	-0.009	0.130	-0.011	-0.073	0.943
	DatabaseHack	-0.071	0.201	-0.088	-0.354	0.726
	UnauthShare	-0.215	0.155	-0.344	-1.386	0.176

Model Summary		
Model	**Adjusted R square**	**Std. Error of the Estimate**
1	0.468	0.33505
2	0.259	0.26897

3	0.449	0.31509
4	0.303	0.43703

*P-value < 0.05

The results showed that Pricing and Compatibility are the significant factors of inhibition of the adoption of the RFID technology, both of which has P-value less than 0.05. While Efficiency leads as a contributing decision to adopt, the significance is less important compared to the inhibiting factors. Based on our findings, the statistical results strongly supported the hypotheses on Price. In addition, Perceived Usefulness had a high impact on adoption intention. However, there is no significant impact on Perceived Ease of Use which eventually leads to adoption intention.

Table 5: Hypothesis Conclusion

Hypothesis Conclusion	
Hypothesis	**Outcome**
H_1	Accepted
H_2	Accepted
H_3	Accepted
H_4	Rejected

5. DISCUSSION AND CONCLUSION

The objective of this study is to explore the factors that cause RFID technology adoption inhibition in Thai industries. Based on the findings, it is strongly suggested that price, compatibility and efficiency with the technology has shown more significant impact than other factors, and lead to technology inhibition.

The price of the RFID towards the industries prevailed ($P<0.05$) implied that manufacturing industries are not willing to invest in the technology due to its price. Despite the fact that RFID has been released as general availability, the price associated with system deployment is somewhat costly, particularly in large companies. Smaller companies might also not find the price justifiable.

The result of the Compatibility factor, with the significance value at 0.021, suggested that many companies are still familiar with legacy systems and lack of support and encouragement on the new technology adoption. While the companies believe that the system can contribute to their organization in terms of efficiency, its important is foreshadowed by the price factor.

Furthermore, our results illustrated that there is no connection between Perceived Ease of Use and Adoption Intention. Therefore, with these factors in consideration, many companies are still not ready for a replacement or reimplementation of their existing systems with RFID technology. The adoption rate of such a technology is still limited.

This study is one of the first in-depth analyses on RFID technology adoption in Thailand. Our finding can enhance and becomes a supplement to existing studies on technology adoption.

This study faced limitations in terms of sample size. This issue might cause limitations on the generalizability of our outcomes. The lack of sample generalizability means that future studies should collect and verify the model based on data from additional sources for better reliability.

Since the scope of this study does not cover certain features which causes inhibition of the technology adoption, future studies can be extended by integrating additional factors to extend our model. Future studies may focus on the cause and effect, performance and efficiency as a result of future RFID adoptions, compare and contrast them between RFID implementers and traditional users.

6. REFERENCES

Aanza AutoID Group (2004), Evolving from Bar Code to RFID in the Supply Chain, Page 3 Retrieved from: http://aanza-autoid.com/sitebuildercontent/sitebuilderfiles/Moving5.pdf

Adaptalift H. (2012), RFID VS Barcodes: Advantages and disadvantages comparison, Retrieved from: http://www.aalhysterforklifts.com.au/index.php/about/blog-post/rfid_vs_barcodes_advantages_and_disadvantages_comparison

Ajzen, I., (1991), The theory of planned behavior. Organizational Behavior and Human Decision Processes, Volume 50, Number 2, Page 179-211.

Anonymous (2012), EAN International, Retrieved from: http://www.gs1us.org/resources/standards/ean-upc

Blognone (2012), NBTC warns, RFID with high frequency spectrum are subject to regulation violation, Retrieved from: http://www.blognone.com/node/36760.

Industrial Estate Authority of Thailand (2012), Retrieved from: http://www.ieat.go.th/main/default/factory.

RFID Institute of Thailand, The Federation of Thai Industries, (2009a), "RFID adoption trend in Thailand" (Online, Thai language) <URL: http://www.rfid.or.th/th/industry/technology.asp> Last accessed: October 4, 2012.

RFID Institute of Thailand, NECTEC, NSTDA, (2009b) "The Use of RFID Technology in Dairy and Cattle Farms" (Online, Thai language) <URL: http://www.rfid.or.th/webdatas/Banner/ANIMAL-1.jpg> Last accessed: October 4, 2012.

RFID Institute of Thailand, NECTEC, NSTDA, (2009c) "The use of RFID Technology in Swine Breeding and Farming" (Online, Thai language) <URL: http://www.rfid.or.th/webdatas/Banner/ANIMAL-2.jpg> Last accessed: October 4, 2012.

Venkatesh, V. and Morris, M.G. (2000), "Why Don't Men Ever Stop to Ask for Directions? Gender, Social Influence, and Their Role in Technology Acceptance and Usage Behavior," MIS Quarterly, Vol.24, No.1, pp. 115-139.

Viswanath V., Michael G.M., Gordon B.D., Fred D.D., MIS Quarterly (2003), "User Acceptance of Information Technology: Toward a Unified View", Vol.27, No.3, pp. 425-478.

Wixom B.H., Todd P.A. (2005), Information Systems Research "A Theoretical Integration of User Satisfaction and Technology Acceptance." Vol.16, No.1, pp. 85-102.