

# Technological Attributes That Influence RFID Adoption in Logistics Organization (A Work In progress)

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Abstract— Radio Frequency Identification (RFID) is an automation technology that provides visibility for management process in logistics. It employs tags that are connected via radio frequency and are monitored through a network to make anything with a tag visible to logistics management. Despite the high amount of data that may be placed in the tags and the evident efficiency that it may provide in tracking and tracing assets with tags, this innovation has not been fully adopted in logistics organizations. Among the many benefits of investing and adopting RFID are the reduction in waste, manual checks, costs, claims and deductions, and an overall improvement in asset utilization.[28] Using literature databases and the internet, this paper aims to study and review past studies depicting technological determinants and considerations used when adopting this particular technology. A combined TOE and DOI Framework and constructs were used to determine and explain technological determinants of RFID adoption in logistics. This paper also aims to provide key findings and pave the way for future research on the adoption of RFID in logistics. Further research is recommended to encompass all constructs, under a unified data collection method, processing and analysis to create a comprehensive work and establish determinants and the relationship under all the constructs to identify the factors that influence RFID technology adoption in logistics.

**Key Words**— Adoption; Diffusion of Innovations; RFID; Compatibility; Competence. Complexity

# Introduction *RFID Adoption in Logistics* Organizations

Radio Frequency Identification (RFID) is an automation technology that provides visibility and movement monitoring of assets. It uses non-contact sensor technology using radio frequency (RF) signals. [26] The technology consists of tags, readers with antennae, and a network. The tags have a chip that stores data, usually information about an asset. Once these tags are sensed by the readers, its location is communicated through the network. The location of the asset is dependent on where there is a reader



within the network, the presence of the tags in area of the reader and the software that supports the readers to present the location and information about the asset. RFID technology has been around since the 1970's. Developed in the Lawrence Livemore Laboratory (LLL) where a handheld receiver returned a signal when stimulated by RF power. The scientists that developed this left LLL and created their own company from this technology to create RFID entry, the first commercial application of RFID technology. [27] It is evident that visibility of the asset will provide great

accuracy, precision, efficiency and effectivity in delivering logistics services.

Using the Diffusion of Innovation Rogers (1990) and Technology, Organization and Framework (TOE) Tornatzky and Fleischer (1990), frameworks under the technology constructs of compatibility, competence and complexity, this paper aims to study and provide insights on the decision process and the effects of the technology constructs in the adoption of RFID in logistics organizations. [5] This paper is also aimed the see the extent of TOE and DOI constructs can influence RFID adoption in logistics and to recommend future research to benefit decision makers in RFID adoption.

Technological compatibility and competence influence the RFID adoption in a positive way whereas complexity of the technology influences the adoption negatively. Where compatibility is not confined to a new system being compatible with the old, that it must also fit the organization's overall strategy and infrastructure. Competence is the organization's knowledge and experience of the technology, that the more knowledge and experience, the more likely the technology will be adopted. Complexity is how difficult the technology is wielded, the more complex the system in relation to the organization, the more it is less likely to be adopted. Complexity uncertainty is mitigated when the technology is made explicit and clear to the organization. This encompasses all levels of the organization and technology.

While there are conflicting views on the constructs specifically in complexity, it is evident that the technology constructs are influencers in the decision process to adopt RFID technology. There are also multiple definitions of the attributes to this construct. Further study is recommended to include organization and environment in the TOE framework together with technology to determine their relationships during the adoption stage. Further a unified data collection model is suggested using a unified processing and analytical model be used.

# I. THERETICAL FRAMEWORK

#### Diffusion of Innovations - DOI (Rogers 1995)

Technology adoption is the choice to acquire and use new invention or innovations. [1] The innovation process has been studied for over 20 years and the most widely referenced is Everett Roger's book Diffusion of Innovations (DOI). This framework has been widely used in many researches in varied disciplines. Dooley (2009) and Stuart (2000) mentioned that this model was used in the field of political science, communications, public health, history, economics, technology and education and describes that

Roger's framework is the most widely used theoretical framework in the field of technology diffusion and adoption. [2]

Rogers (2003) described the diffusion of technologies in five consecutive stages, Knowledge, Persuasion, Decision, Implementation and Confirmation. This process is both an information seeking and processing where the individual or organization aims to reduce the uncertainty of the advantages and disadvantages of the technology being adopted. These stages are governed by communications channel and in sequence the time the information is transferred from one stage to the other. Assuming that the organization has felt the need, or in its organization innovativeness, or to conform to a social norm, this starts the knowledge stage, where the organization gathers the information necessary to move into the Persuasion Stage. "The formation of a favourable or unfavourable attitude toward an innovation does not always lead directly or indirectly to an adoption or rejection" (Rogers, 2003, p. 176). [2] Rogers (2013) describes that in the Persuasion stage the decision to adopt may rely on the technology's degree to provide "relative advantage" or how the innovation can bring benefit to the organization. Whereas "complexity" is the degree of difficulty of the use of the innovative technology. "Compatibility" as the degree to which an innovation is consistent with existing business processes,



practices and value systems [4]. The persuasion stage is where the availability and the characteristics of the technology is presented paving the way to the decision whether to adopt or reject the innovation.

Rogers (2003) describes that the diffusion of innovation is a reduction in uncertainty and proposes that the uncertainty is reduced by the attributes of the innovation. There are five attributes that describe the innovation, relative advantage; compatibility; complexity; trialability and observability. Although there are many researches on the attributes of the innovation, very little has been done on the effects of the perceived characteristics of the rate of innovation. Compatibility is an attribute of innovation as described by Rogers (2003) as "the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters" (p. 15). [3] In the IT realm the lack of compatibility with perceived needs may affect the use of the innovation (McKenzie, 2001; Sherry, 1997). [4] If the innovation is aligned to the needs then the rate of adoption increases and uncertainty decreases as they are directly proportional. Complexity of the innovation is described by Rogers (2003) as "the degree to which an innovation is perceived as relatively difficult to understand and use" (p. 15). [4] [3]. As opposite to the other attributes, this is the only one that is inversely proportional to the rate of innovation adoption. Hence the more complex the innovation then the less likely it is to be adopted.

Relative advantage is defined by Rogers (2003) [4] as "the degree to which an innovation is perceived as being better than he idea it supersedes" (p. 229). Rogers also categorized innovations in two: preventive and incremental (nonpreventive) innovations. "A preventive innovation is a new idea that an individual adopts now in order to lower the probability of some unwanted future event" (Rogers, 2003, p. 233). Preventive innovations are highly uncertain and slow down the rate of adoption while incremental innovations are beneficial innovations in a short period of time. The framework is widely used in the technological adoption in information technology based innovation in a variety of disciplines, the technology attributes is a very important part of any diffusion as mitigating the uncertainty may increase the chances and likelihood of adoption. Where the attribute of focus is compatibility, complexity and perceived or relative value of the innovation.

Figure 1 Diffusion of Innovations (DOI) Process Flow

## Technology, Organization and Environment Framework - TOE framework (Tornatzky and Fleischer 1990)

Developed in 1990 by Tornatzky and Fleischer, which identifies the three (3) three aspects or context that an organization is influenced in adopting or implementing a technological innovation. The Technology, Organization and the Environment context. The Organization Context addresses the descriptive measure of the organization of the adopters such as size, scope, manegerial structure and communitcations process.[5] The Environment context is concerned with the market or industry that the adopter is operating in, such as industry and market structure, competitors, government dealings and other external activities that the adopter is involved. The Technology context deals with availability and the characteristics of the technology being adopted. These characteristics include compatibility, complexity and perceived value which is also synonimous to the Diffusion of Technology by Rogers (1990).

This framework focuses on the characteristics and the attributes of the technology, organization but also brings in a new and important component, TOE includes an Environment context which shows constraints and opportunities for technological innovation as opposed to the market or industry that the adopter is operating in. *"TOE framework makes Rogers' innovation diffusion theory better able to explain intra-firm innovation diffusion "*(Hsu *et al.* 2006).[5]



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Figure 2 Technology Organization and Environment (TOE) Framework

# Combination of TOE and DOI

Several authors have used TOE and DOI to study and understand IT adoption, decisions. (Thong 1999, Gibbs and Kraemer 2004, Hsu et al. 2006, Zhu et al. 2006a, Li 2008, Soares-Aguiar and Palma-Dos-Reis 2008, Chong et al. 2009, Oliveira and Martins 2010b) [5] TOE and DOI was also used in combination with Institution Theory in the work of Lacovou et al (1995) to better understand IT innovation decisions. Chong et al in (2009) used these two frameworks with CEO characteristics and information sharing culture characteristics to further understand how technological adoptions are decided upon. Zhu et al (2006a) added relative advantage, complexity and compatibility with the two frameworks to further the study.[5] In this paper the technological constructs of both DOI and TOE shall be used in the determinants that influence the adoption of RFID technology. Where technoology constructs in DOI refers to attributes pertaining complexity, compatiblity and competence in the area of persuasion. The same attributes are used in the TOE framework under a technology contstruct that determines technollogical attributes.

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Figure 3 DOI and TOI Combination

#### II. Method

This paper referred to and reviewed qualitative and quantitative research from electronic databases. Topics relevant to the subject were chosen from the EBSCO Host Online Research databases and EBSCO Discovery Service Interface through the registration on the De La Salle University Library Online Library Facility and the Internet through search engines. Researches relevant to the topic of technological adoption, and its application to RFID adoption of organizations directly or indirectly to the supply chain and logistics industry in varied countries were considered for this paper. The words, phrases and tail end search words like "Technology Adoption", "RFID Adoption", "Diffusion of Innovation", and "TOE Framework" were used in the search for relevant to the topic "RFID Adoption in the Logistics Industry". Majority of the works available were recent and no year discrimination was done on the work considered. RFID technology application to the logistics organizations recent studies used were focused in the adoption decision process, information system, project management, and technology requirements were used.

All articles considered were written in English, are in the topic of RFID adoption in logistics organizations published in journals and have empirical studies. Additional references were also used in the literary list and reference of the used studies to further the research. All gathered studies were read, reviewed and evaluated and all relevant topics were used to achieve the objectives of this study.



The studies and researches used on this paper were arranged and organized in on the constructs of the TOE framework under Technology, focusing on technology compatibility, complexity and competence of the adoption of RFID in logistics organizations, to isolate and focus on the objective of the paper. Data collection, country of origin, area of logistics and sample size were the focus of review of the referred studies and papers used in this work.

#### III. RESULTS

### **Technology Compatibility**

Park and Hwan Rim (2012) [6] in their study "The Relationship Analysis of RFID Adoption and Organizational Performance" using TOE Framework by Tornatzky and Fleischer hypothesized that an organization's adoption of the technology of RFID will be influenced by technology compatibility and drawing from the work of Ramamutrthy et al. [7], on the adoption of EDI, showed that adoption of innovative technology is positively influenced by technological compatibility. Through the works of Brown & Russell [8] and Wang et al. [9], they established that both technological compatibility and complexity importantly influenced the adoption of RFID. From all these studies Park and Hwan Rim (2012) hypothesized "The technology compatibility has a positive effect on RFID adoption". Their study is based on collected and processed data from 130 responses from companies using RFID that were contacted through phone or email where 82.5% mail respondents and where 50.5% of respondents in their 30's. The scope of their technological scan on compatibility were guided by the following measurement: compatibility between RFID and existing equipment and facilities, Compatibility of RFID with routine tasks performed in the company and Appropriateness of RFID to organizational goals, values, beliefs or strategies. Using Partial Least Squares (PLS) equation modelling to process the data and minimize endogenous variable errors, they found that technological compatibility has a strong influence on the adoption of RFID and also confirmed that compatibility of RFID technology to organizational strategy is an important determinant in its adoption. [6]

Fazel et al (2011) [10] studied the readiness of the adoption of RFID technologies in the Iranian supply chain. Using the TOE framework and using survey to collect data from 89 people where 55.06% of the participants have bachelor's degree and 92% were male and above the age of 35 show that compatibility is an important influence in the adoption of RFID technology (Schmitt and Michahelles, 2009) [11] "Compatibility has been defined as the degree to which a technology is perceived to be consistent with an organization's strategic intent, infrastructure, practices, and

needs (Baek and Lee, 2001; Rogers, 2003; Teo et al., 2004)."[10] Their research shows that in order to have a successful implementation an organization must have a flexible IT infrastructure that may accommodate RFID adoption and that data sources and RFID related technologies must be able to seamlessly connect to existing infrastructure and information system (Janz et al., 2005).[12]. The scope of their research was guided by the technology construct of TOE framework and uses the Binomial and Friedman's Test to process the data collected in the quantitative study. Their result show that technological capability is the most important influence to attain optimal situation in the adoption of RFID among the characteristics of the technology construct in the TOE framework. [10].

Tan et al (2012) [13] researched on the adoption of technology innovation in Halal Logistics providers in Malaysia. Using the Technology construct of TOE they studied compatibility of the innovation being adopted. Using Nvivo 9 software analysis tool to quantitatively analyse, enhance and expand analytical areas. [16] The data was obtained through face to face interview, phone interviews using structured guidelines among high level employees in Malaysian logistics providers. [13] Their study implies that the application of the RFID in Halal systems is compatible to the Halal requirements of tracking and tracing, specifically in the identification of container vans. That this is important to identify what is in the containers and to identify if it is aligned with Halal methods. This research shows that compatibility is a key influence in the adoption of RFID in the Halal Logistics Providers and that the success of implementation is dependent on the compatibility of ICT characteristics with current requirements.



Alhashedi et al (2012) [14] using the TOE framework the RFID Adoption in Hajj Organizations. Using selfadministered questionnaires to 79 organizations with 50 items and applying a seven point Likert scale anchored by strongly agree to strongly disagree, they hypothesized on the influence of compatibility in the adoption of RFID among Hajj organizations. Their hypothesis is *that "Compatibility will have a positive effect on Hajj organizations intention to adopt RFID technology"*. [14] The study shows that in the field of tracking, compatibility is a key influence in the adoption of innovations.

# **Technology Complexity**

Using Park and Hwan Rim (2012) [6] in their study "The Relationship Analysis of RFID Adoption and Organizational Performance" using TOE Framework by Tornatzky and Fleischer hypothesized that an organization's adoption of the technology of RFID will be influenced by technology complexity. Through the works of Brown & Russell [8] and Wang et al. [9], they established that both technological compatibility and complexity importantly influenced the adoption of RFID. From all these studies Park and Hwan Rim (2012) hypothesized "The technology complexity has a negative effect on RFID adoption". Their study is based on collected and processed data from 130 responses from companies using RFID that were contacted through phone or email where 82.5% mail respondents and where 50.5% of respondents in their 30's. The scope of their technological scan on complexity were guided by the following measurement: RFID is perceived as complicated to use in our organization; Developing RFID is considered a complicated process in our organization; Implementing and using a RFID is considered a process requiring a great deal of efforts in our organization. Their study shows that complexity "showed no significant influence on the adoption of RFID" [6]. Their study gives more importance to capability, perceived value in the technology construct over the complexity of the RFID technology, hence organizations will not consider the complexity of the adopted technology.

Fazel et al (2011) [10] studied the readiness of the adoption of RFID technologies in the Iranian supply chain. Using the TOE framework and using survey to collect data from 89 people where 55.06% of the participants have bachelor's degree and 92% were male and above the age of 35 show that compatibility is an important influence in the adoption of RFID technology. The scope of their research was guided by the technology construct of TOE framework and uses the Binomial and Friedman's Test to process the data collected in the quantitative study. They state that if the technology being adopted is perceived to be too complex, the organization may defer RFID adoption. (Bradford and Florin, 2003) [15]. their research scope is guided by the questions on how the RFID technology is to integrate to the current IT system, and the essential skill of the adopter that will use them. Their study yield that the complexity in adoption is a result of the comparison between the current barcode systems being used in Iranian supply chain. That the implementation and the adopter knowledge to operate RFID will make the adoption complex. Overall they see that complexity occurs when there is less adopter knowledge on the new innovation and when it will supersede a system still aligned with company strategy and is broadly known by the adopters.

Tan et al (2012) [13] researched on the adoption of technology innovation in Halal Logistics providers in Malaysia. Using the Technology construct of TOE they studied the complexity of adopting RFID technology in Halal logistics service providers. Using Nvivo 9 software analysis tool to quantitatively analyse and enhance and expand analytical areas. [16] The data was obtained through face to face interview, phone interviews using structured guidelines among high level employees in Malaysian logistics providers. [13] Their study yielded that together with the technological complexities, knowledge of the adopter is also considered a technological complexity in the adoption of RFID in the tracking of the containers. Some CEO's in some cases are "worried" that their employee adopter may not have enough knowledge to wield RFID. Nevertheless, their described complexity is not considered a critical factor in the adoption of technology as these complexities may be reduced by planning and explicitly introducing the technology to the target adopters.

Alhashedi et al (2012) [14] using the TOE framework the RFID Adoption in Hajj Organizations. Using selfadministered questionnaires to 79 organizations with 50 items and applying a seven point Likert scale anchored by



strongly agree to strongly disagree, they hypothesized on the influence of complexity in the adoption of RFID among Hajj organizations. Their hypothesis is that "Complexity will have a negative effect on Hajj organizations intention to adopt RFID technology". [14] The complexity is brought about the tracking population and the geographic location. In this study, these difficulties are considered as a complexity. They state that complexity is consistently important during the process of adoption. Ultimately the study states that the complexity has a negative effect on this particular paper.

# **Technology Competence**

Park and Hwan Rim (2012) [6] in their study "The Relationship Analysis of RFID Adoption and Organizational Performance" using TOE Framework by Tornatzky and Fleischer hypothesized that an organization's adoption of the technology of RFID will be influenced by technology competence. Using the same method and analysis in the same study that also cover compatibility and complexity, Park and Hwan Rim (2012) leverages off the work of Kim & Garrison [23] who found that technological knowledge positively influenced the adoption of RFID for a supply organization. Park and Hwan Rim (2012) chain hypothesized that technology competence has a positive effect on RFID adoption. Their research scope was focused by the following questions Amount of IT infrastructure related to the deployment of RFID; Familiarity with RFID technology; Level of employees' knowledge about RFID. Using Reliability analysis their study yielded that technology competence has strong influence on the adoption of RFID on the context of their research hypothesis. This competence influence points to the importance of organizational "capacities" such as infrastructure and knowledge of the adopters on RFID technology.

In Lin and Ho study of "The Antecedents and Consequences of RFID Technology Adoption for China's Logistics Companies", for The International Journal of Applied Management and Technology, hypothesized that "The more the organizational accumulation of related knowledge in the firm, the more willingness that the logistics company will have to adopt RFID technology. "Leveraging off the work of (Tornatzky & Fleischer, 1990; Chau & Tam, 1997) [21] that the operational knowledge is an important factor in the adoption of RFID technologies. They also found that Grant (1996) and Simonin (1999) [20] concluded that any organization with experiences in adopting related technologies will have higher affinity of technological innovation. Also organizations with high levels of innovation will tend innovate more frequently and in a more radical way as stated by Clark & Fujimoto, (1989) [22]. Further organizations that have integrated capacity to innovate will be more cognizant in its expression to solve problems and adopt technologies such like RFID. As a result of accumulated research and development activities according to Rogers (2003) will create competence in the organization and may influence the adoption of RFID technology.

Alqathani and Womba (2012) [23] defines competence as the organization's readiness to adopt a technology in the context of resources and services offered by IT professionals Kraemer et al 2006 [24]. Their research is focused on the infrastructure of the company, experience and familiarity of the adopters within the organization, and that the organization has high knowledge of the RFID technology. Using a five point Likert scale, with questions to be answered from strongly agree to strongly disagree. Their quantitative analysis is based on responses of organizations through a questionnaire yielded that competence is positively related to the adoption of the RFID technology and is a significant determinant in its adoption which is aligned with the work of Brown and Russell (2007) [25].

# IV. DISCUSSIONS AND CONCLUSION

This paper was written, using searched results using key words to create a near comprehensive study of the adoption of RFID technology in logistics organizations. The search yielded results from varied countries and different areas of logistics, and it is the aim of this paper to provide insights for mangers and leaders in the decision making process of the adoption of RFID technologies in logistics. Using the combined DOI Rogers (1990), and TOE Framework Tornatzky and Fleischer (1990) of under the technological construct to identify the influences of the technology constructs of compatibility, complexity and competence on the adoption of RFID technology. The studies and literature used in this paper supports the construct of the combined



DOI and TOE framework that covers the technological aspects of RFID adoption in logistics organizations. The data collection used on the studies were questionnaire governed by the Likert scale using choices from Strongly Agree to Strongly Disagree, where there were various methods used to process and analyse the data to support the technological construct focused on the adoption process.

The literature used in this paper identifies determinants, under the technology construct of combined DOI and TOE Framework used in the decision making process on the adoption of RFID technology. That compatibility, complexity and competence to the innovative technology are attributes that influence decision makers, and have to consider in adopting RFID technology in logistics. That compatibility has a positive effect on this adoption and is not limited to technology (old) that is being replaced but also compatible with the current IT infrastructure as well as the organizations overall strategy. That complexity is focused more in the implementation and is given more meaning in the by Rogers (2003) [3] "as degree of difficulty of the use of the innovative technology". Though there are conflicting and opposite views among the studies, one thing is certain that this determinant's influence is mitigated when the technology is made explicit to the whole organization. The explicitness reduces this determinant's uncertainty. Lastly all works used point out that competence on the technology will positively influence the adoption of the technology. This encompasses both the decision makers but the adopters and users as well. The more educated and knowledgeable an organization is about the technology the more influence and the likelihood that the technology will be adopted.

It is recommended that a more comprehensive study be done under the TOE Framework to encompass all the constructs and to create a concrete relationship between the three (Technology, Organization and Environment) using a unified data collection, processing and analysis structure to determine the factors that influence the decision in the adoption of RFID technology in logistics.

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