# USER ACCEPTANCE BARRIERS FOR WAREHOUSE ENVIRONMENT MOBILE WIRELESS TECHNOLOGY

by

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# ABSTRACT


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Title: User Acceptance Barrier for Warehouse Environment Mobile Wireless Technology
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This research adopted Technology Acceptance Model 2 to investigate users' acceptance barriers for mobile wireless technologies such as RFID, bar-code scanners and Personal Digital Assistants (PDA) in warehouse environments in Lafayette and West Lafayette, Indiana.

Through survey data collections from two companies that met the research requirement and through statistical analysis of the data, the researcher found answers to the research questions.

System functionality is the most important factor in determining the users' intention to use. System failure would be the biggest acceptance barrier. Secondly, it is critical for companies to establish and strengthen the link between job relevance and the mobile wireless technology, especially at an early adoption phase. The ability to understand system output and receive encouragement and support from leadership would also help the users to accept mobile wireless technology.

# CHAPTER 1. INTRODUCTION

## 1.1 Background

A supply chain is a network that connects participants to processes, and funnels the products from the original suppliers to end customers. Each participant focuses on a few specialties or functions, such as manufacturing, wholesale, distribution, and retail sectors. Supply Chain Management is an approach to integrate key business processes throughout a framework, to add more value to the customer, and reduce redundancy (Gunasekaran & Ngai, 2005). Currently, companies are willing to adopt supply chain management practices to coordinate and integrate business activities to benefit their own internal structure, as well as the entire supply chain. To achieve these benefits, companies use advanced technologies, such as radio frequency identification (RFID), information technology systems and mobile wireless tools used to manage supply chains operation to obtain the benefits to the supply chain (Ketikidis, Koh, Dimitriadis, Gunasekaran & Kehajova, 2008).

This research focuses on the mobile wireless applications in the supply chain over all other advanced technologies due to the rapid growth and widespread use of mobile wireless technologies in industry. According to Park and Chen (2007), personal digital assistants (PDA) and smartphones represented 3.65 million units worldwide in the first quarter of 2006 with a 6.6 percent increase from the same quarter in the previous year. The use of mobile wireless technology and information systems can bring benefits to a supply chain with information quality, resource planning, inventory control, and cost savings (Ketikidis et al, 2008). Mobile wireless tools can help collect valuable real-time information, which allows the integrated information technology systems to provide feedback to each mobile wireless tool to guide operators to work more efficiently. The information systems behind mobile wireless technology are the essential links connecting and integrating activities from both the inside and outside of an organization (Gunasekaran & Ngai, 2005). The usage and benefits of mobile wireless technologies are related to inventory management, warehouse, distribution and logistics related operations, so this research focused on mobile wireless technology usage in warehouse environments. Mobile wireless applications have obvious advantages for efficiency and cost reduction while also adding freedom and flexibility in Supply Chain Management. However, there is a research gap on what barriers there are to stop companies' employees from intending to accept and use mobile wireless applications.

## 1.2 Scope

This research is limited to warehouses within retail, manufacturing, distribution and service, and for companies located in Lafayette and West Lafayette, Indiana. Three types of mobile wireless technologies will be addressed including RFID, bar-code handheld scanner and personal digital assistant (PDA). This research was conducted only on hourly associates or entry level workers from companies that met the requirements to participate.

## 1.3 Significance

Reducing costs and improving work efficiency are often the goals of implementing mobile wireless technology systems (Ketikidis et al, 2008). The installation of new mobile wireless technologies such as RFID can require large capital investments (Kim & Garrison, 2010). Not using high investment mobile wireless systems appropriately or not using the new systems at all, would not result in the initial goal of cutting costs and improving efficiency for companies. A successful technology investment would bring companies benefits. In contrast, a failed system implementation will lead companies to financial losses, employee dissatisfaction, and other undesirable consequences (Venkatesh, 2000). This research will help identify acceptance barriers of mobile wireless technology that may prevent employees from using mobile wireless tools properly and help companies' management to better understand what employees' expectations, questions and concerns are while working with mobile wireless tools. After finding the answers to the above questions, management may take action to overcome the acceptance barriers in daily working conditions for employees. Further research will assist companies to maximize the benefits mobile wireless tools generate and may help prevent an implementation of a mobile wireless system from turning into a return on investment disaster for company stockholders.

## 1.4 Research Question

The research question is: What are user acceptance barriers that exist in warehouse mobile wireless technology?

The current issues with mobile wireless technologies in the supply chain can be summarized into three key points: unreliable functionality, not user friendly (that cause individual user frustration) and antithetical attitudes or a lack of company leadership support. The goal of this research is to identify whether those issues are barriers for users to adopt mobile wireless technologies in a warehouse environment. Three hypotheses are included below:

**Hypothesis 1: Functionality**

a. The usefulness of mobile wireless technology's function will encourage users in warehouse environments to accept this technology.
b. The job relevance of mobile wireless technology will foster users in warehouse environments to accept this technology.
c. The good output quality of mobile wireless technology will foster users in warehouse environments to accept this technology.

**Hypothesis 2: User-friendly**

a. The ease of use of mobile wireless technology will foster users in a warehouse environment to accept this technology.
b. The ability to understand the result of mobile wireless technology will foster users in a warehouse environment to accept this technology.

**Hypothesis 3: Management leadership support**

a. The subjective norm from company leadership is to encourage use of mobile wireless technology and to foster users in warehouse environments to accept this technology.

b. The good societal image of mobile wireless technology established by company management leadership will foster users in warehouse environments to accept this technology.

## 1.5 Problem Statement

The best technology is the technology that is easily adoptable by human operators. The primary goal for this research is to identify user acceptance challenges to use mobile wireless technology through a survey. The gap between literature theories of mobile wireless application advantages and the mobile wireless adoption situations from a company's viewpoint will be captured. The research process can help companies to gain understanding of how to overcome users' acceptance barriers of mobile wireless technology to support better performance outcomes. The results of this research can be useful for supply chain managers and company executives to evaluate their current mobile wireless technology situations and user acceptance rates.

## 1.6 Assumptions

The research question is facilitated for clarity by making clear assumptions. The assumptions of this study have been made as follows:

- Information collected from sources is accurate and unbiased.
- The respondents will answer the survey honestly.
- The number of participants is sufficient to testify the hypotheses that are being studied.

- All participants have direct interaction with RFID or bar-code handheld scanners or PDA at work.
- All participants are trained on RFID or bar-code handheld scanners or PDA system or have working knowledge of those technologies above.

## 1.7 Limitations

The limitations for this study include:

- Companies may refuse to provide information and data or conduct the survey due to company contracts or trade secret protections.
- The numbers of participants are different for each sample company.
- The duration of introducing the research and answering the survey varied from 7 to 10 minutes for each participant.
- The participating companies determine how many individual participants take a part in the study.
- The survey collection action will take place in private environment such as a conference room or break room in the participating companies' facilities to protect individual subjects from physical or psychological harm following Institutional Review Board standards.
- This research adopted mixed methods of surveying, including face-to-face surveys, mailed surveys and electronic survey methods for the time convenience.

## 1.8 Delimitations

The delimitations of this research study include:

- The research is delimited to warehouse environments in manufacturing, distribution, retail and service companies.
- The geographic location of this research is delimited to Lafayette and West Lafayette, Indiana of United States.
- The researcher will not attempt to change employee nor company working preferences towards mobile technology.
- The research methodology will neglect different implementation stages of mobile technology.

## 1.9 Definitions

We define the following terms:

[Mobile wireless technology:] According to Malladi and Agrawal, "mobile wireless technology consists of two aspects: mobility and computing." Mobile computing represents users' continuous access to network resource without limitation on time and location (2002). Dubendorf defined wireless as the "form of data transmission is conducted through radio waves, infrared waves or microwaves rather than using wires" (2003).

[Wholesaler:] Based on Business Dictionary website, a wholesaler is a person or firm that buys large quantities of goods from various producers or vendors, warehouses them, and resells to retailers.

[RFID:] RFID refers to Radio Frequency Identification Technology. An RFID system is "consisted of tags, readers, and an application host. The readers can communicate with tags wirelessly to obtain the information stored on the tags. Passive tags are the cheapest which receive energy from the readers' communication signals to power up their function and communication with the reader." (Penttila, Pere, Soini, Sydanheimo, & Kivikoski, 2005).

## 1.10 Summary

Through the successful implementation of mobile wireless technology, supply chain participants, such as manufacturers, retailers and distributors can achieve effective supply chain performance (Kim & Garrison, 2010). The whole supply chain can pursue even higher coordination to create a high-level of synergy. For example, incoming order information scanned by an RFID or bar-code reader at the distribution warehouse will update to the inventory database. That information can be seen from the supplier and customer end users to help improve inventory information accuracy in order to prevent stock-outs or over stock situation.

This chapter defined the research question statement for identifying users' acceptance barriers of mobile wireless technology in warehouse environments, and research limitations and delimitations that would be used later in this research to restrain the research boundary. This chapter also described the importance of answering the question statement to the application of mobile wireless technology in supply chain. The next chapter is targeted at reviewing previous literature study in the aspects of mobile wireless technology and potential users' acceptance barriers of mobile wireless technologies. The researcher reviewed the research theoretical framework user acceptance model and survey methodology in the next chapter as well.

# CHAPTER 2. LITERATURE REVIEW

## 2.1 Introduction

Internet communication enables members in supply chains to have more accessible relationships, and electronic devices that are enabling internet communications are getting smaller and trending to be wireless so people can easily carry them around (Barnes, 2002). Mobile wireless technology is growing at an amazing speed. By 2005, barcodes were used by almost all retailers around the world (Smith, 2005). There are between five and 10 trillion new barcodes printed every year, and approximately five billion barcodes scans every day (Wlyd, 2006). Mobile wireless tools in supply chain operations are assisting businesses to cut costs and respond faster. These factors are causing companies to start implementing mobile wireless devices to assist with day-to-day operations. Adoption of mobile devices is an unstoppable trend in supply chains. There are many research projects that have already been performed in areas such as RFID usage and its benefits in the supply chain; as well as the necessity to have internet information systems in supply chain operations. In order to provide reliable answers to the research questions of this study, the researcher searched for prior published work to summarize what questions have been answered, and what has not yet been done. This chapter serves as a review of terms that will help readers to better understand the expressions and concepts that will be mentioned in the study.

The end of this chapter will summarize how the prior work is related to this study and what gaps are in the research. The summary will help researchers identify potential future research opportunities.

## 2.2 Information Technology in Supply Chain

Before reviewing the main topic of this research paper, mobile wireless technology in the supply chain, it is important to summarize what the literature says about information technology within the supply chain first. Mobile wireless technologies do not only provide benefits for day-to-day operations, but also integrate with existing information technology in the supply chain, to add additional information and data that can be analyzed later to provide insights for process improvement. An interorganisational information system (IOS) consists of communication networks, hardware IT applications, data transmission and human input (Williamson, Harrison & Jordan, 2004). The hardware IT applications include mobile wireless technologies so it is impossible to discuss mobile wireless technologies without mentioning information systems.

Gunasekaran and Ngai (2005) summarized in their article that supply chain management's task is to integrate key value-adding business activities of producing products or services from original supplier to end users. In Gunasekaran and Ngai's views, supply chain management is a set of approaches that can be utilized to collaborate among important supply chain participants including suppliers, manufacturers, distributors, and stores effectively. Information technology is the rope that ties together those important nodes, just like the metaphor Gunasekaran and Ngai (2005) used in their article, "the nerve system for supply chain management." Daugherty, Richey, Roath, Min, Chen, Arndt, and Genchev, (2006) agreed with Gunasekaran and Ngai that collaborative and integrative companies have a tendency to be more successful than isolated companies. At the same time, information technology also enhances deeper and faster communication with the customers.

The benefits of adopting information technology in supply chain management can be categorized into three main areas. The first area in information technology that supports companies' supply chain is strategic planning (Williamson et al, 2004). Strategic planning will have a long-term influence on company performance. Developing virtual enterprise partnerships or integrated networks in supply chains are considered as strategic plans. Information technology plays a fundamental role in making the right information available to form partnerships quickly, and hence develop a virtual enterprise. Information technology ensures two-way information flow upstream and downstream in the supply chain (McLaren, Head & Yuan, 2002) to support important decisions in virtual enterprise and collaborative-supported work environments (Gunasekaran & Ngai, 2005). Information technology enables effective technology transfer in a network of partnerships. For example, the effective use of ERP systems and computer-aided design software can integrate coordination with suppliers and customers (Williamson et al, 2004). The use of information systems can influence other partners in virtual enterprises to start adopting those technologies and learn from a partner's previous knowledge and experience. Information technology can be a judged as criteria to make an organization qualify or not qualify as a partner in a virtual enterprise.

Another beneficial aspect of adopting information technology is cost savings. According to Chow, Madu, Kuei, Lu, Lin, and Tseng (2008), the absence of information technology will cause the organization to become obsolete and cause serious problems in supply chains from delayed, distorted, and inadequate information. One important wellknown effect is called the “Bullwhip Effect” and was first identified by Forrester (1962). The cause of the “Bullwhip Effect” is the miscommunication and inadequate information acquired about actual demand along the supply chain. The result is redundant inventory stored with every member in the supply chain, each attempting to prevent stock-outs. Having an effective information system can help eliminate redundant inventory and activities (Closs, Goldsby & Clinton, 1997). Companies engaging in E-commerce can reduce paper transactions, shorten order cycle time, and substitute surplus physical inventory with the help of information systems (Murillo, 2001). E-commerce companies can also use information systems to reach new market segments and geographical regions (Overby & Min, 2001).

The third benefit of applying information technology systems is customer service. The fast transmission of purchase order information can provide customers with updated and even real-time information they would like to know about their purchase orders. For example, the logistics company UPS uses strategic application of the information systems to benefit clients (Van Hoek & Chong, 2001). Customers can also receive their orders within shorter lead times. Information technology systems also enable businesses to communicate with customers constantly to better maintain customer relationships.

Feld and Stoddard (2004) believed that information technology is the heart of operations, instead of a simple tool for operations. The infrastructure for information technology systems contains major three parts: internet connectivity, hardware and software. In the information technology system infrastructure, the wireless mobile hardware is the topic of this research paper.

## 2.3 Mobile Management Supply Chain

The industry has benefited from wired technology for the past few years, but wired technology is limited due to its lack of mobility. Mobile wireless technologies free users from their desks and offer the flexibility to have access to the internet and operate from anywhere anytime (Kim, Mim, & Holmes, 2006; Kumar & Zahn, 2003). Mobile technology systems can integrate into existing IT systems or replace dependence on wired systems (Eng, 2006). This provides companies and users the flexibility to apply wireless technology to any IT-enabled supply chain functions, and extends existing supply chain management capabilities whenever and wherever. The handheld computing market is growing tremendously. This growth is driven by a transformation into virtual enterprise environment and the requirement to access work resources remotely and quickly (Kumar & Zahn, 2003). Mobile Supply Chain Management refers to the use of mobile applications and devices to aid the conduct of supply chain activities, and help firms to gain cost reduction, supply chain responsiveness and competitive advantages.

### 2.3.1 RFID

RFID (radio frequency identification) is a wireless technology which can identify and gather information on items without human intervention (Tajima, 2007; Wlyd, 2006). A RFID system consists of three key components: tag, reader, and middleware. A tag includes a microchip which stores product identification data and an antenna transmits the data through radio waves. The reader sends out signals to promote the tag to broadcast the stored data through radio waves back to the reader. The readers then convert the received radio waves into digital information and forward them into a computer system (Tajima, 2007). RFID readers can be either handheld or fixed-mount devices (Domdouzis, Kumar & Anumba, 2007). The third key component is a middleware that bridges RFID hardware and enterprise applications (McFarlane, Sarma, Chirn, Wong, & Ashton, 2003). The middleware connects the RFID readers with computer systems so that the data captured from readers can be put into the system and shared or processed later.

According to Tajima (2007), there are a lot of benefits to using RFID. First of all, RFID microchips can contain more data than just the destinations and product names. RFID has the capability to carry more detailed product information such as quality control, supplier information, and customer specifications. Secondly, the reader can also receive more than just one RFID tag signals at once so it saves more time than using bar codes. Thirdly, RFID technology does not require physical contact between readers and tags so the tags signal can be received through layers of packages without undoing packaging. RFID scanners also do not require straight line up positions with the tag so it will save cost on designing special conveyor belts for the positioning. A main characteristic of RFID is the ability to trace the subject globally. With the help of other technologies, such as global positioning systems (GPS), RFID can provide real-time update of current states of subjects. This unique feature provides visibility in the supply chain, especially the global supply chain (Tajima, 2007).

RFID is still a relatively new technology to the supply chain even though the technology can be traced back to 1960s (Tajima, 2007). According to Roberti (2003), the world's leading retailers such as Germany Metro Group, United Kingdom Marks and Spencer, and US Walmart did not start using RFID to track supplies until 2003. One big reason for those world's leading retailers to start adopting RFID was the need to fix problems of inaccuracy in inventory management in the warehouse. DeHoratius and Raman (2008) reported that 65 percent of inventory records in retail stores were inaccurate. The consequences of having inaccurate inventory records are additional inventory, loss of sales, and undesired costs associated with extra material handling. To correct the inaccuracy recode problems, retailers' warehouse managers will usually start a physical count on warehouse on-hand inventory. Due to the nature of wide range and high storage capacity, RFID can scan and count multiple physical on-hand inventory items at once and compare the reading data with system record and then correct the inaccurate records on the computer system. The process can shrink down from days and weeks to just a few days, and even a few hours. A shorter physical count helps retailers reduce labor hours spent during the process and respond to customers' requests sooner.

A mobile wireless RFID reader will be able to capture data more effectively. A RFID enabled PDA in a construction supply chain can increase the speed and accuracy on information communication and circuitously enhance productivity in the construction process (Wang, Lin & Lin, 2007). In the case study, RFID enabled PDA was used in the whole construction process: production phase, test and storage phase, delivery phase, on-site and inspection phase, inventory phase and installation phase to track the material flow with accurate, synchronized and updated information (Wang, et al, 2007).

Even though RFID has various advantages in the warehouse environment, there are still some adoption barriers between the ideal vision and current situation due to the following reasons: high unit cost of tags, unreliable performance, and popularity of bar codes which will be discussed in details in the next subsection. However, there is no research that has been done lately to re-evaluate mobile wireless RFID readers' utilization conditions.

### 2.3.2 Bar-code

Bar-coding is another commonly used wireless technology in the warehouse environment. Bar-code have similar advantages as RFID such as increased accuracy of data entry, improved inventory control and management, decreased physical inventory counting time and higher customer service level, among others (Manthou & Vlachopoulou, 2007). Navas commented bar-code as the most effective front end to inventory control systems through automatic data collection (1996). Bar-code systems can assist companies on information sharing within the organization as well as communicating with external suppliers. Bar-codes also have an outstanding cost advantage. Unlike RFID, companies do not need to pay for the tags; instead, most of the time companies can print bar-code tags on their own.

### 2.3.3 Personal Digital Assistant

Personal Digital Assistant (PDA) is a compact handheld computer device with touch screen, keyboard input area or other customizable application buttons to allow human interaction with the device wirelessly (Baumgart, 2005; Lu, Xiao, Sears, Jacko, 2005). PDAs are generally compatible with information management software and connection to local area networks (Lu et al, 2005). PDA is widely used in healthcare and industrial supply chains with its ability for data acquisition and resultant processing.

Palm, the world leading handheld computing company, believes that mobile wireless handheld computing is next hit as individual productivity tool (Kumar & Zahn, 2003).

**2.4 Potential Barrier and Challenges for Implementation**

Even though RFID is not a new technology and it brings many benefits to supply chain and operations in warehouse environment, there are still many barriers or challenges for adoption.

The first and also the most discussed barrier in the literature is the overall high cost. RFID has been used for decades, but the manufacturing cost for tags is still relatively high compared to substitute technology. The high manufacturing cost is due to many manufacturing difficulties and constraints for mass production of tags (Tajima, 2007). In addition to the expensive price of tags, RFID implementation usually incurs "hidden costs." According to Angeles, often times, companies needs to remap the existing warehouse layout or material handling equipment and hardware to coordinate the adoption of RFID. Another hidden source of costs is the need to modify existing information technology or even acquire new information technology systems (2005). The overall high cost causes a lack of confidence in return-on-investment (ROI) from the management level. Based on a survey conducted by ARC Advisory Group, more than half of the respondent companies did not expect a positive ROI from RFID adoption (2004). Tajima concluded that the high cost of implementation for a large-scale RFID system was a serious barrier (2005). The missing confidence in ROI leads to low support from company management or executive level, which could lead to failure in initial deployment or abort deployment of RFID.

A barrier for both RFID and bar-code deployment is the unreliable performance. Many researchers found the high percentage of RFID defective tags and false read in pilot projects ranging from 20% to 50%, which is not ideal (Sullivan & Dunn, 2004; Wyld, 2006). False reads could come from reader collision as more tags and readers come into use in the warehouse. The interference from other wireless devices such as employees' mobile phones could also cause reader collisions (Twist, 2005). RFID reader manufacturers are developing solutions such as touch screens for material handlers to activate the reader only when they need to and correct the wrong actions manually, until a software or reader development can capture the false reading and correct it automatically (Angeles, 2005). On the other side, bar-code can fail easily at the same time as well. According to Nachtrieb, who is an expert in bar-code technology with over 30 years of hands-on specialized experience in barcode quality, a bar-code can fail for many reasons. For example, the poor print quality that causes excessive bars and space in barcode leads to reading failure. A wrong combination of colors can also lead to reading failure as well, for example a white background with red bars or green background with black bards. Other common reasons for reading failures Nachtrieb mentioned are shrink wrapping or printing on clear polybag. In additional to those common reasons, bar-code scanning requires direct straight reading which can cause reading failures from non-straight angles (2013). Compared to RFID, bar-code readers also fail to scan multiple bar-code tags at the same time.

Another performance barrier is with the complexity of mobile wireless technology systems integration with existing application and information technology systems. Angeles mentioned in the paper, if a company failed to link RFID into the company's existing information technology application systems, the new system would fail to deliver the promised benefits. The incompatibility with existing systems would lead to an incomplete understanding of how RFID technology is beneficial to its existing operations and the wrong impression of what RFID essentially can do (2005). Research demonstrated the problem of integration with suppliers', customers' and companies' own existing systems while using a new system such as RFID and bar-code is significant (Ketikidis, et al, 2008). The lack of capabilities to interpret the large volume of data coming in existing information technology after implementing RFID also contributes to complexity and stress to the current information technology which can cause resistance to the adoption of RFID (RFID Journal, Sept. 23, 2002). Li and Visich also addressed that RFID vulnerability to computer virus also complicates system functionality (2006).The difficulty to integrate with existing information systems in supply chain and process extra information, added to the complexity of employees' daily operations, which can outweigh the benefits of RFID and bar-code systems. The complexity and misunderstanding of work with a system can add additional stress on operators. The problem of resistance to change from employees, employee skills and knowledge shortage were proven as significant factors in testing when using information systems solutions such as RFID and bar-code systems (Ketikidis, et al, 2008). In other research, the barriers of resistance to change to IT-enabled technology systems and low priority by the management were also proven to be significant among 11 identified barriers (Jharkharia & Shankar, 2005).

Another adoption barrier is indirect and not obvious. Based on the information provided in the RFID Journal, companies' deployment of RFID is due to enforcement from their powerful customers. For example, Wal-Mart required its selected major suppliers to use RFID by the year 2005 (June 16, 2003). The enforced adoption, rather than initiation from a company's own interests, could drive companies away from truly understanding and appreciating how RFID can actually benefit the company operation. This kind of enforcement from powerful customers can be a barrier rather than an incentive for RFID adoption. Companies can easily abort RFID adoption after concluding business relationships with powerful customers due to employees and managements inaccurate understanding and impression of RFID advantages. The enforcement also causes the companies left to practice RFID interface with related business applications and information technology on their own with no motivation to seek help (Angeles, 2005).

Other small barriers such as the mobile devices are vulnerable in extreme working environments like rain, wet, dust and physical shocks also need to be addressed (Wang et al, 2007).

Without good knowledge of information technology system solutions such as mobile wireless technology applications, mistakes could be very costly. Real time decision making is irreversible and affects multiple functions through 'knock-on' supply chain effects, and cause customer dissatisfaction (Eng, 2006). Some industry analysts also note that many companies are struggling to implement mobile wireless applications to their businesses and end users to eliminate response lag time, delays in transaction processing and customer service, as well as missed market opportunities such as order-to-demand. Successful implementation of mobile supply chain management requires knowledge embedded in systems of interactions in the supply chain. Mobile supply chain management is likely to derive from knowledge of the supply chain across different activities and functions. Cross functional knowledge of disparate supply chain functions and activities.

The researcher provided a summary of the potential acceptance barriers for mobile wireless technology that were listed in the literature.

| Barriers | Consequence |
|---|---|
| High installation cost | Lack of management support |
| Unreliable performance | System failure |
| Additional scanning and interaction with computers | Users frustration and stress |
| Complexity of mobile wireless technology integrate with existing IT system | System failure & users frustration and stress |
| Powerful customer or supplier enforcement | Lack of management and operators support and motivation |
| Lack of proper knowledge of application and importance to supply chain management | System failure |

*Figure 1* A Summary of Potential Acceptance Barriers of Mobile WirelessTechnology

## 2.5 User Acceptance Model TAM 2 and SUS

Technology Acceptance Model (TAM) was developed by Davis which provided "a valid and reliable measure that predicts the acceptance of a new technology by end-users" (1989). The TAM is based on two specific beliefs that perceived usefulness and perceived ease of use of a technology system determine a person's behavioral intention to use (Venkatesh & Davis, 2000). TAM has proved to be a powerful model to predict users' acceptance with substantial theoretical and empirical support. By 2000, the

Institute for Scientific Information's Social Science Citation Index listed 424 journal citations to two TAM articles written by Venkatesh and Davis (2000); and Venkatesh (2000). After Davis introduced TAM in 1989, Venkatesh and Davis worked on updating the theory. The updated TAM 2 is a theory that "incorporates additional social theoretical constructs spanning social influence processes (subjective norm, voluntariness, and image) and cognitive instrumental processes (job relevance, output quality, result demonstrability)" to explain the perceived usefulness of a new technology which leads to people's intention to accept (Venkatesh & Davis, 2000). The subjective norm is defined as a person's perception that if the majority of people who are important to this person think he or she should perform this behavior; the person will be motivated to comply with that behavior (Fishbein & Ajzen, 1975). Subjective norms help undercover the conditions that can impact social influence on user behavior from a management perspective. Another social theory in TAM 2 refers to a situation in which an innovation is used to enhance someone's status in the social systems (Moore & Benbasat, 1991). According to Venkatesh and Davis (2000), the power increase from the social status elevation provides higher productivity, which gives this person an impression that using this system will improve his or her performance. In the cognitive instrumental processes, the job relevance means the degree of individual's agreement of a target technology matches with the target technology applicable degree to his or her job (Venkatesh & Davis, 2000). Except for job relevance, people also consider the output quality which refers to how well systems perform those tasks. Davis, Bagozzi, and Warshaw have proven the relationship between the output quality and the perceived usefulness that was, the output quality was expected to explain the perceived usefulness (1992). The last cognitive instrumental process is the result of demonstrability, which reflects that if a system, produces job-relevant excellent results but in an unclear and unobvious way, the users are unlikely to understand how useful this system truly is (Moore & Benbasat, 1991).

The result demonstrability emphasized the importance of training employees with enough knowledge and understanding of a new system and what this system can actually do. In Venkatesh and Davis' theory, the subjective norm, voluntariness, image, job relevance, output quality and result demonstrability have impact on perceived ease of use which has an impact on perceived usefulness. Both perceived ease of use and perceived usefulness together determine users' intention to accept the technology.

Figure 2 below shows TAM 2 theory framework from Venkatesh and Davis' article (2000).

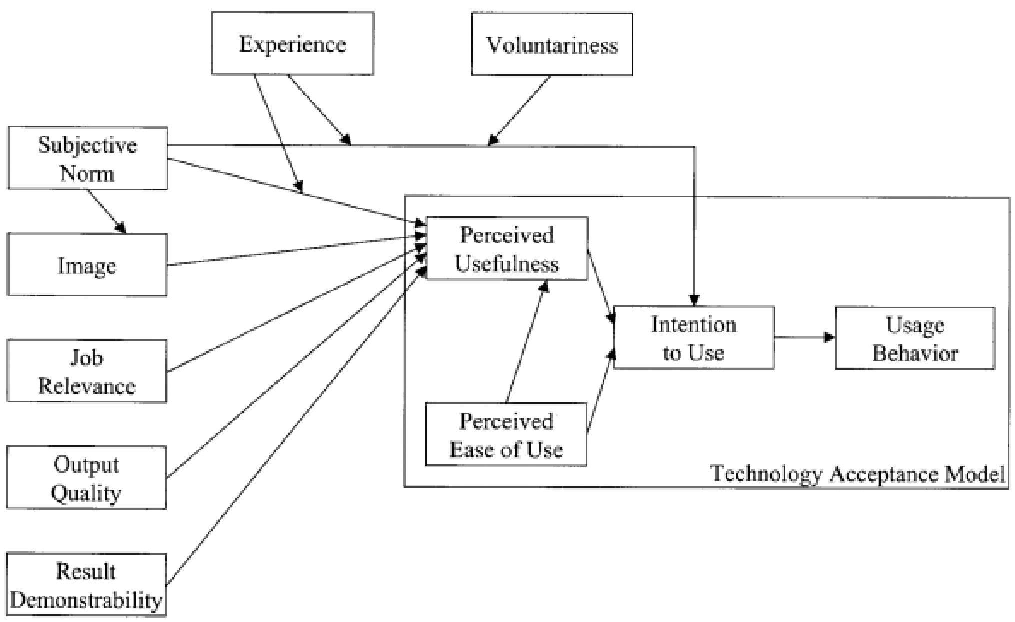



*Figure 2* Technology Acceptance Model 2 (Venkatesh & Davis, 2000)

The System Usability Scale (SUS) is a ten-question survey instrument developed by Brooke in 1986 for general assessments of system usability (Brooke, 2013). SUS was described as a "quick and dirty" assessment method to evaluate industrial systems.

However, the “quick and dirty” doesn’t affect the effectiveness and reliability of this survey instrument. According to a study by Bangor, Kortum, and Miller, 2,324 SUS surveys showed high reliability with a 0.91 alpha score (2008). The researchers Tullis and Stetson also compared SUS with other five other survey instruments such as Questionnaire for User Interaction Satisfaction and Computer System Usability Scale from Google Scholar and Purdue University library. The Usability Questionnaire, on measuring the usability of two websites concluded that SUS provided very reliable results (2004). The questions in SUS reflect effectiveness, efficiency and satisfaction of a system which align with ISO 9241-11 classes of usability measurement (2013).

### 2.6 Survey and Response Rate

Based on Groves, Fowler, Couper, Lepkowski, Singer and Tourangeau’s definition, a survey is “a systematic method for gathering information from a sample group to construct quantitative descriptions of attributes of larger population which the sample group belongs to" (2009). There has been an increase in use of empirical data to simulate, develop and test theories in operation management researches (Forza, 2002). Surveys can be used for different research purposes and is usually recognized between exploratory, confirmatory and descriptive survey research (Malhotra & Grover, 1998). Exploratory survey research happens at the early phase of a research topic to obtain preliminary insights. Exploratory survey research can help settle the concepts that need to be researched to reveal more facts about a topic or concept. Confirmatory survey research helps further approve and test well-defined theories, models and hypothesis through hypothesis testing. Descriptive survey research may be used to further theory refinement which aims to understand and describe the distribution of the population of a certain topic and phenomenon (Malhotra & Grover, 1998).

Forza also provided a theory-testing survey research process as shown below in Figure 3. (2002).

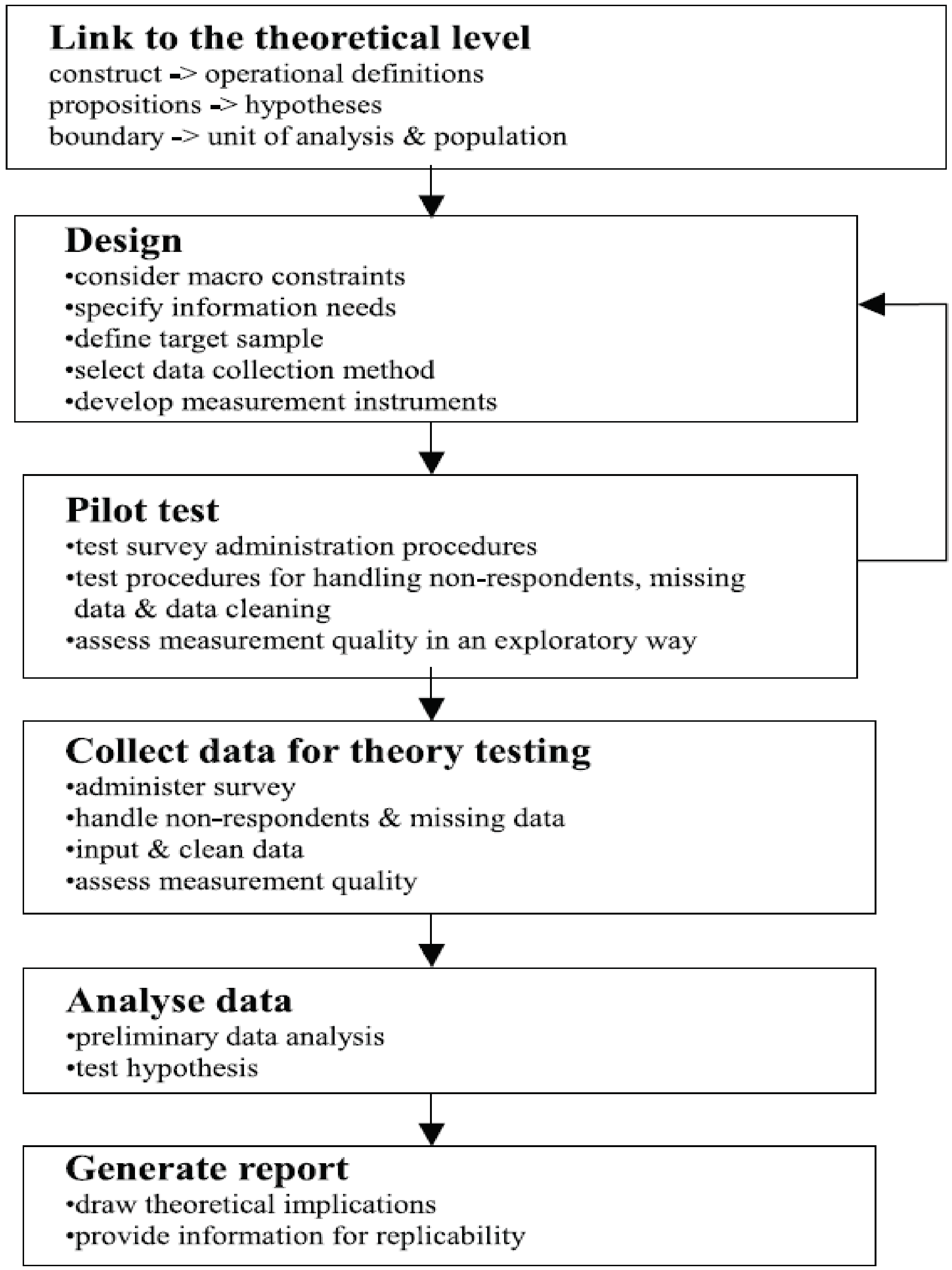



*Figure 3* Theory Testing Survey Process Chart (Forza, 2002)

In measurement instrument design, Forza pointed out the significance of wording and scaling. The researcher should use the language of the survey that is consistent with the targeted respondent’s level of understanding. The choice of mixing of positive and negative words in questions will help reduce the tendency of respondents to circle answers mechanically. Leading questions and ambiguity should be avoided as much as possible. The scale in the measurement instrument will be used to measure the answers. The scale choice will determine both how easy respondents can answer to the questions and how subsequent analysis can be done. The common scales to measure quantitative metric variables are interval and ratio scales. Interval scale technique includes Likert scale, comparative verbal and frequency scale which highlight the difference, order and distance (Forza, 2002).

When researching the survey response rate, the researcher found out that paper surveys are most likely to achieve a higher response rate than online surveys. Overall, paper-based surveys have a 56% response rate compare to online surveys' 33% response rate. However, a paper based survey that was not conducted through face-to-face administration had response rates as low as non-paper based surveys (Nulty, 2008). There are techniques to follow to maximize the response rates using survey design and how to distribute the surveys. Flanigan, McFarlane and Cook summarized that longer surveys tend to result lower response rate and the identified threshold length of the survey is 1000 words at which the response rate starts to drop. Surveys that are formatted in close-ended question yielded 22% higher response rates than open-ended questions (2008). To achieve a higher response rate with mail surveys, the surveys should be printed in one-sided formats because studies have shown that one-sided print surveys yield higher response rate than two-sided formats. Also if a mailed survey contains a flattering cover letter emphasizing the importance of the respondent expertise or a recognized sponsor, higher response rates are yielded (Flanigan, et al, 2008).

## 2.7 Summary

This section summarized prior research topics related to this research including information technology systems in supply chain, mobile management supply chain, potential barriers and challenges for implementation, the extension of User Acceptance Model TAM 2 and the survey methods.

# CHAPTER 3. FRAMEWORK AND METHODOLOGY

This research aim is to discover the use barriers for mobile wireless technologies in warehouse management. Doing so would smooth the adoption and application process of mobile wireless technology for future supply chain development. The research was conducted using a quantitative approach to test hypotheses based on a literature review and the researcher's prior experience. It was anticipated that the acceptance of mobile wireless technology was determined by the usefulness of the technology, individual user experience with the technology and company management support and leadership style.

## 3.1 Research Framework

The research followed the theory test survey research process provided by Forza (2002). This process began with finding the link to the theoretical level, the theory or hypothesis the researcher wants to prove and the research boundary both of which have already been covered in chapter one. That is to say, what are user acceptance barriers are of mobile wireless technology such as RFID, bar-code handheld scanner or PDA in warehouse environment. The next process was to design research method details which are laid out in this chapter. The researcher modified Venkatesh and Davis' Technology Acceptance Model 2 survey as the data measurement tool and targeted a sample group of employees who work in warehouse environments and use mobile wireless technology systems to assist their daily jobs. After designing a research method, a pilot study should be conducted. According to Oppenheim, a pilot survey is a process of re-conceptualizing the key subject of the study and preparing for the analysis so that the survey will not go too wrong or miss too much (1992). A further adjusted survey will be distributed to an actual targeted sample to collect data for theory testing and analysis.

### 3.2 Methodology Overview

The survey results were analyzed using statistical tools to see what factors enhanced adoption. The survey measurement tool was adopted from Technology Acceptance Model 2 which provided detailed questions within each section. Due to many limitations of this thesis project, the researcher cannot collect the information from the whole population of the warehouse environment businesses who are using mobile wireless technology systems RFID, bar-code and PDA. A sample became a better solution to help the collected information from a part of the population to represent the whole population and reduce the workload. The modified survey was sent in a mixed method of face-to-face, mailed and electronic surveys to groups of samples within the population. Samples' behavior intention in using mobile wireless technology would be studied through the analysis of returned survey responses. Then the researcher could conclude what barriers were blocking users to adopt mobile wireless technology and what factors were enhancing the adoption by the sample population.

### 3.3 Theoretical Framework

The researcher reviewed literature on technology users' acceptance evaluation models. The Technology Acceptance Model 2 (TAM 2), by Davis and Venkatesh (2000), and the System Usability Scale (SUS) instrument, by Brooke (1996) are most suitable for the research purpose and have been tested and proven valid in other research. The TAM 2 survey had reliable Cronbach Alpha scores over 0.8 (Venkatesh & Davis, 2000) and SUS survey had an Alpha score 0.91 (Bangor, Kortum & Miller, 2008). The original TAM was designed to assess users' acceptance for information technology and explains users' intention to accept a technology from two points: perceived usefulness and perceived ease of use. In the advanced TAM 2, the perceived usefulness is also affected by subjective norm, image, volunteer, job relevance, output quality and result demonstrability (Venkatesh & Davis, 2000). The SUS is a more generalized assessment of usability on variety of products or services (Brooke, 2013). This research combines the validated surveys using TAM 2 theory and SUS questions for "perceived ease of use" section in the TAM 2 theoretical framework. The research object is to identify wireless technology acceptance barriers in technology function usefulness, users' interception and company leadership influence through the use of TAM 2 and SUS instrument (Venkatesh & Davis, 2000; Brooke, 1996).

Since both TAM 2 and SUS method are carried out in survey format, the survey instruments were adopted for this research as well. According to Groves, et al, "a survey is a systematic method for gathering information from a sample group to construct quantitative descriptions of attributes of larger population which the sample group belongs to." (2009). The researcher modified the TAM 2 survey instrument with SUS questions, which are both found to be reliable and effective in many field of studies. The respondent will answer each survey question on a Likert scale to the extent to which individual agrees to it from 1-extremely disagree to 5-extremely agree. This research survey consists of nine sections corresponding to the framework of TAM 2 created by Venkatesh and Davis (2000).

### 3.4 Survey Design

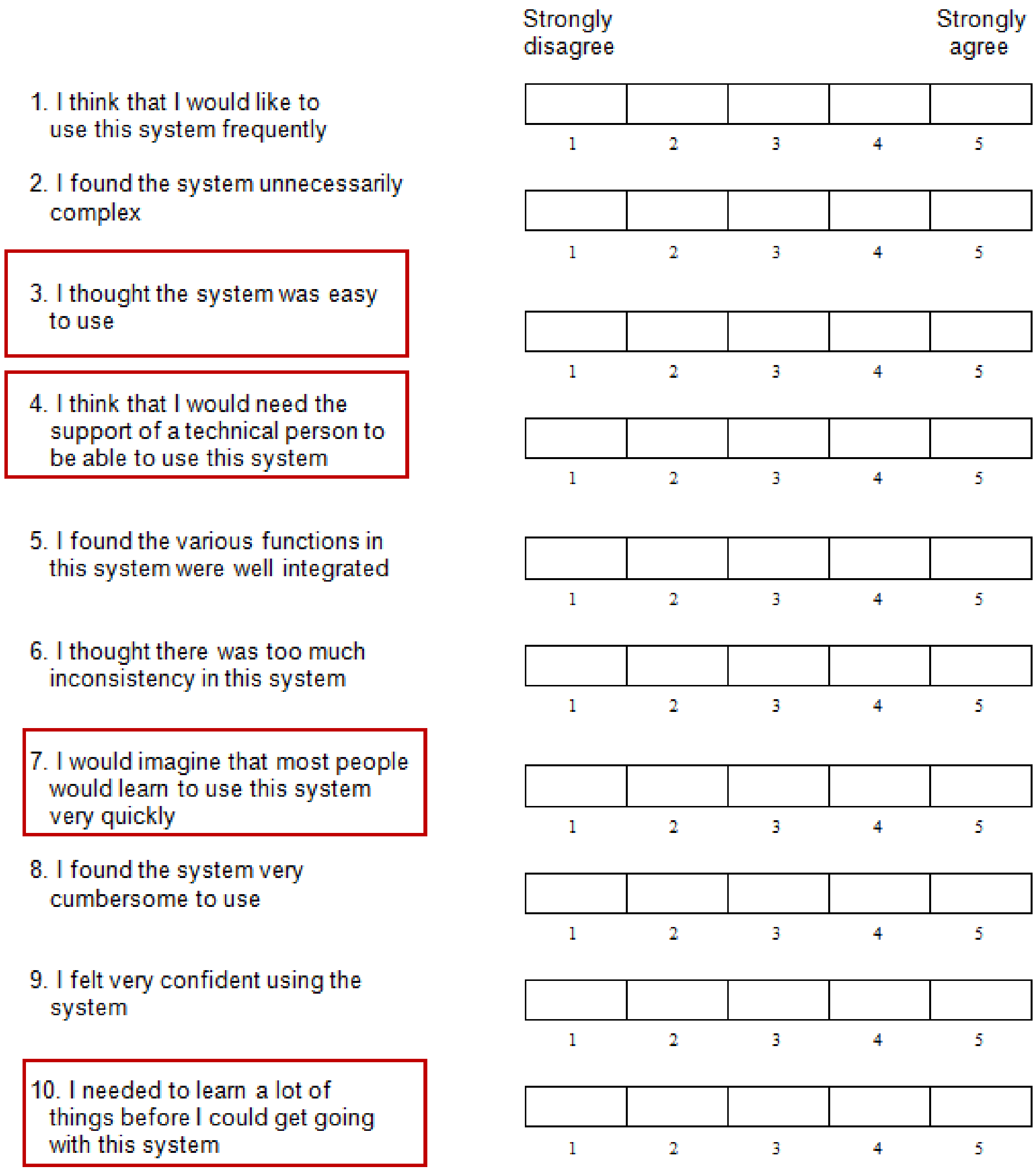
This research survey was modified from the original Technology Acceptance Model 2 (TAM 2) and System Usability Scale (SUS) surveys (Venkatesh & Davis, 2000; Brooke, 1996). The structure of the TAM 2 model survey was not altered, only a few questions were modified for the current research purpose.

This first modified section was 'Perceived Ease of Use,' the researcher found that the questions under this section were ambiguous and hard to understand. Three questions from "quick and dirty" SUS survey were modified and inserted into this section. The charts below showed the original questions of the 'Perceived Ease of Use' section in the TAM 2 model and highlighted questions from the SUS that were modified and inserted into this research survey (Venkatesh & Davis, 2000; Brooke, 1996).

Perceived Ease of Use

My interaction with the system is clear and understandable.
Interacting with the system does not require a lot of my mental effort.
I find the system to be easy to use.
I find it easy to get the system to do what I want it to do.

*Figure 4* Perceived Ease of Use Section of TAM 2 Original Survey (Venkatesh & Davis 2000)


Strongly disagree — Strongly agree

1. I think that I would like to use this system frequently — 1 2 3 4 5
2. I found the system unnecessarily complex — 1 2 3 4 5
3. I thought the system was easy to use — 1 2 3 4 5
4. I think that I would need the support of a technical person to be able to use this system — 1 2 3 4 5
5. I found the various functions in this system were well integrated — 1 2 3 4 5
6. I thought there was too much inconsistency in this system — 1 2 3 4 5
7. I would imagine that most people would learn to use this system very quickly — 1 2 3 4 5
8. I found the system very cumbersome to use — 1 2 3 4 5
9. I felt very confident using the system — 1 2 3 4 5
10. I needed to learn a lot of things before I could get going with this system — 1 2 3 4 5

*Figure 5* System Usability Scale Original Survey (Brooke, 1996)

The 'Perceived Ease of Use' section after modification shows in the chart below.

**Perceived ease of use**

This section of questions asks to what extent you think this technology is easy to use and free of effort.

| | Strongly disagree | Somewhat disagree | Neither agree nor disagree | Somewhat agree | Strongly agree |
|---|---|---|---|---|---|
| I found the system is easy to use. | ○ | ○ | ○ | ○ | ○ |
| I don't need to learn a lot of things before I could get going with this system. | ○ | ○ | ○ | ○ | ○ |
| I would imagine that I would learn to use this system very quickly. | ○ | ○ | ○ | ○ | ○ |
| I don't think that I would need the support of a technical person to be able to use the system. | ○ | ○ | ○ | ○ | ○ |

*Figure 6* Modified Perceived Ease of Use in Current Survey

The second modified section was the 'Subjective Norm' section. The original questions from 'Subjective Norm' in the TAM 2 model were not specific enough and were unrelated to a working environment (Venkatesh & Davis, 2000). The chart below shows the comparison between the original questions and the modified version in the current study.

Subjective Norm

People who influence my behavior think that I should use the system.

People who are important to me think that I should use the system.

*Figure 7* Subjective Norm Section of TAM 2 Original Survey (Venkatesh & Davis 2000)

**Subjective norm**

This section of questions asks what you think those people who are important to you think you should or should not use the mobile wireless technology.

| | Strongly disagree | Somewhat disagree | Neither agree nor disagree | Somewhat agree | Strongly agree |
|---|---|---|---|---|---|
| My co-workers who influence my behavior think that I should use this system. | ○ | ○ | ○ | ○ | ○ |
| My supervisors/team leads who are important to me think that I should use this system. | ○ | ○ | ○ | ○ | ○ |

*Figure 8* Modified Subjective Norm in Current Survey

The last question section that was edited in the TAM 2 model was 'Image.' The original questions in the 'Image' section were ambiguous and contained a language level that might not be easily understood by the targeted sample (Venkatesh & Davis, 2000). The comparison of original and modified questions is shown below.

Image
- People in my organization who use the system have more prestige than those who do not.
- People in my organization who use the system have a high profile.
- Having the system is a status symbol in my organization.

*Figure 9* Image Section of TAM 2 Original Survey (Venkatesh & Davis 2000)

**Image**
This section of questions asks if using the mobile wireless technology is a status symbol in your organization.

| | Strongly disagree | Somewhat disagree | Neither agree nor disagree | Somewhat agree | Strongly agree |
|---|---|---|---|---|---|
| People in my organization who uses the system have a better position. | ○ | ○ | ○ | ○ | ○ |
| The ability to use the system is limited to certain employees. | ○ | ○ | ○ | ○ | ○ |
| Having access to the system is a symbol of status in my organization. | ○ | ○ | ○ | ○ | ○ |

*Figure 10* Modified Image Section in Current Survey

### 3.5 Pilot Study

Before distribution of the survey to actual targeted samples, a pilot test to validate the survey was administered to identify potential mistakes or missing data points. A group of knowledgeable supply chain graduate students were asked to review the survey and provide feedback and comments. Three peers were Master and Ph.D. students of

Purdue University studying Supply Chain Management Technology with rich research and industry experience.

Demographic questions at the beginning of the survey were added as advised, to capture important sample demographic characteristics. A few questions within a section which were highly related were removed to avoid potential chance to cause errors during statistical analysis. Also a short survey would generate higher response and complete rate according to previous study. Ambiguous wording was another error that was caught during the pilot study. For example, the phrase “status symbol” was causing confusion and was modified it to “symbol of status.” One spelling error was corrected from “image” to “imagine.” In the survey cover letter, the introductory phrase was “find user adoption barriers for mobile wireless technology....” which was the research problem statement but it is a specialist term that wasn’t easily understood by the targeted population. The statement was rephrased to “find out what is stopping people from using mobile wireless technology…”

Overall, the errors captured in this pilot study match the table of frequent survey error details discovered in survey pilot testing which was summarized by Andrews, Nonnecke and Preece and presented below (2003).

Demographic data requests that are inappropriate for the survey
Overlapping question scales (e.g., 1 to 3, 3 to 6) or selection options
Questions that few or no one answers
Too many questions that highly correlate
Too many open-ended questions
Open-ended questions that do not provide useful information
Incorrect defaults (hidden or revealed)
Small text boxes that do not scroll
Ambiguous wording
Bias in question/answer wording
Inconsistent terminology
Nonorthogonal or overlapping categories
Specialist terms or technical vocabulary not familiar to the target population
Answers that cannot be undone
Insufficient space for open-ended question answers
Inconsistent wording and spelling errors
Inaccurate or missing instructions
Inaccurate time to complete estimates

*Figure 11* Common Errors Found in Pilot Survey (Andrew, Nonnecke and Preece, 2003)

### 3.6 Population and Sample Set

The population of the study was limited to companies who were currently using mobile wireless technology such as RFID, bar-code handheld scanners or Personal Digital Assistant devices (PDA) in their warehouse business in Lafayette and West Lafayette, Indiana. The researcher selected nine businesses to sample from the population, and each business sampled contributed at least 10 survey respondents.

Invitation letters were sent to the companies that met the research criteria, companies in Lafayette and West Lafayette that have adopted mobile wireless technology such as RFID, bar-code handheld scanners or PDAs in warehouse. The researcher contacted three manufacturing companies that met the criteria above. Two manufacturing companies responded and one agreed to participate in the research. The research also reached out to two distributors that met the criteria, one company responded and agreed to participate. Zero response was received from the four retail companies contacted. To protect the rights and privacy of individual participants and participant companies and IRB standards, the company name will be coded. Company X is a multinational company which designs, manufactures and sells machinery and engines to customers over the world. This company is headquartered in America and has approximately 110,000 employees. Currently, Company X is adopting handheld bar-code scanners and mobile wireless PDA in the warehouse to assist material management operation. Participants from Company X worked at the warehouse sector of business. Company Y is a public research institution that has over 40,000 employees. Company Y is currently adopting handheld bar-code scanners in the warehouse distribution center and IPad as PDA in the maintenance area which is seen as inventory warehouse area. Participants from Company Y were warehouse operators and maintenance crew.

The participants' composition breakdown is shown below. As Table 1 shows, a majority of over 80% participants came from Company X.

*Table 1*
Participant Composition

| Company | Participants | Percentage |
|---|---|---|
| X | 38 | 76% |
| Y | 12 | 24% |
| Participant Total: | 50 | 100% |

The professional profile information of the survey participants is displayed in the Table 2. 26.3% participants from Company X were female which is around the number Harress showed in his study that the female workforce accounts for 27% of the total manufacturing workforce population (2013). Over half of the participants, 52.5% of the sample populations from Company X were ranged between 35 to 59 and a large proportion 44.7% of participants were aged less than 35 years.

The demographic information included participants education level and work experience. The majority of Company X participants had a high school or equivalent degree (47.3%). The second largest education group was “some college completed” which accounted for 21.1% of the sample. The majority of the participants had more than three years working experience (94%) and mobile wireless technology experience (76.3%). However, there were more participants who had less than one year experience with mobile wireless technology (13.2%) than participants who had one to three years’ experience (10.5%).

*Table 2*
Participants Professional Profiles

| Gender | Co. X | Co. X % | Co. Y | Co. Y % | Total Co. (X+Y) | Total Co. % |
|---|---|---|---|---|---|---|
| Female | 10 | 26.3% | 4 | 33.3% | 14 | 28% |
| Male | 28 | 73.7% | 8 | 66.7% | 36 | 72% |
| | | | | | | |
| Age | Co. X | Co. X % | Co. Y | Co. Y % | Total Co. (X+Y) | Total Co. % |
| 18-35 | 17 | 44.7% | 4 | 33.3% | 21 | 42% |
| 35-59 | 20 | 52.6% | 7 | 58.3% | 27 | 54% |
| >60 | 1 | 2.6% | 1 | 8.3% | 2 | 4% |
| | | | | | | |
| Education Level | Co. X | Co. X % | Co. Y | Co. Y % | Total Co. (X+Y) | Total Co. % |
| Completed some high school | 4 | 10.5% | 1 | 8.3% | 5 | 10% |
| High school graduate/GED | 18 | 47.3% | 3 | 25.0% | 21 | 42% |
| Completed some college | 8 | 21.1% | 3 | 25.0% | 11 | 22% |
| Associate degree | 5 | 13.2% | 1 | 8.3% | 6 | 12% |
| Bachelor's degress | 3 | 7.9% | 4 | 33.3% | 7 | 14% |
| | | | | | | |
| Work Experience (Years) | Co. X | Co. X % | Co. Y | Co. Y % | Total Co. (X+Y) | Total Co. % |
| <1 | 1 | 2.6% | 0 | 0.0% | 1 | 2% |
| >1 to 3 | 1 | 2.6% | 1 | 8.3% | 2 | 4% |
| >3 | 36 | 94.7% | 11 | 91.7% | 47 | 94% |
| | | | | | | |
| Mobile Wireless Technology Experience ( | Co. X | Co. X % | Co. Y | Co. Y % | Total Co. (X+Y) | Total Co. % |
| <1 | 5 | 13.2% | 0 | 0.00% | 5 | 10% |
| >1 to 3 | 4 | 10.5% | 2 | 16.70% | 6 | 12% |
| >3 | 29 | 76.3% | 12 | 83.30% | 41 | 82% |

Company Y is a warehouse distribution center for public research institution. Company Y has higher female participants' percentage of 33.3% compared to 26.3% female participants rate from Company X. Company Y also has higher percentage (58.3%) of participants aged between 35 to 59 compared to Company X, and lower percent of employees aged under 35 years old of 33.3%. Participants from Company Y have higher education level as well. The most common education level of participants in Company X is high school graduate or equivalent. However, the most common education level of participants in Company Y is bachelor's degree with a percentage of 33.3% compared to 7.9% of participants in Company X has a Bachelor degree. Only 33.3 % of participants from Company Y has high school equivalent degree or less compared to 57.8% of participants from Company Y in the same category. Company Y has slightly less work experienced participants than Company X with a percentage of 91.7% compare to 94.7%. However, participants from Company Y has more experience with mobile wireless technology with 100% of participants have more than 1 year experience compare to 86.8% of participants from Company X have more than 1 year experience.

Overall between Company X and Company Y, there were more male participants than female with a ratio of 2.57:1. The majority age group was "between 35 to 59" with 54% percentage. The most common degree earned was high school and equivalent of 42% and the second common education level is "completed some college" with a percentage of 22%. Over 90% of sample population has more than three years of working experience and 82% of sample has more than three years of experience with mobile wireless technology.

### 3.7 Data collection procedure

To study the users' acceptance with mobile wireless technology in warehouse environments, the researcher contacted companies who are currently using mobile wireless technology such as RFID, Bar-code handheld scanners or Personal Digital Assistance (PDA) in their warehouse operation. The company's management levels who were reached out to, for example, included the company president, operation manager or department director to get permission to conduct the surveys within the company. The researcher asked permission to enter the company facility to conduct the surveys face-to-face with their employees, who have direct interaction with mobile wireless technologies, at the break room or conference room. Alternatively, the researcher asked the management level for access to individual employees' email address to distribute the survey in an electronic version. Purdue Qualtrics was used to create the survey and provide printed hard copies for the mailed survey and face-to-face survey. To follow human subject research regulation and to protect participants' human rights, the researcher filed Exempt Research Request through Purdue Institutional Review Board and obtained IRB approval. The information is kept confidential and would not be used for purposes other than research.

Company X: The Company X Operation Manager was contacted and given an explanation of the research purpose. The Operation Manager agreed to allow the researcher to come into the company facilities and scheduled three sessions to survey the participants. The Company X facilities was visited during the designated break time to conduct the survey. Company X has two major warehouse facilities to support the main manufacturing plant. The two warehouses were visited during three different sessions and covered three crews in two shifts. The researcher decided to cover these two warehouses in three different shifts because that would give the research the most time efficient sample collection with the highest amount of potential qualified participants.

Session 1: The first survey session was scheduled on October 17th, 2016 during the first-shift morning meeting at Company X's larger warehouse among the two major warehouses, named Warehouse A. The morning meeting started at 6:30 am. After the supervisor finished his meeting agenda, he left the room and staff to the researcher. The purpose of the research was briefly introduced to the staff, potential concerns were addressed, and volunteer participants were recruited. There were a total 18 employees that qualified and all 18 people participated in the survey. The survey was administrated using paper and pencil. The survey roughly took six to seven minutes to complete, was collected as the participants finished, and was put carefully into a file envelope. The researcher left the Warehouse A facility around 6:55 am. The following sessions followed a similar procedure.

Session 2: The second survey session was on October 21st, 2016 during the first-shift morning meeting at Company X's other major warehouse, Warehouse B. The first-shift morning meeting started at 6:30 am as usual. As the supervisor finished morning meeting and left the room, the research purpose was introduced and volunteer participants were recruited. Of the 31 employees, 12 employees were qualified for participating in the research survey, and all 12 of them agreed to participate. The researcher handed out the paper surveys and pencils and collected finished surveys as participants left. The surveys were then put into a file envelope as the researcher left the facility.

Session 3: The last survey session was scheduled on October 28th, 2016 during the second-shift meeting at Company X largest Warehouse A. The second-shift meeting started at 2:30 pm and volunteer participants were recruited after the supervisor finished the meeting agenda. The crew size was eight and all eight were qualified for and participated in the survey. The same procedure was repeated as the previous two sessions. The finished surveys were collected, and filed in an envelope, and the researcher left Warehouse A at 2:50 pm.

A mix of mail and electronic survey methods were used for Company Y. After receiving a response from the warehouse supervisor at Company Y, the warehouse supervisor suggested conducting a mailed survey method to those warehouse operators and to send electronic survey links to the maintenance crew who have email access. Mailed surveys were sent to a crew of 14 who work at the Company Y's warehouse distribution center. Nine surveys were returned, but one of them was not completed. The response rate for the mailed survey was 64%; the completed survey rate was 57%. The electronic Qualtrics survey link was also sent to the maintenance crew manager who distributed the survey link to six maintenance crews that use IPads in the warehouse area to track inventory. Four of the seven crew members returned completed surveys. The overall completed survey response rate from Company Y was 57%.

## 3.8 Data Analysis

After collecting the survey results, the researcher conducted descriptive statistical analysis on the data to find out what factors have a significant impact on mobile technology user acceptance in warehouse environments using the TAM 2 theory.

Under the TAM 2 theory model, the users' intention to use was the dependent variable that could potentially be determined by the rest of the independent variables including subjective norm, image, job relevance, result demonstrability, perceived ease of use, and perceived usefulness (Venkatesh & Davis, 2000). The regression analysis would be used to test if any of the independent variables or a group of the independent variables could explain users' intention to use mobile wireless technology in a warehouse environment.

In order to generate ab analysis and conclusion from the data, the researcher sought help from Purdue Statistics Department Consulting Services for the statistical data analysis.

### 3.9 Summary

This chapter described the methodology used in this research. It provides detailed information on the overall approach and framework of this research, how many samples were collected, what type of approach was used and how the data was analyzed.

# CHAPTER 4. RESULTS

## 4.1 Result Overview

Regression analysis was selected as the main statistical tool to analyze the survey result because the researcher was interested in finding significant factors that could explain the users' intention to use mobile wireless technology. Regression analysis is a statistical process of analyzing the relationship between several variables. The modified survey from Technology Acceptance Model 2 (TAM 2) contains nine sections of questions which are one dependent variable and eight independent variables (Venkatesh & Davis, 2000). Regression analysis was the perfect tool to study the relationship among those nine variables. One advantage of regression analysis is that it can explain the relationship between variables while test the significance level of each independent variables within a model and how well does one model of independent variables explain the dependent variable. SAS was chosen to process the data because SAS is reliable software which is highly functional in processing regression analysis.

Before the data analysis in SAS was started, basic statistical descriptive analysis of each question was carried out in Qualtrics. Based on the basic statistical descriptive analysis results on section Volunteer shown in Figure 12 and Figure 13, the highest mean for Company X participants in Volunteer section was 1.95 and low was 1.58. The highest mean for Company Y participants in the same section was 2.17. The researcher decided to take this variable out of the regression analysis for model building and use it as a dummy variable instead. The low means of the Volunteer section of the survey indicates that for both Company X and Y, it is mandatory to use mobile wireless technology in their work environment.

| Field | Minimum | Maximum | Mean | Std Deviation | Variance |
|---|---|---|---|---|---|
| My use of the system is voluntary. | 1.00 | 5.00 | 1.95 | 1.36 | 1.84 |
| My supervisor does not require me to use the system. | 1.00 | 5.00 | 1.58 | 1.14 | 1.30 |
| Although it might be helpful, using the system is certainly not compulsory in my job. | 1.00 | 5.00 | 1.84 | 1.27 | 1.61 |

*Figure 12* Company X Participants Answers on Volunteer Section Statistic Result

| Field | Minimum | Maximum | Mean | Std Deviation |
|---|---|---|---|---|
| My use of the system is voluntary. | 1.00 | 4.00 | 2.00 | 1.08 |
| My supervisor does not require me to use the system. | 1.00 | 4.00 | 2.00 | 1.08 |
| Although it might be helpful, using the system is certainly not compulsory in my job. | 1.00 | 4.00 | 2.17 | 1.07 |

*Figure 13* Company Y Participants Answers on Volunteer Section Statistic Result

**4.2 Total Sample Set Analysis**

The survey data were collected from two companies, Company X and Company Y. Even though all the participants from both companies are working in warehouse environment, Company X and Y are in different industries. Company X is in the manufacturing industry while Company Y is in the service industry. Though these two sample sets might have different characteristics and conclusions, the researcher decided to analyze the overall sample set as a whole first.

Before running the regression analysis, a correlation analysis was conducted to determine the interactions between variables. The result is in Figure 14. The researcher ignored the interaction between intentions to use (ITO) with the rest of variables. Intentions to use are the dependent variable that can be explained by independent variables so there is no doubt, intentions to use will have highly correlated interaction with some of the rest variables. As shown in Figure 14, among the rest of the independent variables, perceived usefulness (PU) had significant high-correlated interactions with perceived ease of use (PEU), job relevance (JR), output quality (OQ) and result demonstrability (RD) which is close to the conclusion drawn by Venkatesh and Davis in previous literature review on TAM 2 (2000). However, no firm conclusion should be drawn in this research before regression analysis.

| Pearson Correlation Coefficients, N = 50 Prob > \|r\| under H0: Rho=0 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ITO | PU | PEU | SN | IM | JR | OQ | RD |
| ITO | 1.00000 | 0.85019<br><.0001 | 0.47616<br>0.0005 | 0.47289<br>0.0005 | -0.28543<br>0.0445 | 0.73394<br><.0001 | 0.49326<br>0.0003 | 0.62857<br><.0001 |
| PU | 0.85019<br><.0001 | 1.00000 | 0.59303<br><.0001 | 0.50941<br>0.0002 | -0.24911<br>0.0811 | 0.77776<br><.0001 | 0.62235<br><.0001 | 0.66574<br><.0001 |
| PEU | 0.47616<br>0.0005 | 0.59303<br><.0001 | 1.00000 | 0.46827<br>0.0006 | -0.28703<br>0.0433 | 0.49195<br>0.0003 | 0.60849<br><.0001 | 0.51541<br>0.0001 |
| SN | 0.47289<br>0.0005 | 0.50941<br>0.0002 | 0.46827<br>0.0006 | 1.00000 | -0.32072<br>0.0232 | 0.41630<br>0.0026 | 0.40200<br>0.0038 | 0.38161<br>0.0062 |
| IM | -0.28543<br>0.0445 | -0.24911<br>0.0811 | -0.28703<br>0.0433 | -0.32072<br>0.0232 | 1.00000 | -0.23896<br>0.0947 | -0.14006<br>0.3320 | -0.35337<br>0.0118 |
| JR | 0.73394<br><.0001 | 0.77776<br><.0001 | 0.49195<br>0.0003 | 0.41630<br>0.0026 | -0.23896<br>0.0947 | 1.00000 | 0.58346<br><.0001 | 0.67253<br><.0001 |
| OQ | 0.49326<br>0.0003 | 0.62235<br><.0001 | 0.60849<br><.0001 | 0.40200<br>0.0038 | -0.14006<br>0.3320 | 0.58346<br><.0001 | 1.00000 | 0.56898<br><.0001 |
| RD | 0.62857<br><.0001 | 0.66574<br><.0001 | 0.51541<br>0.0001 | 0.38161<br>0.0062 | -0.35337<br>0.0118 | 0.67253<br><.0001 | 0.56898<br><.0001 | 1.00000 |

*Figure 14* All Variables Correlation Coefficient Table

### 4.2.1 Full Model

Regression analyses on the full model included all seven independent variables. The results are shown below in Figure 15. The adjusted R square was 0.7096 which indicated that over 70% of observation of intention to use mobile wireless technology in this sample set could be explained by this model. In the full model tested, only perceived usefulness was proved to be significant with a P-value less than 0.0001. That being said, only perceived usefulness played an important role in explaining users' intention to use among all the independent variables. One explanation for this result was that perceived usefulness had significant highly-correlated interactions with perceived ease of use, job relevance, output quality and result demonstrability based on previous correlation analysis. Those variables that had high correlations with perceived usefulness were represented by perceived usefulness. Under the TAM 2 extension model, perceived usefulness was the dependent variable that can be explained by perceived ease of use, job relevance, output quality, result demonstrability, subjective norm (SN) and image (IM) (Venkatesh & Davis, 2000). Because of the many highly correlated variables included, the full model was not a good model to represent the dependent variable.

| | | | |
|---|---|---|---|
| Root MSE | 0.40829 | R-Square | 0.7511 |
| Dependent Mean | 4.65000 | Adj R-Sq | 0.7096 |
| Coeff Var | 8.78042 | | |

| Parameter Estimates | | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| | Type I SS | Type II SS |
| Intercept | 1 | 1.36208 | 0.47078 | 2.89 | 0.0060 | 1081.12500 | 1.39544 |
| PU | 1 | 0.62166 | 0.12289 | 5.06 | <.0001 | 20.32922 | 4.26593 |
| PEU | 1 | -0.05162 | 0.09604 | -0.54 | 0.5938 | 0.03408 | 0.04815 |
| SN | 1 | 0.04272 | 0.07356 | 0.58 | 0.5645 | 0.08896 | 0.05623 |
| IM | 1 | -0.03464 | 0.05980 | -0.58 | 0.5655 | 0.15360 | 0.05593 |
| JR | 1 | 0.13817 | 0.10593 | 1.30 | 0.1992 | 0.35533 | 0.28362 |
| OQ | 1 | -0.07509 | 0.09215 | -0.81 | 0.4198 | 0.08042 | 0.11068 |
| RD | 1 | 0.07557 | 0.10776 | 0.70 | 0.4870 | 0.08197 | 0.08197 |

*Figure 15* Full Model Regression Result

### 4.2.2 Stepwise Regression

In order to find a better fit regression model to explain the intention to use and avoid highly correlated variables within one model, the researcher conducted a forward selection stepwise regression which adds one significant variable at a time and the stepwise regression result is in Figure 16 and Figure 17. Only two variables, perceived usefulness and job relevance were chosen in the “best-fit” regression model based on stepwise regression method. The adjusted R square improved from .07096 to 0.725 meaning more observations could be explained by this new model. The new model from stepwise regression can explain up to 72.5% of variance of intention of use. The stepwise model showed, among all the independent variables, perceived usefulness and job relevance played the most significant role in determining the dependent variable intention to use. The combination of these two independent variables could explain the variance of intention to use in the most effective way.

| Variable | Parameter Estimate | Standard Error | Type II SS | F Value | Pr > F |
|---|---|---|---|---|---|
| Intercept | 1.23326 | 0.30465 | 2.58690 | 16.39 | 0.0002 |
| PU | 0.61620 | 0.10387 | 5.55548 | 35.19 | <.0001 |
| JR | 0.14881 | 0.09639 | 0.37626 | 2.38 | 0.1293 |

*Figure 16* Stepwise Regression Model Result

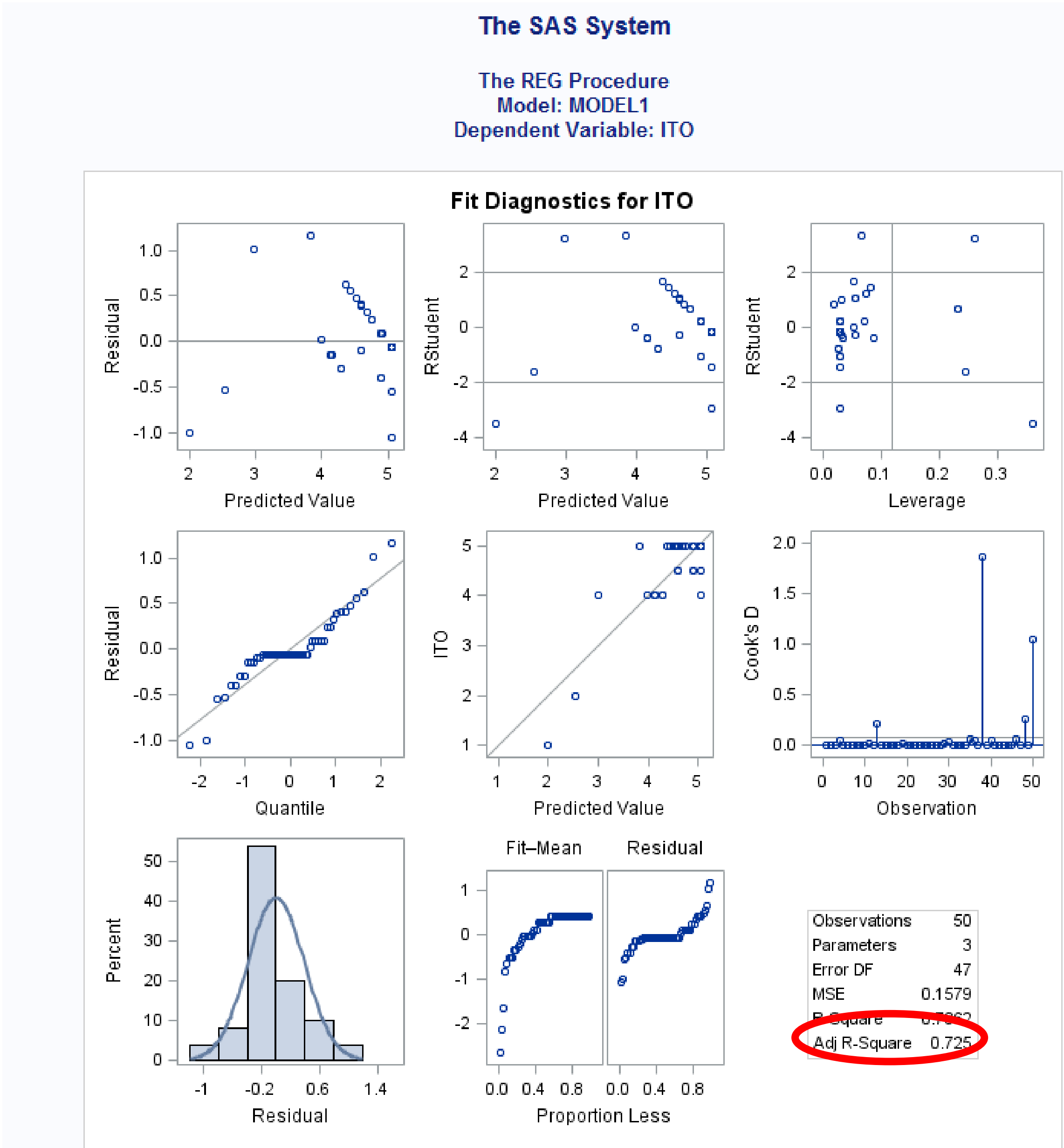



*Figure 17* Stepwise Regression Model Result Adj R-square

To confirm the model selection using a stepwise regression model, the researcher chose to run the model selection again on different criteria. Figure 18 presents the results of the model selection based on Adjusted R square, C(p), aic and bic values. The model that has the highest Adjusted R square and the lowest C(p), aic and bic value will be the best model. Based on those criteria, the model that contains only perceived usefulness and job relevance is the best fit model. This result matched with the stepwise regression result to the model containing only perceived usefulness and job relevance was proved to be best model based on different criteria. This result proved that stepwise regression analysis was correct to find the best fit model for this research sample set and purpose and would be used as the only tool to find the "best-fit" model.

| Number in Model | Adjusted R-Square | R-Square | C(p) | AIC | BIC | Variables in Model |
|---|---|---|---|---|---|---|
| 2 | 0.7250 | 0.7362 | 0.5081 | -89.3954 | -86.6855 | PU JR |
| 3 | 0.7243 | 0.7412 | 1.6663 | -88.3502 | -85.2318 | PU JR OQ |
| 3 | 0.7239 | 0.7408 | 1.7364 | -88.2699 | -85.1652 | PU IM JR |
| 4 | 0.7228 | 0.7454 | 2.9500 | -87.1771 | -83.5896 | PU IM JR OQ |
| 4 | 0.7228 | 0.7454 | 2.9524 | -87.1743 | -83.5874 | PU JR OQ RD |
| 3 | 0.7215 | 0.7385 | 2.1129 | -87.8413 | -84.8093 | PU JR RD |
| 4 | 0.7210 | 0.7438 | 3.2288 | -86.8536 | -83.3363 | PU SN JR OQ |
| 4 | 0.7210 | 0.7437 | 3.2338 | -86.8478 | -83.3318 | PU PEU IM JR |
| 3 | 0.7209 | 0.7380 | 2.2108 | -87.7305 | -84.7173 | PU SN JR |
| 3 | 0.7209 | 0.7380 | 2.2118 | -87.7294 | -84.7163 | PU PEU JR |
| 5 | 0.7192 | 0.7479 | 4.5344 | -85.6633 | -81.6187 | PU IM JR OQ RD |

*Figure 18* Regression Model Selection on Different Criteria

### 4.2.3 Technology Acceptance Model 2 Evaluation

The researcher examined the theoretical TAM 2 basic model; explained intention to use through perceived usefulness, perceived ease of use and subjective norm (Venkatesh & Davis, 2000) as shown in Figure 19.

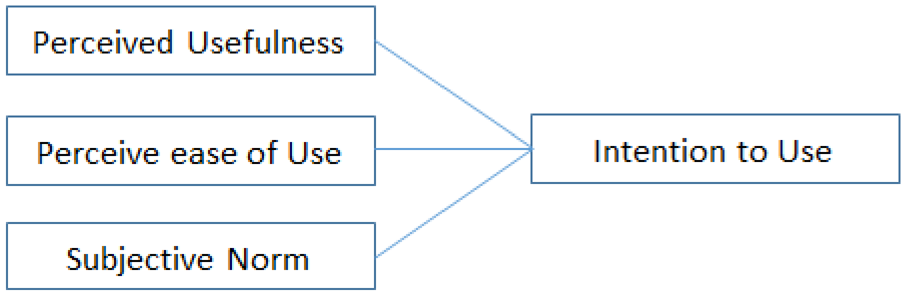



*Figure 19* TAM 2 Basic Model Relationship Chart (Venkatesh & Davis 2000)

The result is presented in Figure 20. This model had a high Adjusted R square of 0.7094 that means the perceived usefulness, perceived ease of use and subject norm in basics TAM 2 model could explain almost 71% of the observations of intent to use under this sample set. The high Adjusted R square meant that the basic TAM 2 model fit very well in the full data set (Venkatesh & Davis, 2000). The result showed that only perceived usefulness had a significant influence on deciding users' intent to use with a high positive parameter estimate. The positive parameter estimate meant there was a positive relationship between perceived usefulness and the dependent variable intention to use. A positive perceived usefulness would enhance users' intention to use. The reverse would also be true. The result showed only perceived usefulness was significant maybe due to the fact that perceived usefulness was highly correlated with perceived ease of use and subjective norm, but more samples should be collected to draw an accurate conclusion on this prediction.

| | | | |
|---|---|---|---|
| Root MSE | 0.40841 | R-Square | 0.7272 |
| Dependent Mean | 4.65000 | Adj R-Sq | 0.7094 |
| Coeff Var | 8.78301 | | |

| Parameter Estimates | | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| | Type I SS | Type II SS |
| Intercept | 1 | 1.33593 | 0.34486 | 3.87 | 0.0003 | 1081.12500 | 2.50307 |
| PU | 1 | 0.74230 | 0.08816 | 8.42 | <.0001 | 20.32922 | 11.82549 |
| PEU | 1 | -0.05405 | 0.08803 | -0.61 | 0.5422 | 0.03408 | 0.06288 |
| SN | 1 | 0.05251 | 0.07191 | 0.73 | 0.4689 | 0.08896 | 0.08896 |

*Figure 20* TAM 2 Basic Model Regression Result

The TAM 2 extension model explained dependent variable perceived usefulness through perceived ease of use, subjective norm, image, job relevance, output quality and result demonstrability (Venkatesh & Davis, 2000) as shown in Figure 21.

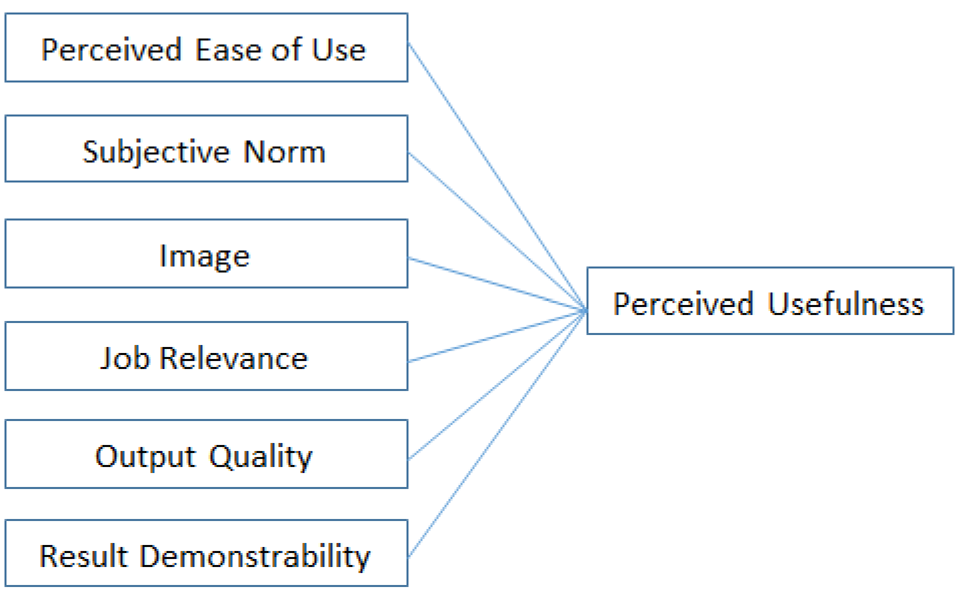



*Figure 21* TAM 2 Extension Model Relationship Chart (Venkatesh & Davis 2000)

As seen in the Figure 22, this model had a relatively high Adjusted R square value of 0.6603 meaning over 66% of variance of perceived usefulness can be explained by this model. Job relevance was the only factor that had significant positive impacts in determining perceived usefulness at a significant level of 0.15. Based on the result from the TAM 2 extension model analysis, in order to improve the perceived usefulness, companies should work on strengthening the job relevance link between mobile wireless system and daily jobs.

| | | | |
|---|---|---|---|
| Root MSE | 0.50666 | R-Square | 0.7019 |
| Dependent Mean | 4.47500 | Adj R-Sq | 0.6603 |
| Coeff Var | 11.32204 | | |

| Parameter Estimates | | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| | Type I SS | Type II SS |
| Intercept | 1 | 0.14999 | 0.58376 | 0.26 | 0.7984 | 1001.28125 | 0.01695 |
| SN | 1 | 0.12884 | 0.08914 | 1.45 | 0.1556 | 9.60960 | 0.53629 |
| IM | 1 | 0.02087 | 0.07414 | 0.28 | 0.7797 | 0.30336 | 0.02034 |
| JR | 1 | 0.44749 | 0.11235 | 3.98 | 0.0003 | 14.03870 | 4.07218 |
| OQ | 1 | 0.10002 | 0.11333 | 0.88 | 0.3824 | 1.05228 | 0.19992 |
| RD | 1 | 0.16826 | 0.13124 | 1.28 | 0.2067 | 0.54304 | 0.42196 |
| PEU | 1 | 0.15400 | 0.11684 | 1.32 | 0.1945 | 0.44592 | 0.44592 |

*Figure 22* TAM 2 Perceived Usefulness Explanation Regression Result

### 4.2.4 Hypothesis Tests

Before conducting the survey, three main hypotheses were developed. The first hypothesis was that the functionality of a mobile wireless technology system should be able to explain users' intention to use. The relationship is shown in Figure 23 below.

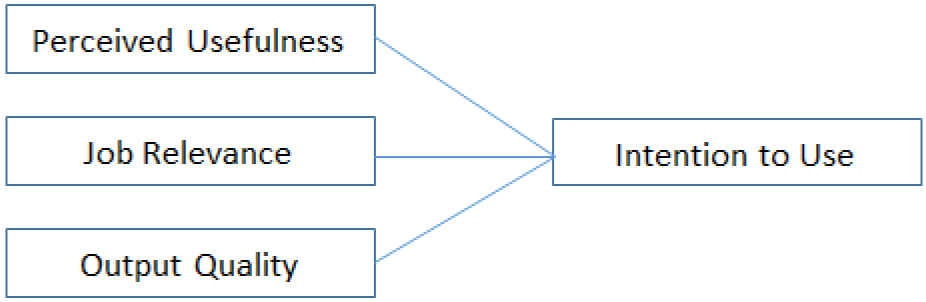



*Figure 23* Hypothesis 1 Functionality Explain Intention to Use

The researcher grouped perceived usefulness, job relevance and output quality into the functionality as independent variables and tested the functionality model in regression analysis. The result is exhibited below in Figure 24. This model had an excellent Adjusted R square value of 0.7243 which means the model of perceived usefulness, job relevance and output quality can explain over 72% observation of intention to use. This model had a higher Adjusted R square value than the basic TAM 2 model, which means this model could explain more intention to use than the basic TAM 2 model (Venkatesh & Davis, 2000). Under this hypothetical model, both perceived usefulness and job relevance were proved to be significantly important in determining intent to use and had a positive relationship with the dependent variable. Positive perceived usefulness and job relevance values would boost users' intention to use. This result matched with the stepwise regression analysis from earlier.

| | | | |
|---|---|---|---|
| Root MSE | 0.39780 | R-Square | 0.7412 |
| Dependent Mean | 4.65000 | Adj R-Sq | 0.7243 |
| Coeff Var | 8.55480 | | |

| Parameter Estimates | | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| | Type I SS | Type II SS |
| Intercept | 1 | 1.30214 | 0.31367 | 4.15 | 0.0001 | 1081.12500 | 2.72711 |
| PU | 1 | 0.65046 | 0.11018 | 5.90 | <.0001 | 20.32922 | 5.51547 |
| JR | 1 | 0.16756 | 0.09854 | 1.70 | 0.0958 | 0.37626 | 0.45758 |
| OQ | 1 | -0.07632 | 0.08104 | -0.94 | 0.3513 | 0.14033 | 0.14033 |

*Figure 24* H1: Functionality Explain Intention to Use Result

The second hypothesis was the ease of use and understanding from the user perspective can explain users' intention to use.

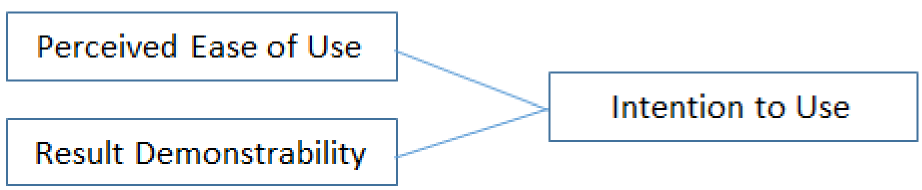



*Figure 25* Hypothesis 2 Perceived Ease of Use and Understand Explain Intention to Use

The regression result is demonstrated in the figure below. The ease of use model that contains perceived ease of use and result demonstrability, could explain 40% of the observation. Both independent variables, perceived ease of use and result demonstrability, were found to be significant and important in explaining intention to use with a positive enhancement effect at significance level of 0.15 in this model. However, perceived ease of use had a less significant impact on the dependent variable than result demonstrability. One potential explanation is the variance of perceived ease of use was not significant enough among the two participating companies. According to the management levels, both companies provided adequate training with mobile wireless technology and ensured the employees have access to technical help if needed. Also, 82% of the overall sample population had more than three years' experience working with mobile wireless technology. They were familiar with the technology and very experienced.

| | | | |
|---|---|---|---|
| Root MSE | 0.58575 | R-Square | 0.4266 |
| Dependent Mean | 4.65000 | Adj R-Sq | 0.4022 |
| Coeff Var | 12.59678 | | |

| Parameter Estimates | | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| | Type I SS | Type II SS |
| Intercept | 1 | 1.83711 | 0.49243 | 3.73 | 0.0005 | 1081.12500 | 4.77542 |
| PEU | 1 | 0.18518 | 0.11517 | 1.61 | 0.1146 | 6.37664 | 0.88705 |
| RD | 1 | 0.48292 | 0.11930 | 4.05 | 0.0002 | 5.62250 | 5.62250 |

*Figure 26* H2: Ease of Use and Understand Explain Intention to Use Result

The last hypothesis was that if management support or leadership style would explain users' intention to use mobile wireless technology at warehouse working environment as their relationship shown below.

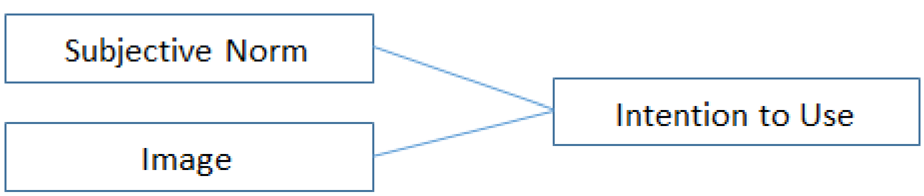



*Figure 27* Hypothesis 3 Management Support/Leadership Style Explain Intention to Use

This model consists of variables subjective norm and image and would only count for 21% of explanation to users' intention to use. Even if the subjective norm showed significant, this hypothesis can barely hold true due to the low value of the Adjusted R square. The reason this model failed to explain users' intention to use may be because both companies showed great interest in the successful implementation of their mobile wireless technology systems and offered encouragement and support to their employees. The variance of this model was not significant enough.

| | | | |
|---|---|---|---|
| Root MSE | 0.67279 | R-Square | 0.2436 |
| Dependent Mean | 4.65000 | Adj R-Sq | 0.2114 |
| Coeff Var | 14.46867 | | |

| Parameter Estimates | | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| | Type I SS | Type II SS |
| Intercept | 1 | 3.52935 | 0.56285 | 6.27 | <.0001 | 1081.12500 | 17.79774 |
| SN | 1 | 0.33159 | 0.10448 | 3.17 | 0.0027 | 6.28954 | 4.55914 |
| IM | 1 | -0.10378 | 0.09323 | -1.11 | 0.2713 | 0.56089 | 0.56089 |

*Figure 28* H3: Management Support and Leadership Style Explain Intention to Use Result

### 4.3 Company X Sample Set Analysis

Company X is a manufacturing company which has two major warehouse locations within Lafayette and West Lafayette area. Thirty-eight total sample responses were collected from Company X. The researcher decided to repeat the same analysis on Company X's responses to compare the difference between overall sample set and Company X's sample.

### 4.3.1 Full Model

Regression analysis was started with the full model that uses all independent variables: perceived usefulness, perceived ease of use, job relevance, output quality, result demonstrability, subjective norm and image, to explain dependent variable intention to use. The result appears in the figure below. Compare to the same full model regression ran on the overall sample set, the full model of Company X's sample set had higher Adjusted R square (0.7673). The model could explain up to 76% of intention to use in Company X. Except for perceived usefulness; the subjective norm was also tested to be significant and had a positive influence on users' intention to use in Company X.

| | | | |
|---|---|---|---|
| Root MSE | 0.33992 | R-Square | 0.8113 |
| Dependent Mean | 4.73684 | Adj R-Sq | 0.7673 |
| Coeff Var | 7.17604 | | |

| Parameter Estimates | | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| | Type I SS | Type II SS |
| Intercept | 1 | 0.80804 | 0.53096 | 1.52 | 0.1385 | 852.63158 | 0.26760 |
| PU | 1 | 0.76501 | 0.13316 | 5.74 | <.0001 | 13.65837 | 3.81339 |
| PEU | 1 | -0.07386 | 0.09989 | -0.74 | 0.4654 | 0.00134 | 0.06318 |
| SN | 1 | 0.27667 | 0.10021 | 2.76 | 0.0097 | 1.02766 | 0.88075 |
| IM | 1 | 0.00324 | 0.06185 | 0.05 | 0.9585 | 0.00714 | 0.00031795 |
| JR | 1 | -0.07781 | 0.11857 | -0.66 | 0.5167 | 0.05381 | 0.04976 |
| OQ | 1 | -0.10693 | 0.09529 | -1.12 | 0.2707 | 0.12368 | 0.14550 |
| RD | 1 | 0.06664 | 0.13055 | 0.51 | 0.6135 | 0.03011 | 0.03011 |

*Figure 29* Full Model Regression Result on Company X's Data

### 4.3.2. Stepwise Regression

The researcher continued with stepwise regression analysis to find a better fit model. The stepwise regression presented a “best-fit” model of independent variables perceived usefulness, subjective norm and output quality and a very high Adjusted R square value of 0.7874, which was very different compared to the stepwise regression result on the full sample set. The stepwise regression analysis on the full sample set presented the best fit model with perceived usefulness and job relevance, and Adjusted R square value as 0.725. Stepwise analysis presents the best model to explain a certain data set. The different results of stepwise analysis model on the full data set and Company X’s data set occurred because they were still two different data sets, even though the full data set contained Company X’s data, Company Y’s data would still impact the result on full data set analysis. It highlights the importance of separating the data set by certain categories to gain more insights for each category. In this research, the category was industry segment. This stepwise regression result meant, for Company X, that the influence of perceived usefulness, perceived ease of use and subject norm were the most representative variables in determining the users’ intention to use. This group of variables could explain 78.7% of observations of users’ intention to use.

| Variable | Parameter Estimate | Standard Error | Type II SS | F Value | Pr > F |
|---|---|---|---|---|---|
| Intercept | 0.82179 | 0.36570 | 0.53289 | 5.05 | 0.0312 |
| PU | 0.73852 | 0.09302 | 6.65142 | 63.03 | <.0001 |
| SN | 0.24169 | 0.07724 | 1.03323 | 9.79 | 0.0036 |
| OQ | -0.13319 | 0.07913 | 0.29899 | 2.83 | 0.1015 |

*Figure 30* Stepwise Regression Result on Company X’s Data

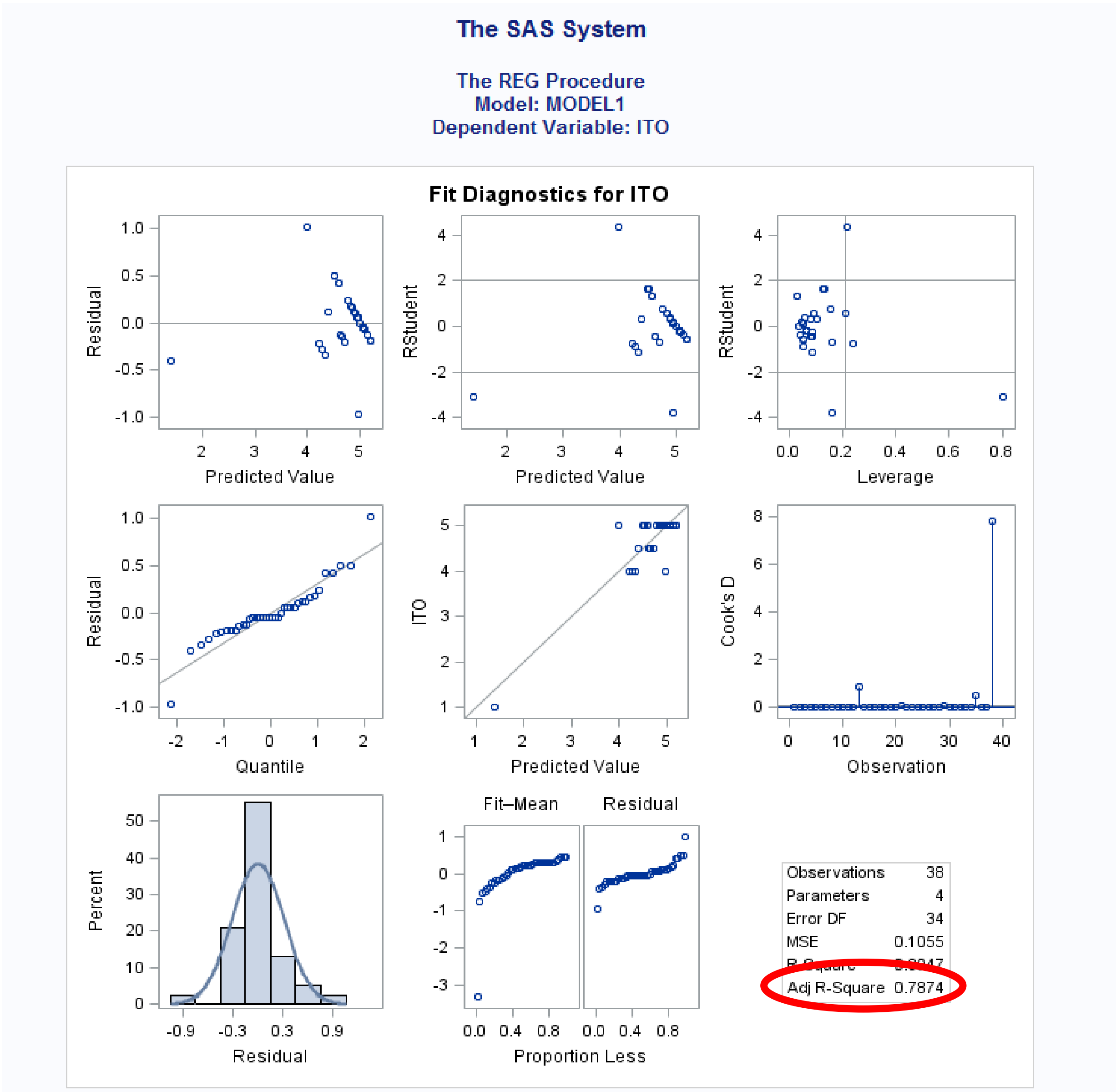



*Figure 31* Stepwise Regression Adj R-Square on Company X's Data

### 4.3.3. Technology Acceptance Model 2 Evaluation

Similar differences found in the full model regression analysis from earlier were also found in the TAM 2 basic model (Venkatesh & Davis, 2000) regression analysis. The regression test of the TAM 2 basic model on Company X's data presented higher

Adjusted R square of 0.7819, which means the TAM 2 basic model could explain up to 78.2% of variance of intention to use in Company X. That means the TAM 2 model could explain Company X data better than it can explain the full data set. Both perceived usefulness and subjective norm were tested to have significant positive effects on determining intention to use. The insignificance of perceived ease of use may be due to the fact that Company X provided adequate training and a dedicated trainer on mobile wireless technology and, based on the demographic information, more than 74% of participants from Company X had more than 3 years of experience working with mobile wireless technology so they were very skilled and experienced in using this technology.

| | | | |
|---|---|---|---|
| Root MSE | 0.32904 | R-Square | 0.7996 |
| Dependent Mean | 4.73684 | Adj R-Sq | 0.7819 |
| Coeff Var | 6.94637 | | |

| Parameter Estimates | | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| | Type I SS | Type II SS |
| Intercept | 1 | 0.74992 | 0.36321 | 2.06 | 0.0466 | 852.63158 | 0.46155 |
| PU | 1 | 0.72915 | 0.09410 | 7.75 | <.0001 | 13.65837 | 6.50050 |
| PEU | 1 | -0.11850 | 0.08593 | -1.38 | 0.1769 | 0.00134 | 0.20591 |
| SN | 1 | 0.25618 | 0.08315 | 3.08 | 0.0041 | 1.02766 | 1.02766 |

*Figure 32* TAM 2 Basic Model Regression Result on Company X's Data

The regression analysis of TAM 2 extension model of explaining perceived usefulness (Venkatesh & Davis, 2000) showed different result on Company X's data. Based on the result in Figure 33, the TAM 2 extension model's perceived usefulness explanation in Company X's data, had an Adjusted R square of 0.6129 with independent variables job relevance, result demonstrability and perceived ease of use shown significant. The TAM 2 extension model analysis explained that, to users in Company X, only job relevance, result demonstrability and perceived ease of use were important to their perceived usefulness. To improve the perceived usefulness of their mobile wireless technology, Company X's management level should start working on emphasizing or strengthening the link of the job relevance to the mobile wireless technology with their employees, as well as improve the system's result demonstrability to their employees. Additionally, train employees to know how to operate the system, and more importantly understand the system's output.

| | | | |
|---|---|---|---|
| Root MSE | 0.45847 | R-Square | 0.6757 |
| Dependent Mean | 4.63158 | Adj R-Sq | 0.6129 |
| Coeff Var | 9.89868 | | |

| Parameter Estimates | | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| | Type I SS | Type II SS |
| Intercept | 1 | 1.17790 | 0.68418 | 1.72 | 0.0951 | 815.15789 | 0.62301 |
| SN | 1 | -0.02125 | 0.13510 | -0.16 | 0.8761 | 6.37971 | 0.00520 |
| IM | 1 | -0.04878 | 0.08296 | -0.59 | 0.5608 | 0.27902 | 0.07268 |
| JR | 1 | 0.32864 | 0.14864 | 2.21 | 0.0345 | 5.27302 | 1.02752 |
| OQ | 1 | -0.00832 | 0.12852 | -0.06 | 0.9488 | 0.34510 | 0.00087992 |
| RD | 1 | 0.30760 | 0.16718 | 1.84 | 0.0754 | 0.73190 | 0.71152 |
| PEU | 1 | 0.21231 | 0.12921 | 1.64 | 0.1105 | 0.56747 | 0.56747 |

*Figure 33* TAM2 Perceived Usefulness Explanation Regression Result on Company X's Data

### 4.3.4 Hypothesis Test

The first hypothesis tested the influence of functionality on intention to use through independent variables perceived usefulness, job relevance and output quality.

The Adjusted R square did not have an obvious difference than the result generated from the full sample set. Under the functionality model, only perceived usefulness was a significant factor with a positive impact on the dependent variable. This result suggested that, from a functionality perspective of the mobile wireless technology, the perceived usefulness is more important to users in Company X. One flaw of this model is that this model contained highly-correlated variables. Job relevance was proven important in explaining perceived usefulness and highly-correlated to perceived usefulness, the importance of job relevance in this model was covered by the perceived usefulness.

| | | | |
|---|---|---|---|
| Root MSE | 0.36734 | R-Square | 0.7502 |
| Dependent Mean | 4.73684 | Adj R-Sq | 0.7282 |
| Coeff Var | 7.75487 | | |

| Parameter Estimates | | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| | Type I SS | Type II SS |
| Intercept | 1 | 1.01643 | 0.40737 | 2.50 | 0.0176 | 852.63158 | 0.84005 |
| PU | 1 | 0.82150 | 0.12708 | 6.46 | <.0001 | 13.65837 | 5.63917 |
| JR | 1 | 0.05346 | 0.10748 | 0.50 | 0.6221 | 0.01323 | 0.03339 |
| OQ | 1 | -0.07960 | 0.08856 | -0.90 | 0.3751 | 0.10901 | 0.10901 |

*Figure 34* H1: Functionality Explain Intention to Use Result on Company X’s Data

The second hypothesis was to check how significant easiness to use and understand from the users’ perspective, in explaining users’ intention to use which result was presented in the Figure 35 below. The researcher performed regression analysis on this model with only Company X’s data. The only major difference was that the hypothesis 2 model had a higher Adjusted R square value on Company X’s data than on the full sample data set, meaning this model can explain Company X’s data better than it can explain the full data set. Both perceived ease of use and result demonstrability were significant in determining users' intent to use. The result demonstrability showed stronger positive influence on the dependent variable than perceived ease of use in this model. This result matched with the TAM 2 extension model (Venkatesh & Davis, 2000) test result, which also highlighted the importance of result demonstrability. Majority of participants from Company X had longer than three years working experience with mobile wireless technology. Here the researcher believes that, the effect of perceived ease of use wore off with employees' experience using mobile wireless technology. To confirm this, more samples should be collected and evidence found in other studies or literature review.

| | | | |
|---|---|---|---|
| Root MSE | 0.51494 | R-Square | 0.4947 |
| Dependent Mean | 4.73684 | Adj R-Sq | 0.4659 |
| Coeff Var | 10.87103 | | |

| Parameter Estimates | | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| | Type I SS | Type II SS |
| Intercept | 1 | 1.71516 | 0.53390 | 3.21 | 0.0028 | 852.63158 | 2.73660 |
| PEU | 1 | 0.18470 | 0.11315 | 1.63 | 0.1116 | 4.08001 | 0.70652 |
| RD | 1 | 0.52267 | 0.12028 | 4.35 | 0.0001 | 5.00757 | 5.00757 |

*Figure 35* H2: Ease of Use and Understanding Explain Intention to Use Result on Company X's Data

The last hypothesis aimed at testing the significance of management support or leadership style in explaining users' intention to use through the independent variables of subjective norm and image. This model achieved tremendously higher Adjusted R square using only Company X's data compared to the result from the full sample set. The Adjusted R square jumped from 0.211 to 0.420, meaning to Company X, the influence of management support or the leadership system is more significant. In this model, subjective norm had a significant positive determination on users' intention to use in Company X. It suggested that if Company X decided to work on enhancing the users' intention to use on their mobile wireless technology from a management perspective, it should start with working on providing more verbal encouragement and support for their employees.

| | | | |
|---|---|---|---|
| Root MSE | 0.53683 | R-Square | 0.4509 |
| Dependent Mean | 4.73684 | Adj R-Sq | 0.4195 |
| Coeff Var | 11.33302 | | |

| Parameter Estimates | | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| | Type I SS | Type II SS |
| Intercept | 1 | 2.88061 | 0.66331 | 4.34 | 0.0001 | 852.63158 | 5.43510 |
| SN | 1 | 0.48247 | 0.11744 | 4.11 | 0.0002 | 8.02025 | 4.86351 |
| IM | 1 | -0.08588 | 0.09012 | -0.95 | 0.3471 | 0.26174 | 0.26174 |

*Figure 36* H3: Management Support or Leadership Style Explain Intention to Use Result on Company X's Data

## 4.4 Company Y Sample Set Analysis

After performing the analysis on Company X's data only, the researcher continued to repeat the same analysis on Company Y's data alone and compared the results with the results from Company X's data as well as results from full data set. Company Y is in the service industry and currently is using handheld bar-code scanners at a central warehouse and recently adopted the Ipad as a mobile wireless PDA for the maintenance crew in the maintenance area to track inventory.

**4.4.1 Full Model**

A full model regression testing was performed as usual on only Company Y's data. The result showed an excellent score of Adjusted R square of 0.820 on Y's data alone meaning this model could explain users' intention to use for Company Y very well, but it may only be because this model included all independent variables. This Adjusted R square value was higher than the values from the full data set or Company X's data only. The analysis results on Company Y's data showed perceived usefulness, perceived ease of use, job relevance and result demonstrability were shown as significant, if 0.15 was chosen as the significance level. This model contained too many correlated variables so even if this model had a high Adjusted R square, this model was not representative. Further analysis should be carried out. Even participants in Company Y who were experienced in mobile wireless technology (83% of the sample population had more than three years working experience with mobile wireless technology), they were still in the phase of training to understand the new system. That's why perceived ease of use was a significant factor here.

| Root MSE | 0.37415 | R-Square | 0.9346 |
|---|---|---|---|
| Dependent Mean | 4.37500 | Adj R-Sq | 0.8202 |
| Coeff Var | 8.55192 | | |

| Parameter Estimates | | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| | Type I SS | Type II SS |
| Intercept | 1 | 0.51774 | 1.12624 | 0.46 | 0.6696 | 229.68750 | 0.02958 |
| PU | 1 | 0.64155 | 0.28451 | 2.25 | 0.0872 | 5.82177 | 0.71182 |
| PEU | 1 | -0.82068 | 0.36438 | -2.25 | 0.0874 | 0.35457 | 0.71011 |
| SN | 1 | 0.12758 | 0.14491 | 0.88 | 0.4283 | 0.46741 | 0.10852 |
| IM | 1 | 0.07338 | 0.18432 | 0.40 | 0.7109 | 0.03249 | 0.02218 |
| JR | 1 | 0.59157 | 0.23653 | 2.50 | 0.0667 | 0.56897 | 0.87564 |
| OQ | 1 | -0.19596 | 0.17928 | -1.09 | 0.3358 | 0.00488 | 0.16724 |
| RD | 1 | 0.61688 | 0.26607 | 2.32 | 0.0813 | 0.75246 | 0.75246 |

*Figure 37* Full Model Regression Result on Company Y's Data

### 4.4.2 Stepwise Regression

The researcher continued with a stepwise analysis to search for a better explanatory model. The stepwise regression model turned out very differently from the full sample data and Company X's data. The "best-fit" model of explaining intention to use from Company Y's data was through the variables of job relevance, perceived usefulness and image. The Adjusted R square value dropped to 0.776 from the previous full model, because less independent variables were included. Under the stepwise model, job relevance was more significant than perceived usefulness. This is a very interesting finding. One explanation for this result was that Company Y recently adopted a new mobile wireless system and was at the early stage of adoption, it is very important to link the system with employee's job function for early stage adoption. It is also important to set up an organization's social system or cultural influence to encourage the use of the new system.

| Variable | Parameter Estimate | Standard Error | Type II SS | F Value | Pr > F |
|---|---|---|---|---|---|
| Intercept | 0.43318 | 0.72644 | 0.06197 | 0.36 | 0.5675 |
| PU | 0.35233 | 0.19101 | 0.59301 | 3.40 | 0.1023 |
| IM | 0.27554 | 0.15920 | 0.52210 | 3.00 | 0.1217 |
| JR | 0.48828 | 0.19721 | 1.06844 | 6.13 | 0.0384 |

*Figure 38* Stepwise Regression Result on Company Y's Data

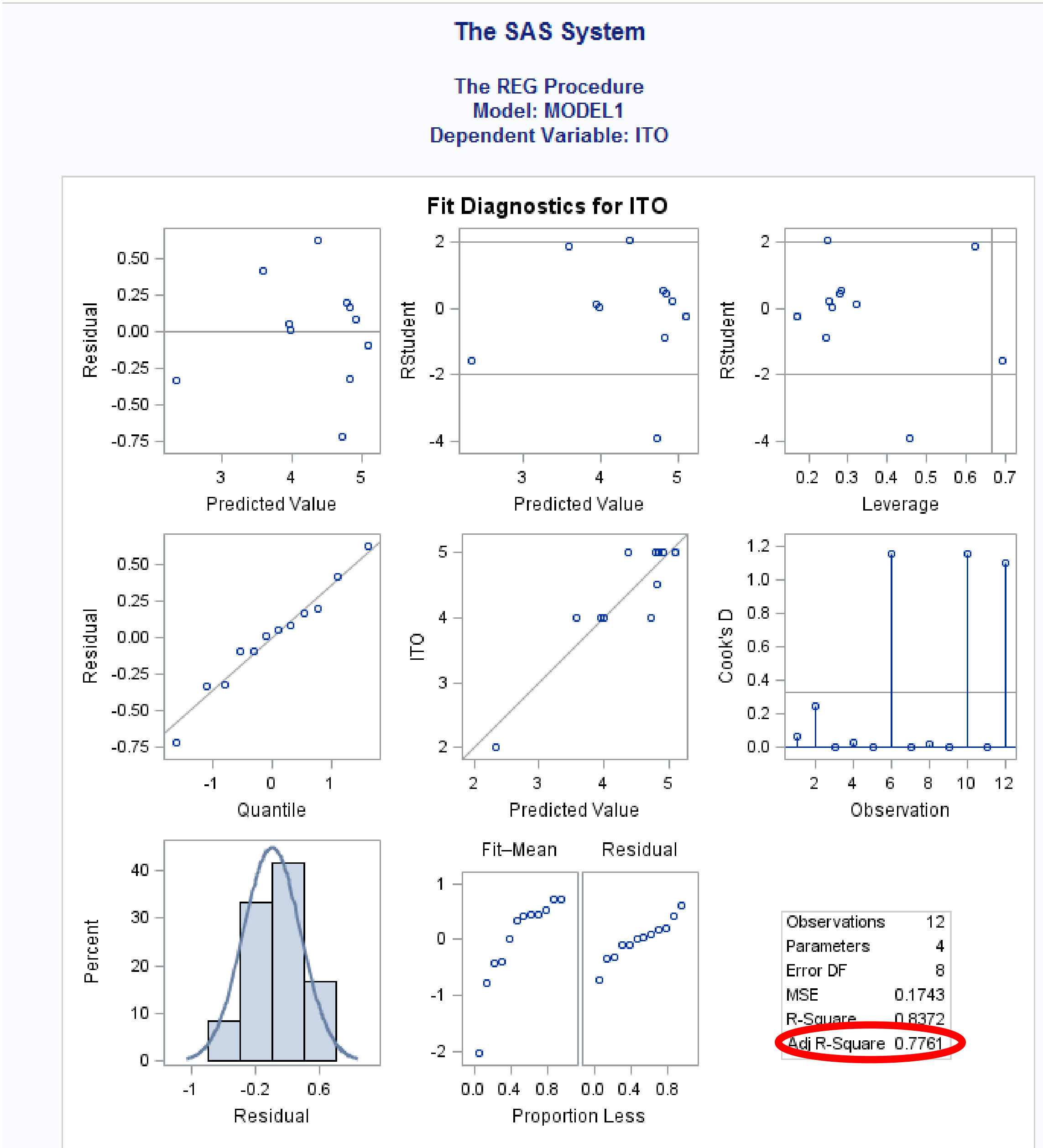



*Figure 39* Stepwise Regression Adj R-Square on Company Y's Data

### 4.4.3 Technology Acceptance Model 2 Evaluation

The researcher evaluated the TAM 2 models on Company Y's data alone. Figure 40 presents the analysis result of the basic TAM 2 model. The basic TAM 2 model used perceived usefulness, perceived ease of use and subjective norm to explain the intention to use (Venkatesh & Davis, 2000). The Adjusted R square generated from Company Y only data was slightly below the Adjusted R square values for the same model from the full sample data and Company X's data. The only significant factor was perceived usefulness. The estimated parameter of perceived usefulness was 0.9237. This large positive parameter value represents a strong positive relationship between perceived usefulness and users' intention to use. For Company Y, employees' intentions to use the new mobile wireless technology were heavily dependent on the perceived usefulness of this system. Company Y should work on enhancing the perceived usefulness to promote the acceptance of the new mobile wireless system.

| | | | |
|---|---|---|---|
| Root MSE | 0.48974 | R-Square | 0.7759 |
| Dependent Mean | 4.37500 | Adj R-Sq | 0.6919 |
| Coeff Var | 11.19401 | | |

| Parameter Estimates | | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| | Type I SS | Type II SS |
| Intercept | 1 | 2.61766 | 0.74433 | 3.52 | 0.0079 | 229.68750 | 2.96631 |
| PU | 1 | 0.92376 | 0.22312 | 4.14 | 0.0033 | 5.82177 | 4.11131 |
| PEU | 1 | -0.29497 | 0.25737 | -1.15 | 0.2849 | 0.35457 | 0.31503 |
| SN | 1 | -0.18635 | 0.13349 | -1.40 | 0.2002 | 0.46741 | 0.46741 |

*Figure 40* TAM2 Basic Model Regression Result on Company Y's Data

The next test was to evaluate the TAM 2 extension model, explains perceived usefulness model on Company Y's data (Venkatesh & Davis, 2000). Figure 41 shows the result. Among all independent variables in explaining perceived usefulness, no factors stood out as. The only one close to significant was job relevance which had P-value of

0.18. One potential explanation to this result was that Company Y's participants were still in the learning process of the newly adopted mobile wireless technology system. They had not formed clear ideas of "usefulness" of the new system. Maybe for Company Y, finding the job relevance at an early stage of a new mobile wireless technology adoption was critical.

| | | | |
|---|---|---|---|
| Root MSE | 0.58812 | R-Square | 0.8676 |
| Dependent Mean | 3.97917 | Adj R-Sq | 0.7086 |
| Coeff Var | 14.77996 | | |

| Parameter Estimates | | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| | Type I SS | Type II SS |
| Intercept | 1 | -1.77847 | 1.58161 | -1.12 | 0.3119 | 190.00521 | 0.43735 |
| SN | 1 | 0.16700 | 0.21518 | 0.78 | 0.4728 | 1.04593 | 0.20833 |
| IM | 1 | 0.28882 | 0.25936 | 1.11 | 0.3161 | 0.93239 | 0.42893 |
| JR | 1 | 0.47357 | 0.30558 | 1.55 | 0.1819 | 8.06290 | 0.83068 |
| OQ | 1 | 0.18511 | 0.26938 | 0.69 | 0.5225 | 0.34941 | 0.16333 |
| RD | 1 | -0.23067 | 0.40531 | -0.57 | 0.5939 | 0.23665 | 0.11203 |
| PEU | 1 | 0.68768 | 0.48320 | 1.42 | 0.2140 | 0.70058 | 0.70058 |

*Figure 41* TAM2 Perceived Usefulness Explanation Regression Result on Company Y's Data

### 4.4.4 Hypothesis Test

The first hypothesis of the functionality model tested on Company Y's data alone generated a slightly lower Adjusted R square value of 0.693 than the results generated earlier from full sample data and Company X's data. However, this model still could explain nearly 70% of users' intention to use in Company Y's data set. In this model, job relevance stood out again as significant. The overlapped finding confirmed the expectation from earlier that, to Company Y job relevance was the most important in determining users' intention to use. The missing link between job relevance and the new mobile wireless technology system may be the users' adoption barrier.

| | | | |
|---|---|---|---|
| Root MSE | 0.48923 | R-Square | 0.7764 |
| Dependent Mean | 4.37500 | Adj R-Sq | 0.6925 |
| Coeff Var | 11.18246 | | |

| Parameter Estimates | | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| | Type I SS | Type II SS |
| Intercept | 1 | 1.33817 | 0.59696 | 2.24 | 0.0553 | 229.68750 | 1.20272 |
| PU | 1 | 0.34663 | 0.24989 | 1.39 | 0.2028 | 5.82177 | 0.46054 |
| JR | 1 | 0.42442 | 0.23197 | 1.83 | 0.1047 | 0.82432 | 0.80122 |
| OQ | 1 | -0.01595 | 0.19414 | -0.08 | 0.9365 | 0.00162 | 0.00162 |

*Figure 42* H1: Functionality Explain Intention to Use on Company Y's Data

The second hypothesis model uses ease of use and understanding for users to explain users' intention to use. This model on Company Y's data generated a weak result. The Adjusted R square turned out only to be 0.134 with no obvious significant factor in this hypothesis model. This result suggested that this model of perceived ease of use and result demonstrability cannot determine users' intention to use in Company Y. This finding may result from the fact that, Company Y just adopted a new mobile wireless system and they were still in the phase of employee training to know how to operate this new system. Even though participants from Company Y were experienced in working with mobile wireless technology and over 64% of them had higher education, it would still take time for them to get familiar with a newly adopted system.

| Root MSE | 0.82110 | R-Square | 0.2913 |
| --- | --- | --- | --- |
| Dependent Mean | 4.37500 | Adj R-Sq | 0.1339 |
| Coeff Var | 18.76805 | | |

| Parameter Estimates | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Variable | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| | Type I SS | Type II SS |
| Intercept | 1 | 2.13894 | 1.19212 | 1.79 | 0.1064 | 229.68750 | 2.17047 |
| PEU | 1 | 0.36748 | 0.40017 | 0.92 | 0.3824 | 2.37125 | 0.56856 |
| RD | 1 | 0.17615 | 0.41179 | 0.43 | 0.6789 | 0.12337 | 0.12337 |

*Figure 43* H2: Ease of Use and Understand Explain Intention to Use on Company Y's Data

The last hypothesis tested the significance of subjective and image on explaining the importance of management support and leadership style in determining users' intention to use. This hypothesis model test showed weaker confidence in Company Y's data. The Adjusted R square value was negative meaning this model cannot explain users' intention to use. Company Y just adopted a new system; it was very likely that the management had not established a clear expectation or organizational structure on the use of this new mobile wireless technology.

| | | | |
|---|---|---|---|
| Root MSE | 0.97120 | R-Square | 0.0086 |
| Dependent Mean | 4.37500 | Adj R-Sq | -0.2117 |
| Coeff Var | 22.19886 | | |

| Parameter Estimates | | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | DF | Parameter Estimate | Standard Error | t Value | Pr > \|t\| | Type I SS | Type II SS |
| Intercept | 1 | 4.62795 | 1.32857 | 3.48 | 0.0069 | 229.68750 | 11.44528 |
| SN | 1 | -0.01409 | 0.25858 | -0.05 | 0.9577 | 0 | 0.00280 |
| IM | 1 | -0.09791 | 0.35093 | -0.28 | 0.7865 | 0.07343 | 0.07343 |

*Figure 44* H3: Management Support and Leadership Style Explain Intention to Use on Company Y's Data

### 4.5 Summary

This chapter provided the results from SAS regression analysis, interpretations of the result and some predicted explanations for some of the observations.

# CHAPTER 5. DISCUSSION

## 5.1 Discussion

Effective and successful implementations of mobile wireless technologies and information systems can bring benefits to a supply chain with aspects including information quality, resource planning, inventory control and cost savings (Ketikidis et al, 2008). The acquisition and implementation of a new mobile wireless technology system usually calls for a large capital investment and labor input (Kim & Garrison, 2010). Ideally, the implementation of any mobile wireless technology system should be carried out smoothly and generate financial benefits to the company and work efficiency for the employees. This research studied users' acceptance barriers of mobile wireless technology that could prevent a successful and beneficial implementation of a mobile wireless technology.

The researcher adopted the theoretical framework of Technology Acceptance Model 2 (TAM 2) developed by Venkatesh and Davis (2002). Through various statistical analyses, the researcher has reasons to believe that the TAM 2 model could successfully explain users' intention to use mobile wireless technology in warehouse environments. Based on the results revealed in the study, the TAM 2 basic model of perceived usefulness, perceived ease of use and subjective norm (Venkatesh & Davis, 2000) can explain up to 71% of users' intention to use. Within the model, the perceived usefulness showed strength in explaining intention to use with a significant enhancement effect (estimated parameter=0.74). This conclusion matches with previous studies carried out by Venkatesh and Davis on different technology systems (2002). However, unlike previous studies, the perceived ease of use and subjective norm did not seem to have strong connection in determining users' intention to use mobile wireless technology under the basic TAM 2 model. The extensive model of TAM 2, use subjective norm, image, job relevance, output quality, and result demonstration to explain perceived usefulness (Venkatesh & Davis, 2000) were also testified to be true in this research with a high Adjusted R Square value of 0.655 which means this model could explain 66% of the variance in perceived usefulness. Under the perceived usefulness explanation model in current research data, only the effect of job relevance was significant and would strengthen the perceived usefulness (estimated parameter=0.456) which was not exactly the same as Venkatesh and Davis' previous studies' results.

Overall, the TAM 2 developed by Venkatesh and Davis (2000) has proven to be a good model to explain users' acceptance barriers of mobile wireless technology under current research scope, which is warehouse environments including manufacturing, distribution and service companies in Lafayette and West Lafayette, Indiana.

The first hypothesis developed by the researcher that the functionality of a mobile wireless technology system would explain users' intention to use was verified to be true. Overall, the model of perceived usefulness, job relevance and output quality could explain up to 70% of variance in users' intention to use. H 1.a "the usefulness of mobile wireless technology function will encourage users in warehouse environments to accept this technology" was confirmed to be true with significantly enhanced influence on intention to use (estimated parameter=0.655). H 1.b "the job relevance of mobile wireless technology will foster users in warehouse environments to accept this technology" was also confirmed to be true with a significant strengthening effect of intention to use (estimated parameter=0.168). H 1.c "the good output quality of mobile wireless technology will foster users in warehouse environments to accept this technology" was determined to be true based on this study's findings.

The second proposed hypothesis that perceived ease of use and understanding of a mobile wireless technology system could explain users' intention to use tested out to be true as well. This model of perceived ease of use and result demonstrability could explain up to 46% of variance in users' intention to use (Adjusted R Square=0.4659). This hypothesis was only proved to be true on the full data set and data solely from Company X. This hypothesis model testing performed poorly from solely Company Y's data (Adjusted R Square=0.1339) and yielded no significant factor. Under the successfully explained model on the full data set and Company X's data, the H 2.b "the ability to understand the result of mobile wireless technology will foster users in a warehouse environment to accept this technology" was validated to be true with a significantly enhanced impact (estimated parameter =0.4829 on full data set, estimated parameter =0.5227 on Company X's data). The H 2.a "the ease of use of mobile wireless technology will foster users in a warehouse environment to accept this technology" did not prove to be true.

The last hypothesis which proposed management leadership support would explain users' intention to use represented different conclusions on the sample data sets. This hypothesis model could barely count to be true with a low Adjusted R Square of 0.2114 on the full sample data set. However, the H 3.a "the subjective norm from company leadership to encourage use of mobile wireless technology will foster users in warehouse environments to accept this technology" was tested to have a significant strengthened outcome on users' intention to use (estimated parameter =0.3316) from the full data set. The third hypothesis model had a higher Adjusted R Square of 0.4195 on Company X's data alone, which means this model could explain up to 42% of users' intention to use in Company X. H 3.a was demonstrated to be true with significantly heightened influence on users' intention to use in Company X as well (estimated parameter =0.4825). This hypothesis under the Company Y's data was not successfully demonstrated to be true.

One possible reason for false H 1 and H 2 results on Company Y's data might be fact that Company Y recently implemented a new mobile wireless technology system. Employees from Company Y had not established a solid knowledge of the new system and did not understand how important this system is to daily work and how this system could help them with work tasks. The management level did not establish clear expectations for employees using the new system. For companies like Company Y who were at beginning phase of adopting a new mobile wireless technology system.

However, to draw a conclusion like that, more data should be collected from companies like Company Y which recently adopted a new mobile wireless technology system. Through this research study, the researcher discovered the importance of separating the data set from different sources to compare for potential influential factors such as different time measurement, industry, and employees' professional profile differences.

## 5.2 Conclusion

The Technology Acceptance Model 2 was validated to be a successful tool to evaluate users' acceptance barriers of mobile wireless technology in warehouse environments.

Based on the TAM 2 model (Venkatesh & Davis, 2000) and the researcher's hypothesis testing result, the perceived usefulness, job relevance, result demonstrability and subjective norm have significant enforcement impact on determining users' intention to use. As a take-away, if any of the subjects become a major barrier of a company's mobile wireless technology system implementation, it would degrade the users' intentions to accept and use this system dramatically.

Previous literature revealed the problem of inconsistent and unreliable functionality of RFID, bar-code handheld readers and PDAs. The functionality meltdown of mobile wireless technology systems should be a company's biggest concern for system implementations since system functionality has the most significant and strongest connection in determining users' intention to use. Job relevance is critical to determine users' intention to use as well. Recall the previous chapter in reviewing potential barriers for mobile wireless technology, one indirect adoption barrier was that many companies adoption of RFID was only due to the enforcement from a powerful customer. The company itself does not have any other incentives to adopt a new technology system. The adoption of a technology system that is non-relevant to the job will weaken users' interests in accepting this technology system. Companies should evaluate current job functions and technology needs and different mobile wireless technology systems character differences in order to make the correct decision in whether or not a new mobile wireless technology should be adopted. If the answer was yes, then they should consider what type of mobile wireless technology would be most suitable for the company needs. The result demonstrability is important for user acceptance as well. As discussed in an earlier chapter, new adopted systems might have difficulties in being compatible or linked with existing information system. The incompatibility could create a problem for users to understand the result generated from the new mobile wireless technology, which tested could prevent users' intention to use. Additionally, when the companies provide training for the mobile wireless technology system, it will be beneficial to train the employees to understand the system outputs and what the system is actually doing. Lastly, the importance of having company management support in encouraging employees to use mobile wireless technology should be addressed during the implementation process. According to the measurement result on subjective norm in this research, the encouragement from a person such as a supervisor, who is important to an employee, would have a positive impact on employee's intention to use a mobile wireless technology system.

### 5.3 Recommendations for Future Study

Further studies with larger sample sizes should be carried out to confirm the findings of this research. The future research can target companies who are under a different phase of mobile wireless technology implementation. For example, separate sample companies who recently adopted a new mobile wireless technology and companies who have adopted the mobile wireless technology for longer than 3 months.

The researcher also recommends conducting face-to-face surveys for future research. Face-to-face survey administration was the most efficient survey collection method during this research and had the highest response and completion rate. It is a good research practice to keep the survey methodology consistent as well. That is what this research failed to do due to time and participating companies' privacy constraints, and this mixed survey method may have resulted in varied response rates and completion rates.

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# APPENDIX A. SURVEY

Dear Participant:

My name is Anran Wang, a graduate student at Purdue University. My research focus is mobile wireless technology usages in supply chain. I am inviting you to participate in my research to find out what are stopping people from using mobile wireless technologies in warehouse environment.

The following survey is developed to ask you to share your experiences and opinions with mobile wireless technologies during daily work activities. The **system** in the survey content refers to mobile wireless technologies such as **handhold bar-code and RFID readers or wireless PDA**. Please answer the questions from scale 1 –strongly disagree to 5-strongly agree to reflect your immediate response. It will take approximately 5-10 minutes to complete a survey.

This survey is completely confidential. Participants are voluntary to complete the survey and may refuse to participate at any time. This survey is for research purpose only. The survey result has no relationship with your employer or employment and only the survey investigator has the access to the survey result.

Further information regarding to the research can be obtained from the researcher Anran Wang at wang862@purdue.edue or (765)-237-7271. Or through the faculty advisor Dr. Kathy Newton at kanewton@purdue.edu. Thank you very much for your participation

Sincerely,

Anran Wang, Master Candidate, Purdue University

Advisor Dr. Kathryne Newton, Department of Technology Leadership and Innovation, Purdue University.

Gender

- Male (1)
- Female (2)
- Prefer not to say (3)

Age Range

- 18-35 (1)
- 36-59 (2)
- 60+ (3)
- Prefer not to say (4)

Education Level

- Completed some high school (1)
- High school graduate/GED (2)
- Completed some college (3)
- Associate degree (4)
- Bachelor's degree (5)
- Other advanced degree beyond a Bachelor's degree (6)
- Prefer not to say (7)

Previous Experience with Mobile Wireless Technology

- < 1 year (1)
- 1-3 years (2)
- 3 years + (3)
- Prefer not to say (4)

Total Numbers Years of Working Experience

- < 1 year (1)
- 1-3 years (2)
- 3 years + (3)
- Prefer not to say (4)

**Intention to use**

This section is asking about your behavioral intention in using mobile wireless technology (RFID or bar-code handhold gun).

| | Strongly disagree (1) | Somewhat disagree (2) | Neither agree nor disagree (3) | Somewhat agree (4) | Strongly agree (5) |
|---|---|---|---|---|---|
| Assuming I have access to this system, I intend to use it. (1) | ❍ | ❍ | ❍ | ❍ | ❍ |
| Given that I have access to the system, I predict that I would use it. (2) | ❍ | ❍ | ❍ | ❍ | ❍ |

**Perceived usefulness**

This section of questions asks to what extent you believe that using the mobile wireless systems enhance your work performance.

| | Strongly disagree (1) | Somewhat disagree (2) | Neither agree nor disagree (3) | Somewhat agree (4) | Strongly agree (5) |
|---|---|---|---|---|---|
| Using the system improves my performance in my job. (1) | ❍ | ❍ | ❍ | ❍ | ❍ |
| Using the system in my job increase my productivity. (2) | ❍ | ❍ | ❍ | ❍ | ❍ |
| Using the system enhances my effectiveness in my job. (3) | ❍ | ❍ | ❍ | ❍ | ❍ |
| I found the system to be useful in my job. (4) | ❍ | ❍ | ❍ | ❍ | ❍ |

**Perceived ease of use**

This section of questions asks to what extent you think this technology is easy to use and free of effort.

| | Strongly disagree (1) | Somewhat disagree (2) | Neither agree nor disagree (3) | Somewhat agree (4) | Strongly agree (5) |
|---|---|---|---|---|---|
| I found the system is easy to use. (2) | ❍ | ❍ | ❍ | ❍ | ❍ |
| I don't need to learn a lot of things before I could get going with this system. (4) | ❍ | ❍ | ❍ | ❍ | ❍ |
| I would imagine that I would learn to use this system very quickly. (6) | ❍ | ❍ | ❍ | ❍ | ❍ |
| I don't think that I would need the support of a technical person to be able to use the system. (8) | ❍ | ❍ | ❍ | ❍ | ❍ |

**Subjective norm**

This section of questions asks what you think those people who are important to you think you should or should not use the mobile wireless technology.

| | Strongly disagree (1) | Somewhat disagree (2) | Neither agree nor disagree (3) | Somewhat agree (4) | Strongly agree (5) |
|---|---|---|---|---|---|
| My co-workers who influence my behavior think that I should use this system. (2) | ❍ | ❍ | ❍ | ❍ | ❍ |
| My supervisors/team leads who are important to me think that I should use this system. (4) | ❍ | ❍ | ❍ | ❍ | ❍ |

**Voluntariness**

This section of questions asks whether the use of the mobile wireless technology occurs in mandatory settings.

| | Strongly disagree (1) | Somewhat disagree (2) | Neither agree nor disagree (3) | Somewhat agree (4) | Strongly agree (5) |
|---|---|---|---|---|---|
| My use of the system is voluntary. (1) | ❍ | ❍ | ❍ | ❍ | ❍ |
| My supervisor does not require me to use the system. (2) | ❍ | ❍ | ❍ | ❍ | ❍ |
| Although it might be helpful, using the system is certainly not compulsory in my job. (3) | ❍ | ❍ | ❍ | ❍ | ❍ |

**Image**

This section of questions asks if using the mobile wireless technology is a status symbol in your organization.

| | Strongly disagree (1) | Somewhat disagree (2) | Neither agree nor disagree (3) | Somewhat agree (4) | Strongly agree (5) |
|---|---|---|---|---|---|
| People in my organization who uses the system have a better position. (1) | ❍ | ❍ | ❍ | ❍ | ❍ |
| The ability to use the system is limited to certain employees. (2) | ❍ | ❍ | ❍ | ❍ | ❍ |
| Having access to the system is a symbol of status in my organization. (3) | ❍ | ❍ | ❍ | ❍ | ❍ |

**Job relevance**

This section of questions asks to what degree this target system is applicable to your job.

| | Strongly disagree (1) | Somewhat disagree (2) | Neither agree nor disagree (3) | Somewhat agree (4) | Strongly agree (5) |
|---|---|---|---|---|---|
| Using the system is important to my job. (1) | ❍ | ❍ | ❍ | ❍ | ❍ |
| The system is relevant to my job. (2) | ❍ | ❍ | ❍ | ❍ | ❍ |

**Output quality**

This section of questions asks how well does the system perform the tasks.

| | Strongly disagree (1) | Somewhat disagree (2) | Neither agree nor disagree (3) | Somewhat agree (4) | Strongly agree (5) |
|---|---|---|---|---|---|
| The quality of the output I get from the system is high. (1) | ❍ | ❍ | ❍ | ❍ | ❍ |
| I have no problem with the quality of the system's output. (2) | ❍ | ❍ | ❍ | ❍ | ❍ |

**Result demonstrability**

This section of questions asks your ability to understand how effective the system is.

| | Strongly disagree (1) | Somewhat disagree (2) | Neither agree nor disagree (3) | Somewhat agree (4) | Strongly agree (5) |
|---|---|---|---|---|---|
| I have no difficulty telling others about the results of using the system. (1) | ❍ | ❍ | ❍ | ❍ | ❍ |
| I believe I could communicate to others the consequences of using the system. (2) | ❍ | ❍ | ❍ | ❍ | ❍ |
| The results of using the system are apparent to me. (3) | ❍ | ❍ | ❍ | ❍ | ❍ |
| I would have difficulty explaining why using the system may or may not be beneficial. (4) | ❍ | ❍ | ❍ | ❍ | ❍ |

# APPENDIX B. FORMS

PURDUE
UNIVERSITY

HUMAN RESEARCH PROTECTION PROGRAM
INSTITUTIONAL REVIEW BOARDS

| | |
|---|---|
| **To:** | KATHRYNE NEWTON<br>YONG |
| **From:** | JEANNIE DICLEMENTI, Chair<br>Social Science IRB |
| **Date:** | 10/28/2016 |
| **Committee Action:** | **Determined Exempt, Category (2)** |
| **IRB Action Date:** | 10/27/2016 |
| **IRB Protocol #:** | 1609018125 |
| **Study Title:** | User acceptance barriers of mobile wireless technology in warehouse environment |

The Institutional Review Board (IRB) has reviewed the above-referenced study application and has determined that it meets the criteria for exemption under 45 CFR 46.101(b).

Before making changes to the study procedures, please submit an Amendment to ensure that the regulatory status of the study has not changed. Changes in key research personnel should also be submitted to the IRB.

Please retain a copy of this letter for your regulatory records. We appreciate your commitment towards ensuring the ethical conduct of human subject research and wish you well with this study.