ORGANISATIONAL FACTORS IN RFID ADOPTION, IMPLEMENTATION, AND BENEFITS

by

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ABSTRACT

This study investigates the impact of organisational and technological factors within pre-adoption, implementation, and post-implementation phases of RFID system deployment. In the pre-adoption phase, the study examines factors that drive and hinder organisations' decision to adopt RFID. In the implementation phase, the study investigates the impact of organisational factors (business size, strength of culture, and business process re-engineering) on influencing the implementation processes of RFID. In the post-implementation phase, the study investigates how the benefits derived from RFID implementation interact with organisational factors (business size, strength of culture, and business process re-engineering) and RFID-related factors (product unit level of tagging, RFID implementation stage, and organisational pedigree in RFID). This study was motivated by the lack of (i) an advisory framework which considers quantifiable firm characteristics and the costs and benefits of implementing RFID, in yielding advice to guide decisions on RFID adoption, and (ii) a framework that covers the complete processes of RFID project deployment (from adoption decision to benefits derived) in yielding advice to guide decisions on RFID adoption.

This study is achieved using a two-phase research approach: questionnaire survey of organisations that have adopted or plan to adopt RFID and case studies of organisations that have integrated RFID into their business processes. In addition, a thorough review of existing literature on RFID in different industrial settings was conducted.

The key findings from the study indicate that RFID adoption is driven by factors from technological, organisational and environmental contexts and that the adoption, implementation and benefits of RFID are influenced by organisational culture strength, business size, and BPR. It was found that strong cultures, organisational size and BPR are all positively correlated with RFID adoption decisions, implementation and benefits. Potential contribution towards the existing body of knowledge is through highlighting the significance of organisational culture strength, business size, and BPR in providing a platform in which RFID will be accepted and implemented successfully to achieve maximum derivable benefits.

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CHAPTER 1 – INTRODUCTION

1.1 Background

Supply chain management (SCM) comprises a set of processes and enabling systems that support business strategies and influence their operational, strategic and tactical decisions, to achieve organisational competitiveness (Stadtler and Kilger, 2008). Organisations aim to boost the competitiveness and efficiency of their supply chains by achieving closer integration of all stakeholders and their functional units, thereby enhancing coordination of materials, information, and financial flows within the network. However, globalisation and the dynamic nature of today's business environment often compels them into collaborating with multiple supply chain stakeholders around the world, in a variety of cultures, and across numerous organisational boundaries. Under such circumstances, the task of achieving effective and efficient supply chain co-ordination and operation becomes daunting (Peña-Mora et al., 2014). Consequently, organisations adopt various strategies to improve their agility and responsiveness, improve the quality of their supply chain activities, and cut down operational costs (Chen et al., 2012; Poon et al., 2009). These strategies may include the adoption of technological innovation and/or the expansion of internal operation procedures into complex supply chain networks.

The development, growth, and proliferation of information Technology (IT) has greatly increased the opportunities for organisations to realize the task of integrating their supply chains. Auto-identification (Auto-ID) technologies comprise a wide variety of information collection tools and techniques capable of object and people identification, and information retrieval, update, storage (Waldner, 2008). They allow organisations to continuously improve their responsiveness and competitiveness by adapting their operations strategies, methods and technologies to near real-time data at the enterprise edge.

Radio Frequency Identification (RFID) is an Auto-ID technology that uses radio waves to capture data and provide real-time, contact-less communication with objects. RFID systems are composed of a transponder (tag), an interrogator (reader), and a middleware system. The transponder consists of a microchip and an antenna, and carries the unique identification code of each object. The reader, made up of an antenna, emits radio signals to interrogate the tag. In turn, the reader receives responses from the tag. This information is then passed unto a middleware computer system (Finkinzeller, 2003).

The advanced real-time communication and unique identification properties of RFID technology enable it to contribute, in multiple ways, to improving supply chain activities and processes. RFID can improve the visibility and traceability of products within the supply chain, reduce operational costs, increase sales by reducing out-of-stocks, and improve accuracy and speed of processes (Li et al., 2006). Consequently, RFID has attracted considerable attention as a technology that improves supply chain performance, thus, numerous organisations have adopted RFID in order to reap the benefits of more efficient and automated business processes (Sheng et al., 2011; Sarac et al., 2010).

1.2 Research context

In the last two decades, RFID technology has been at the forefront to improve numerous processes in a variety of supply chain management facets. As the focus on business improvement moves from single firms to complex supply chains, RFID is considered critical in reducing supply chain costs, improving physical flow co-ordination, and enabling more effective and efficient sharing of information between stakeholders (Sadlovska and Vishwanata, 2009; Viswanathan, 2008). In that regard, organisations change from the conventional approaches of supply chain management to more integrated and synchronized supply chain practices (Bendavid et al., 2009).

Much of the proliferation and growth of RFID, and the stimulation in research interest has been attributed to mandates by major corporations such as Wal-Mart and the US Defense Department to adopt the technology. Since the year 2005, RFID research published through journal articles, special issues, and media releases has sought to explain the technological and organisational aspects related to the adoption of the technology (Gadh et al., 2010; Ngai et al., 2010; Sheng et al., 2011; Wang, 2010; Dai et al., 2009; Huang et al., 2009; Sharma et al., 2009; Dutta and Whang, 2007; Madni et al., 2007; Crawford, 2005). However, despite RFID being considered the prime technology of 21st century management (Chao et al., 2007; Wyld, 2006), its adoption has been weighed down by a variety of issues including technological uncertainties, competition with established auto-ID technologies (e.g. bar code), costly software and services, data management challenges, unclear Return-On-Investments (ROIs), and global standardization issues (Dortch, 2008; Bose and Lam, 2008; Vijayaraman and Osyk, 2006; Li et al., 2006; Wu et al., 2006). Fortunately, today, most of these challenges have been addressed, and there is an increasing number of documented business cases available, which contribute to facilitating the adoption process. Nevertheless, the high cost, to the firm, of implementing RFID calls for an optimal decision to be made on whether or not to adopt the technology.

Consequently, multiple studies on the benefits and costs of RFID implementation in supply chains (Caridi et al., 2013; Vlachos, 2013; Anand and Wamba, 2013; Lee and Lee, 2012; Choi, 2011; Szmerekovsky et al., 2011; Ustundag, 2010; Mehrjerdi, 2010; Miragliotta et al., 2009; Veeramani et al., 2008) and on factors that influence the adoption and diffusion of RFID (Alqahtani and Wamba, 2012; Wang et al., 2010; Li et al., 2010; Lin, 2009; Schmitt and Michahelles, 2009; and Sharma et al., 2007) have been conducted. However, the majority of these studies fail to draw important conclusions that can be applied in practice, as they are limited to simply focusing on the technology itself, often disregarding complex organisational, cultural, and environmental factors that determine how a new technology is adopted, its diffusion within organisations, and how benefits derived from its implementation interact with organisation characteristics (Oliveira and Martins, 2011; MacVaugh and Schiavone, 2010). Thus, there remains a need to develop an advisory framewrok, one which considers quantifiable firm characteristics and the costs and benefits of implementing RFID, in guiding decisions on RFID adoption. For example, it is necessary to determine how RFID adoption decisions, RFID implementation processes and procedures, and derivable RFID benefits interact with factors such as business size, business structure and culture, existing information technologies and systems, and business process re-engineering. The extents to which these factors influence the organisational decision to adopt RFID, the RFID implementation process, and benefits derivable from RFID investments have not been well studied in the extant literature.

Therefore, as highlighted in the preceding paragraph, there still remains some ambiguity surrounding factors that influence organisational decision to adopt RFID, the assessment of RFID impact on supply chain, and the interaction of RFID with technological and organisational characteristics. The next section (1.3) describes how this study contributes towards closing some of these research gaps.

1.3 Research Aim and Objectives

This study aims to investigate factors within the pre-adoption, implementation, and post-implementation phases of RFID system deployment. In the pre-adoption phase, the study aims to investigate factors that influence organisational decision to adopt RFID, including organisational, technological, and environmental drivers and constraints. In the implementation phase, the study investigates the impact of organisational factors (business size, business culture, and business process re-engineering) on influencing the implementation processes of RFID. In the post-implementation phase, this study investigates how the benefits derived from RFID implementation interact with organisational factors (business size, business culture, and business process re-engineering) and RFID-related factors (product unit level of tagging, RFID implementation stage, and organisational pedigree in RFID). Accordingly, five objectives (each one framed into a research question) were formulated to meet the aim of this study. These are:

- To identify the factors that drive and constrain the adoption of RFID

  Question 1: What factors drive and constrain organisational decision to adopt RFID technology?

- To assess the extent to which organisational culture, size, and BPR affect the decision to adopt RFID

  Question 2: How is the decision to adopt RFID enhanced or constrained by an organisation's underlying culture, the size of the organisation, and business process re-engineering?

- To assess the extent to which organisational culture, size, and BPR affect the implementation processes of RFID

  Question 3: If the decision to adopt RFID is taken, how is the implementation process affected by an organisation's underlying culture, the size of the organisation, and business process re-engineering?

- To assess the extent to which organisational culture, size, and BPR affect benefits derived from RFID

  Question 4: What benefits are derived from RFID implementation and how are they affected by an organisation's underlying culture, the size of the organisation, and business process re-engineering?

- To assess the extent to which the implementation stage of RFID, the Product Unit Level of Tagging (PULT), and the organisational pedigree in RFID affect the benefits derived from adopting the technology

  Question 5: How are the benefits derived from RFID implementation affected by the implementation stage of RFID, the Product Unit Level of Tagging (PULT), and the organisational pedigree in RFID?

This thesis sets out to investigate the research questions listed above, with the objective of attaining the aims of the study. The following section gives an overview of the methodology adopted in undertaking this study.

1.4 Research Methodology

This research proceeds by developing research questions from extant literature (Forza, 2002; Newman and Benz, 1998). A survey by questionnaire was deemed suitable, as the research comprises quantifiable attributes (Bryman and Bell, 2003; Newman and Benz, 1998). Thus, survey by questionnaire was adopted as one of the methods for data collection in this research. Four case studies were undertaken to validate the survey results, as well as determine the context in which RFID adoption, organisational characteristics, and benefits interact. Thus, as advocated by Creswell (2009), this research achieved methodological triangulation by combining the two research methods. Figure 1.2 shows the key phases of the research design.

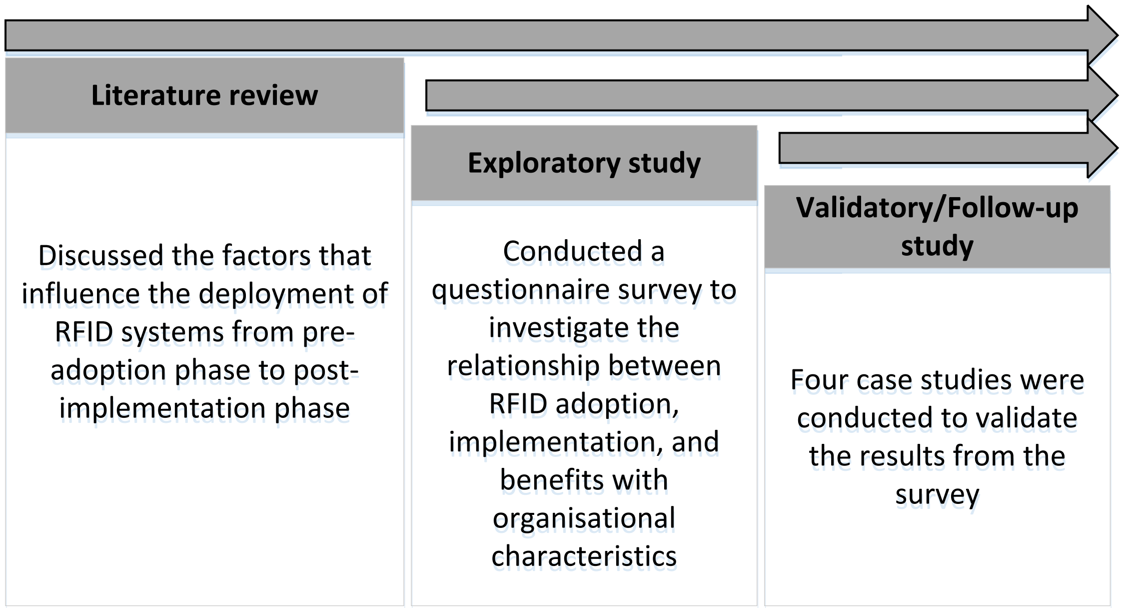


Figure 1.1: *Research design*

1.5 Organisation of the thesis

This thesis is presented in seven chapters, as shown in Figure 1.3, and is categorised as follows. Chapter 1 introduces the research context. It presents a brief introduction of the topic to be investigated, identifying the aims and objectives of the research, the research gaps, and the research questions. Chapter 2 discusses the determinants of RFID adoption, implementation, and benefits. Chapter 3 presents the research framework and its elements. Chapter 4 discusses and justifies the methodology adopted in this research. Chapter 5 reports the survey by questionnaire and discusses the results. Chapter 6 reports four case study investigations on the interaction of RFID adoption, organisational characteristics, and RFID benefits. Chapter 7 presents the conclusions, implications and recommendations from the research.

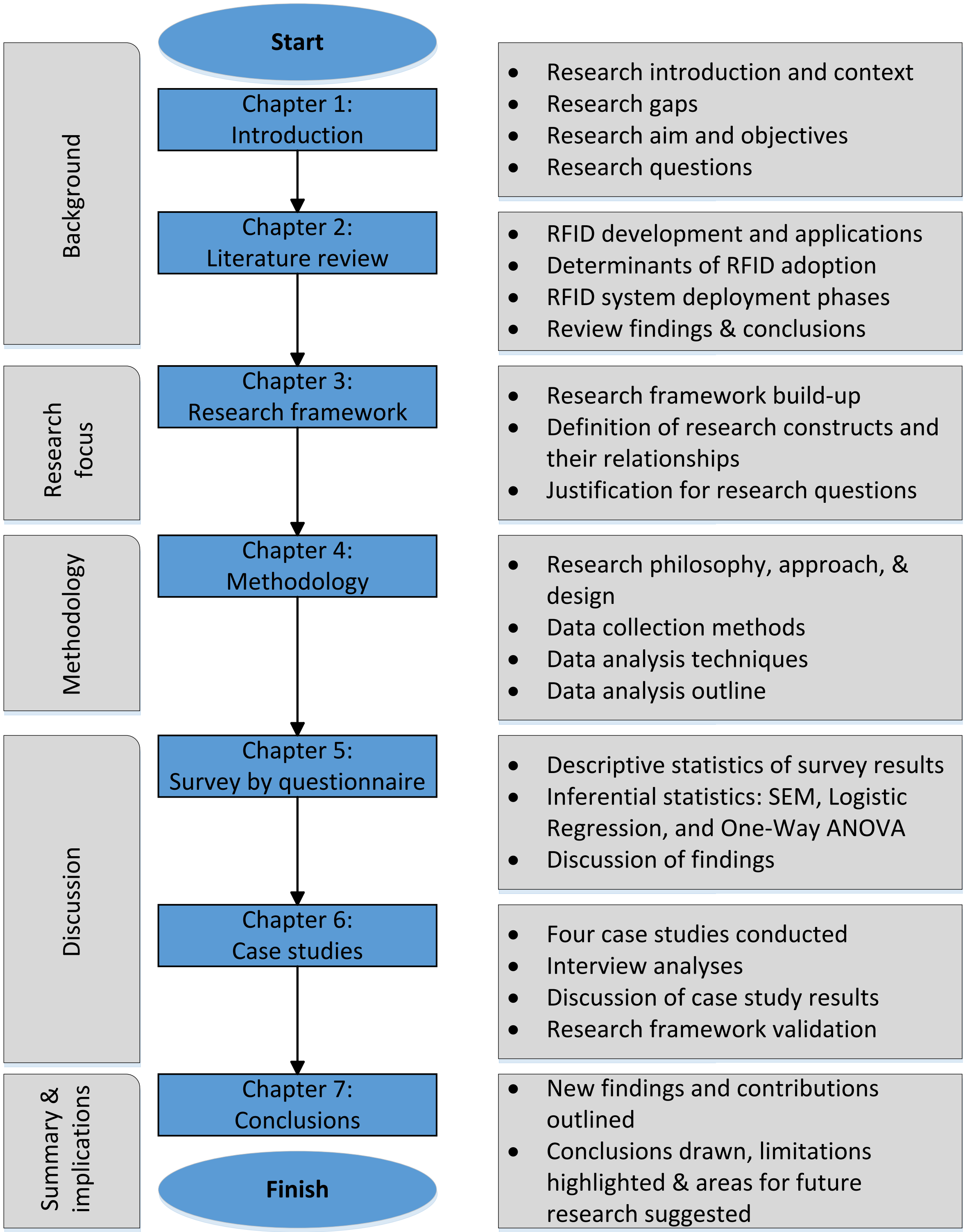


Figure 1.2: *Organisation of the thesis*

CHAPTER 2 – LITERATURE REVIEW

2.1 Introduction

This chapter presents the theoretical basis of the thesis. The chapter begins by (i) providing an overview of RFID technology and discussing its evolution over time, and (ii) outlining and discussing the drivers and constraints of RFID adoption based on two key organisational theories/frameworks of IT adoption, namely, Diffusion of Innovation (DOI) theory, and the Technology-Organisation-Environment (TOE) framework. Subsequently, a discussion on the determinants of RFID adoption, RFID implementation processes, and RFID benefits follows. Finally, the chapter ends by discussing the implications of the review, including research gaps and future research directions.

2.2 RFID Technology

Radio Frequency Identification (RFID) is an automatic identification and data capture technology that is composed of a transponder, a transceiver and a middleware system. The transponder stores and transmits identification data, and communicates with the transceiver, wirelessly delivering information to a database in a digital format. The middleware bridges RFID hardware and enterprise applications (Finkinzeller, 2000).

RFID technology was first conceived in 1948, primarily from radar and radio research undertaken during World War II. However, it took about 4 decades for practical applications of RFID to be fully developed, trialled, and commercialized (Landt, 2005). This was primarily driven by changing business practices and the development of the integrated circuit (microprocessor). Now, RFID has become sufficiently affordable and reliable for widespread use and is thus considered a business solution for the industry (Holloway, 2006; Roberts, 2006). Table 2.1 shows RFID history over the decades since its conception.

Table 2.1: *RFID Historical overview*	
Years	**Development**
1940 to 1960	- RFID invented in 1948 from radio and radar research in World War II - Research and laboratory experiments till the 1960s
1960 to 1980	- Development of theory and field trials - Early implementations of RFID
1980 to 2000	- Mainstream development of commercial RFID applications and standards
2000 to Present	- Fostering global standardisation. Development of implementation frameworks, ROI and business cases. Wider commercial applications

(Source: Association for Automatic Identification and Mobility, October 2001, http://www.aimglobal.org)

Since its conception in 1948, the theoretical exploration of RFID continued into the 1950s, with multiple research papers being published. By the 1960s, laboratory experiments had led to the development of prototype systems. By the late 60s RFID had steadily moved to the forefront, particularly when commercial systems equipped with electronic article surveillance (EAS) were used to prevent the theft of high value items and clothing. Between the 1970s and 1980s, the research interest in RFID had spiralled, with various researchers, developers, and academic institutions venturing into exploring applications such as animal tagging, transportation, and tolling (Landt, 2005). By the 1990s, the integrated circuit was developed and RFID tags were incorporated as single circuits. More recently, advancements have been made in the development of standards, frequency spectrum allocations between countries, and the growth of further commercial applications.

2.2.1 RFID components and processes

RFID technology operates in low, high, ultra-high and super high frequency bands. Low frequency tags operate at 125 or 134 KHz and are ideal for simple usage in access control, and animal and asset tracking. High frequency tags operate between 13.56 to 27 MHz and are suitable for applications requiring medium data rates and read ranges of up to 1.5 metres. Ultra-high frequency tags offer read ranges of up to 15 metres and operate between 850 MHz and 950 MHz. Super high frequency tags operate between 2.400 and 5.875 GHz (Want, 2006).

There are three main types of RFID tags:

a) ***Active tags*** – An active RFID tag comprises of a battery (power source) and a transmitter. In comparison to passive tags, active tags offer longer read ranges and bigger memory. There are two types' active RFID tags – Transponders and Beacons.

Depending on the key functional attributes of the tag, RFID tags can be used for a variety of applications including tolling, real-time location systems (RLTS), and asset tracking.

Image 2.1: A picture of an active RFID tag utilizing the 433 MHz frequency, typically used to accomplish automated vehicle identification (AVI), personnel/asset tracking, and perimeter security functionality (Source: Telsor.com.au)

b) ***Passive tags*** – A passive RFID tag comprises a microchip and an antenna. Dissimilar to active tags, passive RFID tags have no internal power source. Passive RFID tags are generally much smaller than active tags, and depending upon the application, can be a few millimetres thick. Passive tags are used for asset tracking, access control, etc. Image 2.2 shows a picture of one type of passive tag.

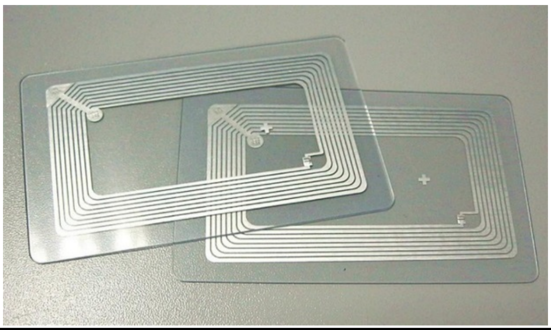


Image 2.2: *A picture of a UHF passive RFID paper printed label, typically used for library applications, asset tracking, and file management (Source: Aliexpress.com)*

c) ***Semi-passive tags*** – Semi-passive tags have an internal power source but do not contain an active transmitter. Semi-passive tags can be used to monitor inputs from sensors – even when the tags aren't in the presence of a radio frequency field. This makes them suited for monitoring and activating or deactivating items remotely, making them ideal for applications such as alarms, seals, or thermostats. (Angeles, 2005).

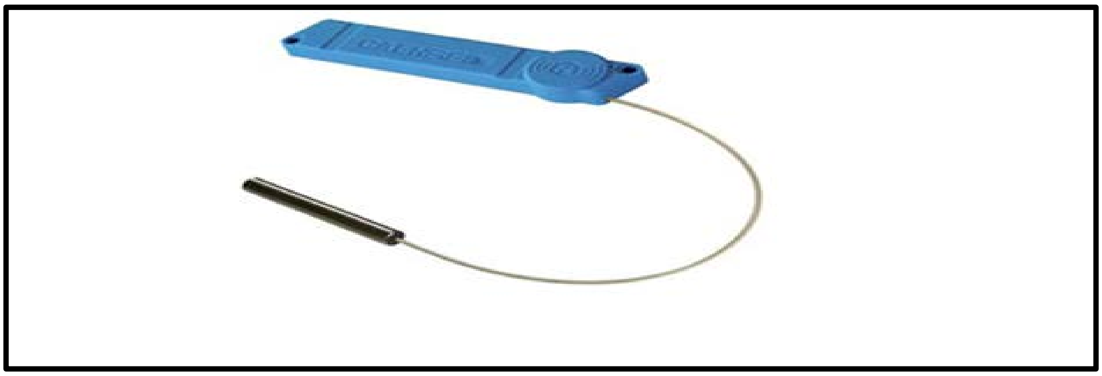
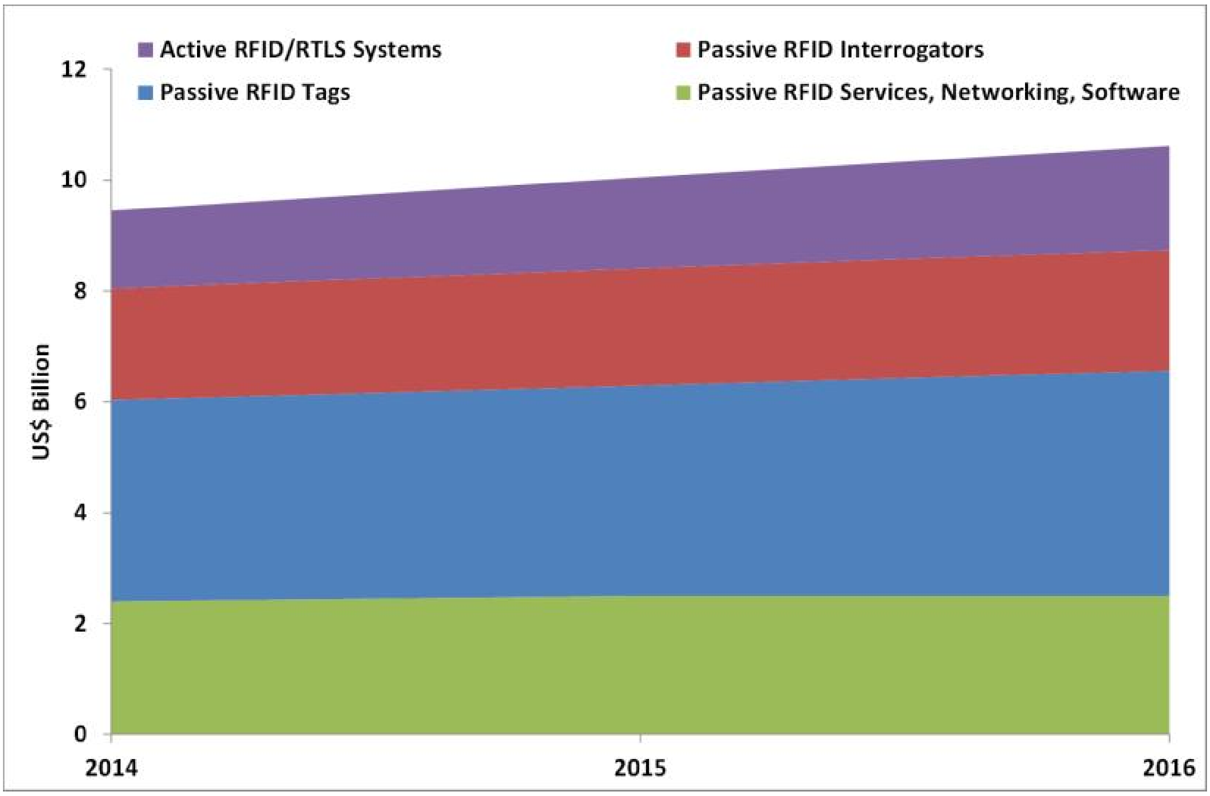


Image 2.3: *A picture of a UHF semi-passive RFID tag with a temperature probe, typically used in a range of industries to monitor temperature in a contained environment (Source: Veryfields.net)*

2.2.2 RFID market development

Since the year 2000, the RFID market has grown substantially. The RFID market has grown from a total worth of USD$2.77 billion in 2006 to USD$10.1 billion by 2016 (IDTechEx, 2016). More than half of that growth was from active RFID applications such as Real Time Location Systems (RTLS), a system that enables users to track and trace the movement of items in their premises in real-time. Further growth came from passive RFID applications, primarily the tagging of high volume items such as consumer goods, drugs, and postal packages (IDTechEx, 2016). Figure 2.1 shows the total RFID market growth from years 2014 to 2016.

Developments in the RFID market over the past decade signify that RFID technology has achieved a significant level of penetration in commerce, mainly boosted by dynamic growth from retail apparel implementations (SMARTRAC, 2015). Major advancements in the RFID industry have also played a role in the proliferation of the technology. For instance, the industry has removed technological obstacles, met interoperability requirements, and worked on global standardization. It has strengthened educational and promotional efforts around UHF RFID, and has provided adequate UHF RFID standards and technology solutions, supported by a significant number of market players serving all aspects of daily life.



(Source: IDTechEx)

Figure 2.1: *Total RFID Market worth in US$ billions**

RFID has become a useful tool in retail, logistics, healthcare and a handful of other enterprise sectors. Of recent, RFID has been transitioning into a supporting player by becoming an essential part of the Internet of Things (IoT).

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction (IOT Agenda, 2016). IoT has evolved from the convergence of wireless technologies, micro-electromechanical systems (MEMS), microservices and the internet. The convergence has enabled data to be analyzed for insights that will drive improvements in organisational processes and operations. While RFID will not be the only technology used in the IoT to identify objects and link them to the Internet, passive ultrahigh frequency (UHF) RFID tags and Near Field Communication (NFC) technologies are emerging as the two most likely standards (Tech4Business, 2014).

In response to developments in IoT, several RFID market players have collaborated with cloud service providers, chipmakers and other tech businesses to promote UHF RFID as an essential part of the IoT. In 2014, Google, Intel and SMARTRAC, along with the leading radio identification industry association AIM Global, formed the RAIN (**RA**dio-frequency **I**dentificatio**N**) Alliance. RAIN's stated goal is to promote awareness, education, and initiatives to accelerate UHF RFID growth and adoption in business and consumer applications worldwide. It is based on this that technology analysts predict the growth of RFID to continue. By 2020, IDTechEx forecast the RFID market will be worth $13.2 billion. The projected growth is expected to come from the sale of tags, readers and software/services for RFID cards, labels, fobs and all other form factors, for both passive and active RFID applications.

2.3 Industrial applications of RFID technology

In a bid to become more competitive and responsive in an increasingly globalized and dynamic business environment, organisations aim to achieve closer integration of all stakeholders and their functional units; reduce costs; and enhance coordination of materials, information, and financial flows within their supply chain networks. As a consequence, organisations are continuously attempting to re-examine and improve their supply chain processes (Viswanathan, 2008; Sadlovska and Vishwanata, 2009). The rapid growth and proliferation of information technologies has greatly increased the opportunities for these organisations to continuously attempt to improve their flexibility, responsiveness and competitiveness by changing their operations strategies, methods and technologies. In this context, RFID has been considered critical in enabling firms to move from a traditional supply chain model to a more integrated, efficient, and synchronized supply chain model (Bendavid et al., 2009).

RFID has an extensive range of applications across multiple industrial settings. Accordingly, numerous review papers have been published in the last decade to provide a comprehensive overview of RFID applications in operational and supply chain processes in those industrial settings. For instance, Sarac et al. (2010) review and classify RFID literature that focuses on alleviating the bullwhip effect, inventory inaccuracy and optimizing replenishment policies. Nemeth et al. (2006) give an overview of current development of RFID technology and processes by investigating the potential benefits and challenges of RFID integration in supply chains. Table 2.2 provides a summary of the contents and outcomes of some of the relatively recent literature reviews on RFID.

Table 2.2: *Some recent literature reviews of RFID in different industrial settings*		
Reference	**Focus of review**	**Summary of outcome**
Costa et al. (2013)	RFID research publications in the agriculture-cum-food sector	This review provides an overview of developments in RFID research in agriculture-food sector. It identifies and evaluates the current and potential applications of RFID in the production and distribution of agricultural produce and products. It also discusses the technical and economic challenges hindering wide implementation of the technology in agriculture-food sector.
Lim et al. (2013)	The benefits, challenges and applications of RFID in warehouse management	The review provides insights into extant works on the integration of RFID into various warehouse functions. It identifies the strong and vital link between the ability of RFID to capture accurate and timely data and warehouse operational performance. It also evaluates the current status of RFID solutions in warehouse functions and suggests future trends and research challenges in this domain.
Wamba et al. (2013)	RFID applications in healthcare settings	This paper provides a comprehensive review of articles focusing on RFID applications in healthcare operations. It provides a classification framework that categorizes RFID publications in the healthcare sector into three groups, namely, asset management, patient management, and staff management-related applications. The review provides managerial insights into the usefulness and relevance of RFID in effective management of operations across the healthcare industry. It concludes by identifying data management, security and privacy as future research directions.
Zhu et al. (2012)	The benefits, challenges and applications of RFID in a variety of industries	This review surveys the current and potential applications of RFID across a variety of industries. It focuses on the ability of RFID to capture accurate and timely data and its subsequent role in providing better supply chain visibility and product traceability. The review also identifies the use of RFID for inventory management, improving business processes and improving supply chain efficiency and performance. Furthermore, the security and privacy issues of RFID are discussed, and the current and future trends in RFID research are identified and suggested, respectively.
Liao et al. (2011)	RFID publications in journals that are indexed in SCI and SSCI from 2004 to 2008	This review identifies relevant technical SCI-indexed journals and a variety of less specialized journals that have published RFID literature between 2004 and 2008. It also provides profiles of RFID publication authors and co-authors, their locations and demographics, as well as the dominant RFID research topics, and citation indices of publications in RFID.

Sarac et al. (2010)	Applications and potential benefits of RFID in supply chain management	This paper surveys the use of simulation modeling, analytical methods, case studies and experiments in analyzing the impact of RFID on supply chain activities. In particular, it focuses on the impact of RFID on cost reduction and value creation in relation to inventory management.
Ngai et al. (2008)	A generic review of RFID publications between 1995 and 2005	This review identifies RFID literature published in academic journals between 1995 and 2005 and classifies the publications into four main categories, namely, RFID technology, RFID applications, security and privacy issues, and others. This classification provides an overview of the anatomy of RFID research from 1995 to 2005 as well as managerial and practical insights into the applications, benefits and challenges of RFID. The review concludes by identifying research gaps and suggesting future research directions.
Chao et al. (2007)	Review and bibliometric analysis of RFID research trends and contributions between 1991 to 2005	This review examines the use of RFID by a variety of enterprises to enhance organisational change and gain competitive advantage. The review also identifies current RFID research trends and suggests future research directions.

RFID adoption rates have been variable across different sectors. While many organisations, especially retailers have either adopted RFID or announced plans for adoption, industries such as manufacturing have been slower in adopting the technology. The adoption of RFID is driven and constrained by numerous factors, as discussed in the succeeding sections (2.4 and 2.5).

2.4 Technology adoption models

RFID is considered by organisations to be a form of technological innovation that greatly increases their opportunities to become more responsive and competitive, by adapting their operations strategies, methods and technologies to near real-time data at the enterprise edge. Like many other forms of technological innovation, organisational decision to adopt RFID is guided by theoretical frameworks, business case development, cost-benefit evaluations, and ROI assessments before an optimal decision of whether to adopt the technology or not, is made.

When selecting and implementing an innovative technology, it becomes paramount for organisations to carefully evaluate different models of IT adoption and balance them against the organisational goals and objectives. This is crucial for selecting and implementing the appropriate and most effective technology, and thus realizing a return-on-investment (Angeles, 2005). There are many theories about technology adoption used in IS research

(Oliveira & Martins, 2011). Some of the widely used technology adoption models include the Diffusion of Innovation (DOI) (Rogers, 1995), the Technology–Organisation–Environment **(**TOE) framework (Tornatzky & Fleischer, 1990), the Technology Acceptance Model (TAM) (Davis, 1986, Davis, 1989; Davis et al., 1989), and the Theory of Planned Behaviour (TPB) (Ajzen, 1985; Ajzen, 1991). As this study focuses on the implementation of RFID at the organisational level, only the DOI and the TOE framework have been discussed. Other models like the TAM and TPB are used at the individual level, particularly in studies seeking to understand the impact of employees and users of a technology on its adoption and diffusion (Oliveira & Martins, 2011).

2.4.1 Diffusion of Innovation (DOI) Theory

Diffusion of Innovation theory is concerned with explaining how, why, and at what rate new ideas and technology spread through cultures. In other words, DOI theory is a process by which an innovation is communicated through certain channels over time and within a specific social system (Rogers, 1995). The innovation process in organisations is much more complex. It usually involves a number of individuals, possibly including both supporters and opponents of the new idea, each of whom plays a role in the innovation adoption decision (Rogers, 1995). The DOI theory identifies five technological characteristics as drivers to any adoption decision: relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003). These five characteristics are explained in greater detail below:

- ***Relative advantage/Perceived benefits*** - This is the degree to which an innovation is perceived as better than the idea it supersedes by a particular group of users, measured in terms that matter to those users, like economic advantage, social prestige, convenience, or satisfaction. The greater the perceived relative advantage of an innovation, the more rapid its rate of adoption is likely to be. There are no absolute rules for what constitutes “relative advantage”. It depends on the particular perceptions and needs of the user group.
- ***Observability*** – The easier it is for individuals to see the results of an innovation, the more likely they are to adopt it. Visible results lower uncertainty and also stimulate peer discussion of a new idea, as partners of an adopter often request information about it.

- ***Compatibility*** - This is the degree to which an innovation is perceived as being consistent with the values, past experiences, and needs of potential adopters. An idea that is incompatible with their values, norms or practices will not be adopted as rapidly as an innovation that is compatible.
- ***Trialability*** - This is the degree to which an innovation can be experimented with on a limited basis. An innovation that is "trialable" represents less risk to the organisation considering adopting it.
- ***Complexity*** – This is the degree to which an innovation is perceived as difficult to understand and use. New ideas that are simpler to understand are adopted more rapidly than innovations that require the adopter to develop new skills and understanding.

In addition, Rogers (1995) further identifies three independent variables that influence the process by which an organisation adopts technological innovation: individual (leader) characteristics, internal characteristics of organisational structure, and external characteristics of the organisation.

(a) ***Individual characteristics*** refer to the leaders' attitude toward change.

(b) ***Internal characteristics*** *of organisational structure* consist of several factors, namely:

- Centralization - This is the degree to which power and control in a system are concentrated in the hands of a relatively few individuals
- Complexity - This is the degree to which an organisation's members possess a relatively high level of knowledge and expertise
- Formalisation - This is the degree to which an organisation emphasizes its members' following rules and procedures
- Interconnectedness - This is the degree to which the units in a social system are linked by interpersonal networks
- Organisational slack - This is the degree to which uncommitted resources are available to an organisation
- Size – This is the number of employees of the organisation

(c) ***External characteristics*** *of the organisation* describe system openness.

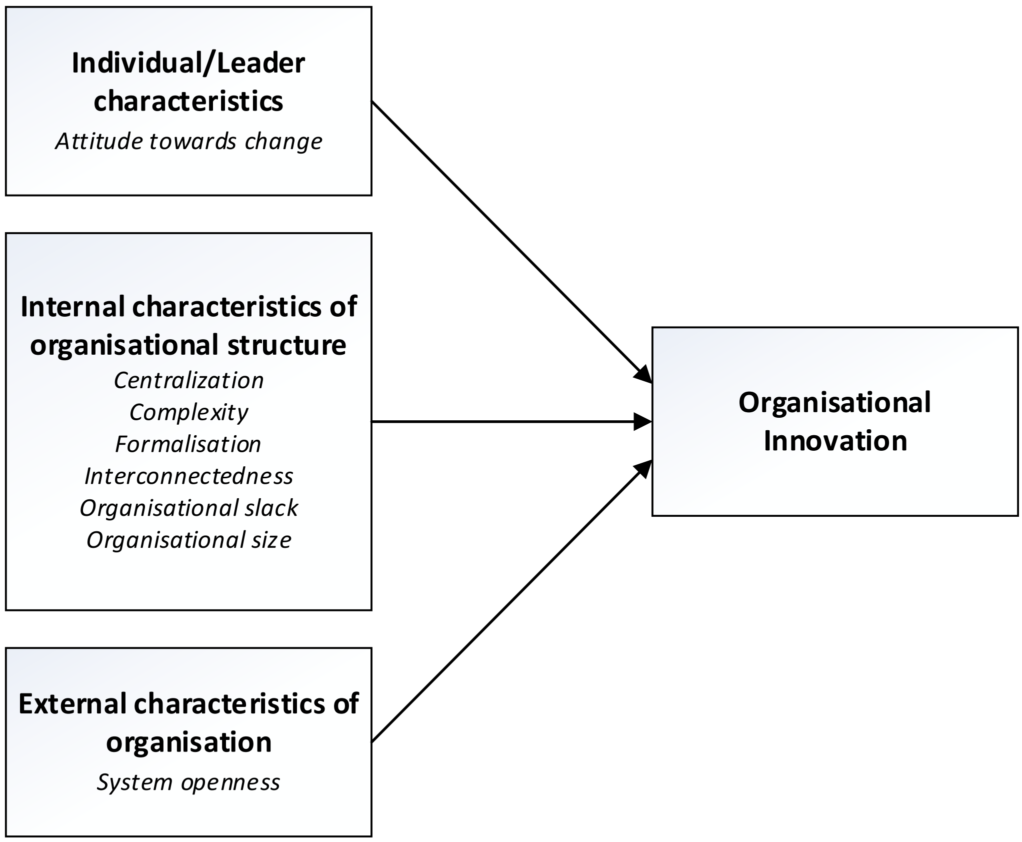


Figure 2.2: *The Diffusion of Innovation model (Source: Rogers, 1995)*

The DOI model has been applied and adapted in various ways. It has been used in studying the adoption of RFID (Jong, 2015; Wang, 2011; Upfold and Liu, 2010); Material Requirements Planning (MRP) systems (Cooper and Zmud, 1990); numerous IS applications (Thong, 1999); adoption and use of intranet applications (Eder and Igbaria, 2001); adoption of Enterprise resource Planning (ERP) systems (Bradford and Florin 2003); e-business applications (Zhu et al. 2006a; Hsu et al. 2006); and e-procurement (Li, 2008); and many more.

2.4.2 Technology–Organisation–Environment (TOE) Framework

The TOE theory was proposed by Tornatzky and Fleischer (1990), to study the adoption of technological innovations. They argued that the decision of a technological innovation adoption is based on factors in the technological, organisational, and environmental contexts (Figure 2.3). The technological context refers to both the internal and external technologies relevant to the organisation. This includes existing technologies and the equipment internal to the organisation (Starbuck, 1976), as well as the set of emerging technologies external to the firm (Thompson, 1967; Khandwalla, 1970; Hage, 1980). The organisational context refers to descriptive measures about the organisation such as the firm's structure and resources, scope (the horizontal extent of a firm's operations), size, and top management support and complexity of its managerial structure. The environmental context is the arena in which an organisation conducts its business. This arena includes the industry, competitors, and dealings with the government (Tornatzky & Fleischer, 1990).

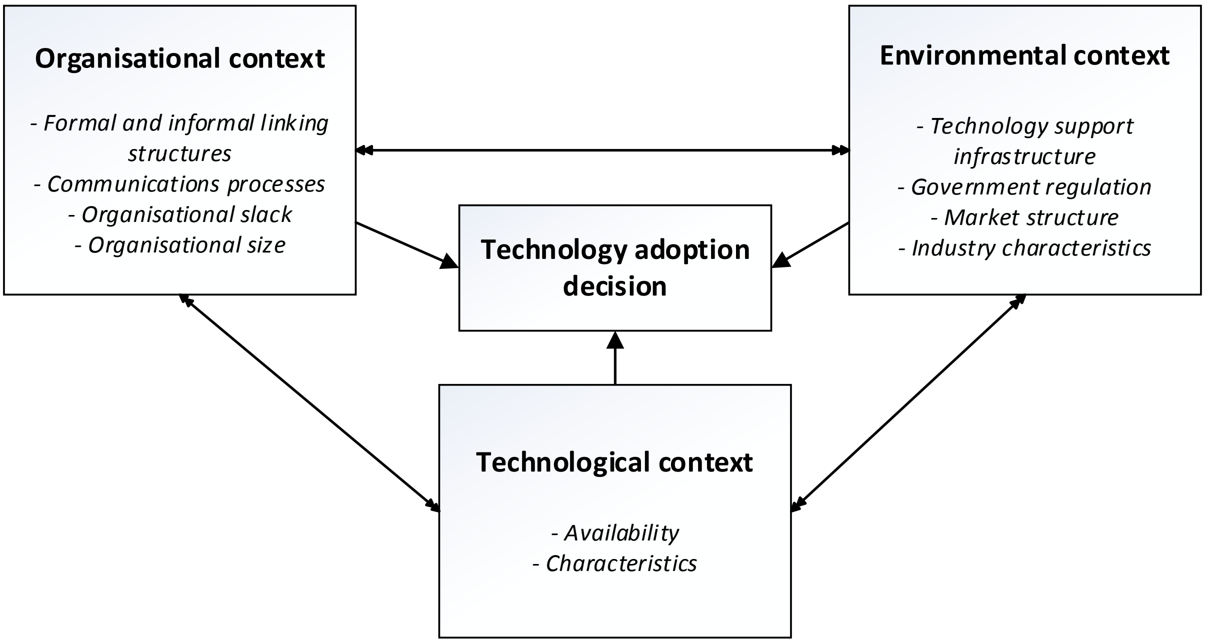


Figure 2.3: *The Technology-Organisation-Environment (TOE) framework (Source: Tornatzky and Fleischer, 1990)*

The TOE framework as originally presented, and later adapted in IT implementation studies, can be used for studying the implementation of different types of IT innovation because it provides a useful analytical framework (Oliveira & Martins, 2011). The TOE framework has a solid theoretical basis and consistent empirical support, and has been found useful in understanding the adoption of technological innovations. The TOE framework has been used in numerous technological, industrial, and cultural contexts, owing to its wide-ranging applicability and explanatory power. It has been used to explain the adoption of electronic data interchange (EDI) (Kuan and Chau 2001), e-marketplace (Joo and Kim, 2004), e-business (Zhu et al. 2006b; Zhu and Kraemer 2005; Zhu et al. 2004; Zhu et al. 2003), RFID systems (Park and Rim, 2011; Wang, 2010), e-procurement systems (Soares-Aguiar and Palma-dos-Reis, 2008), enterprise systems (Ramdani et al. 2009), e-commerce (Oliveira and Martins, 2009; Liu, 2008); enterprise resource planning (ERP) (Pan and Jang, 2008); business to business

(B2B) e-commerce (Teo et al., 2006); knowledge management systems (KMS) (Lee et al., 2009); and multiple IS applications (Thong, 1999). Similarly, the TOE framework has been utilized to explain the adoption of technological innovation in manufacturing settings (Zhu et al. 2006b; Mishra et al. 2007), healthcare and pharmaceutics (Lee and Shim 2007), asset management, and financial services (Zhu et al. 2006b). In the aforementioned studies, the need, search, and decision to adopt innovations have been shown to be influenced by the three elements of technology, organisation, and environment. Although these studies agree with Tornatzky and Fleischer (1990) that the three TOE contexts influence adoption, they adopt a unique set of factors or measures for each specific technology or context that is being studied. Zhu et al. (2004), for instance, proposed "technology readiness" as the pertinent factor in the technological context; "firm size," "financial resources" and "global scope," as the pertinent factors in the organisational context; and "regulatory environment" and "competition intensity" are relevant when researchers wish to understand how the environmental context influences the adoption of e-business. On the other hand, Park and Rim (2011) adopted "technology competence", "technology compatibility", and "technology complexity" as factors in the technological context; "organisational size", "top management support", and "RFID-related costs" as factors in the organisational context; and "government support" and "competitive pressure" as factors in the environmental context that influence adoption of RFID. In summary, it is worth noting that different types of innovations have different factors that influence their adoption. Similarly, different national/cultural contexts and different industries will have differing factors as well (Baker, 2011).

2.4.3 Combination of DOI model and TOE framework

As highlighted in preceding paragraphs, several authors have used both the TOE and DOI to study and understand IT adoption decisions. The TOE and DOI was also used in combination with Institution Theory in the work of Iacovou et al. (1995) to better understand IT innovation decisions. Chong et al. (2009) also used these two frameworks along with CEO characteristics and information sharing culture characteristics to further understand how technological adoptions are decided upon. Zhu et al (2006a) added relative advantage, complexity and compatibility with the two frameworks to further the study (Oliveira and Martins, 2011).

The TOE framework is consistent with the Diffusion of Innovation (DOI) theory in which Rogers (1995) has emphasised technological characteristics, individual characteristics, and both the internal and external characteristics of organisations, as antecedents to any adoption decision (Zhu et al., 2006; Zhu et al., 2003; Thong, 1999; Iacovou et al., 1995; Cooper & Zmud, 1990). These characteristics are similar to the technology and organisation contexts of the TOE framework, however the TOE framework also includes a new and important component which is the environment context (Oliveira & Martins, 2011). The environment context includes both constraints and opportunities for IT innovations. Therefore, the TOE framework makes the DOI theory able to better explain intra-firm innovation adoption (Hsu et al., 2006). For this reason, and drawing upon the empirical support, combined with the existing literature review and theoretical perspectives mentioned earlier, the DOI theory and TOE framework provide a good starting point for this study to analyse and consider appropriate factors for understanding RFID adoption decision-making and processes within organisations (Wang et al., 2010; and Oliveira & Martins, 2011). In view of that, the succeeding section (2.5) discusses the different phases involved in deploying RFID systems.

2.5 RFID system deployment

RFID system deployment describes the processes involved in the implementation of RFID systems from the idea conception/consideration stage to actual implementation/realization of the system in a live working environment. Complete RFID project implementation occurs in three phases. These are the pre-adoption phase, implementation phase and post-implementation phase.

2.5.1 Pre-adoption phase

One of the most popular topics in technology adoption research is the identification of factors that influence the adoption process, with the aim of facilitating or guiding the way to achieving best adoption procedures (Loraas and Wolfe, 2006). The RFID pre-adoption phase includes determining the factors that drive organisations to adopt RFID or barriers that constrain them from adopting RFID.

At the organisational level, a firm is motivated by its objectives, challenges, and/or environment. Thus, it sets out to gain necessary information and knowledge to inform its decision on technology adoption. Ngai et al. (2008) advocate the importance of understanding the concepts of RFID adoption and identifying and analyzing drivers and barriers affecting RFID adoption decisions. Thus, with a view to understanding how individuals, organisations, and groups may perceive the viability of adopting RFID, numerous studies (Alqahtani and Wamba, 2012; Leimeister et al. 2009; Schmitt and Michahelles, 2009; Huber et al., 2007; Eckfeldt, 2005; Swanton, 2005; Asif and Mandviwalla, 2005; Walker, 2004) have adopted the TOE framework, DOI model, and various other technology adoption models as platforms on which to study the adoption and diffusion of RFID. These studies provide evidence that a variety of factors influence decisions to adopt RFID. For example, Brown and Russell (2007) adopted a mixed-method approach to investigate the drivers of RFID adoption in South African retail organisations. The study collected and analyzed quantitative and qualitative data from six retailers. The findings indicated that RFID adoption decisions were determined by technological factors (relative advantage, compatibility, complexity, and cost), organisational factors (culture attributes, information technology expertise, organisation size, organisational readiness), and external factors (competitive pressure, government support, and existence of change agents). Similarly, Wamba et al. (2009) identified 21 factors in the four categories of the TOE framework that were significant in the evaluation and decision to invest in RFID. The 21 factors were mainly technology, resource and environmentally related.

As stated in section 2.4, the TOE model considers three dimensions, namely: technological, organisational, and environmental. These dimensions are discussed in detail in sections 2.5.1.1 to 2.5.1.3.

<u>2.5.1.1 Technological determinants of RFID adoption</u>

The TOE model suggests four technological determinants of innovation adoption –technology complexity, competence, compatibility, and relative advantage.

<u>Technology Compatibility, Complexity and Competence</u>

Compatibility has been defined as the degree to which a technology is perceived to be consistent with an organisation’s strategic intent, infrastructure, practices, and needs (Baek and Lee, 2001; Rogers, 2003; Teo et al., 2004). Rogers (1995) defines Complexity as the degree to which an innovation is perceived as difficult to understand and use. In other words, complexity is how difficult the technology is wielded. New ideas that are simpler to understand are adopted more rapidly than innovations that require the adopter to develop new skills and understanding. Alqathani and Womba (2012) define competence as the organisation's readiness to adopt a technology in the context of resources and services offered by IT professionals Zhu et al. (2006a).

Numerous studies have found that technological compatibility, complexity, and competence have a strong influence on the adoption of RFID (Park and Rim, 2011). In that regard, Fazel et al. (2011) used the TOE framework to study the readiness of the adoption of RFID technologies in Iranian supply chains. The study found that compatibility, complexity, and competence are important determinants of RFID technology adoption. Similarly, Park and Rim (2011) investigated how organisational decision to adopt RFID is influenced by technology compatibility and complexity, and drawing from the work of Ramamutrthy et al. (1999), on the adoption of EDI, showed that adoption of innovative technology is positively influenced by both factors.

Other studies such as Tan et al. (2012) investigated the adoption of RFID technology amongst Logistics providers in Malaysia. Using the Technology construct of TOE, they studied compatibility of the innovation being adopted. Their study found that the application of the RFID in Logistics services is compatible to the industry's regulatory requirements of tracking and tracing, specifically in the identification of container vans. Similarly, Bradford and Florin (2003) investigated how RFID technology integrates with existing IT systems in a Logistic firm. The study found that compatibility is significant in determining RFID adoption and also confirmed that compatibility of RFID technology to organisational strategy is an important determinant in its adoption.

Relative advantage/Perceived benefits

Rogers (2003) defines Relative advantage as "the degree to which an innovation is perceived as being better than he idea it supersedes". This represents the benefits derivable from RFID technology adoption. Perceived benefits have been found to be strong determinants of RFID adoption decisions. Paydar (2013), Attaran (2012) and Goethals and Newlands (2011) state that organisations which implement RFID are driven to adoption by the promise of achieving benefits, particularly achieving higher efficiency, better supply chain monitoring and better collaboration with partners.

2.5.1.2 Organisational determinants of RFID adoption

Tornatzky and Fleischer (1990) argued that organisational factors must be considered in any organisational innovation adoption research. The organisational factors refer to the characteristics and resources of the firm, including the firm's size, culture attributes, degree of centralization, degree of formalization, managerial structure, human resources, amount of slack resources, and linkages among employees.

Numerous organisational characteristics influence the adoption processes of RFID systems. These include organisational strategies, culture, business size, information intensity, and technological maturity (Acar et al., 2005; Caldeira and Ward, 2003; De Burca et al., 2005; Drew, 2003; Levy et al., 2001; Love et al., 2005; Mole et al., 2004). Strategically, IT tools are employed within organisations in order to achieve pre-determined business strategy, therefore, organisational investments in IT are strongly affected by their strategic contexts such as ROIs and cost reduction versus value added strategies (Levy et al., 2001). According to Nguyen (2009), some organisations adopt RFID just to rival/match up to competitors that have implemented the technology. Nguyen (2009) further argues that under such circumstances, lack of definition or strategy of the purposes of RFID adoption may lead problematic implementation or total project failure.

Organisational culture

Organisational culture is a significant determinant of IS/IT implementation in organisations (Bruque and Moyano, 2007; Riolli and Savicki, 2003). According to Carmeli et al. (2008), Hofstede et al. (1990), Jones et al. (2005), and Stewart et al. (2000), there is no clear and unanimous definition of organisational culture. Nevertheless, Marquardt (2002) defines culture as "an organisation's values, beliefs, practices, rituals, and customs". According to Tushman and O'Reilly (1997), organisational culture is a vital component of the operations of any organisation as the success of the organisation is largely dependent on its ability to absorb innovation into its culture and management processes (Tushman and O'Reilly, 1997). Organisational culture that is supportive of innovation encourages the use of innovative solutions to tackle challenges, and considers innovation to be desirable and normal (Lock and Kirkpatrick, 1995). Therefore, the underlying culture of organisations has an impact on the decision to adopt technological innovation like RFID.

Business size

According to extant literature on IT adoption in organisations, business size definable by turnover and/or number of employees is one of the most important determinants of IT adoption (Premkumar, 2003; Love et al., 2005). The importance of business size is partly because of its role as the source of firms' capabilities but also the fact that firms' resources (including financial and human capital) can be an approximation of firm size (Mole et al., 2004; Thong, 2001).

Business size facilitates knowledge acquisition (and/or knowledge generation). Infrastructure-related facilities (IS/IT/ICT) available in the organisation influence RFID adoption (Sharma and Citurs 2005; Sharma et al. 2007). Premkumar (2003) posits that business size is an important determinant between adopters and non-adopters of RFID systems within organisations. The study finds that larger firms have a higher inclination to adopt RFID technologies than smaller ones.

Business size is also an important factor as the RFID integration success depends on the physical, financial, and technological resources of a firm (Brown and Russell 2007; Huyskens and Loebbecke 2007; Matta and Moberg 2006, 2007).

Business Process Re-engineering (BPR)

BPR is the analysis and redesign of workflows within and between organisations in order to optimize end-to-end processes and automate non-value-added tasks (Hammer and Champy, 1993). BPR is aimed at enhancing customer service by improving productivity, eliminating waste and reducing the cost. The main aim of BPR is to realize improvements by fundamentally remodelling organisations to start focussing on making functional or incremental improvements (Ganesh, 2000).

There is a bidirectional relationship between BPR and information technology (IT). While Hammer (1990) argues that IT is a key component in the implementation of BPR, the successful implementation of technological innovation may also largely depend on reengineering. Davenport & Short (1990) advocate that BPR should be conducted after thorough review of IT and business activities and their inter-relationships. They advocate that IT should be considered as more than an automation process but rather as a fundamental way to reshape and redesign business activities and processes. Many factors related to BPR are now considered to be vital components of successful IT deployment efforts (Ganesh, 2000). These include effective alignment of IT infrastructure and BPR strategy, building an effective IT infrastructure, synchronization of IT and business processes, decentralization of resource and processes including decision-making, increasing IT function competency, and effective use of software tools (Ganesh, 2000). Therefore, the analysis of business processes and consequent redesign of workflows is paramount to successful integration of RFID into business processes.

2.5.1.3 Environmental determinants of RFID adoption

The external environment is the setting in which an organisation operates. The external environment influences decision-making behaviors of organisations (Quaddus and Hofmeyer, 2007) and has been recognized to play a significant role in determining RFID adoption decisions (Sharma and Citurs, 2005). In terms of RFID adoption, the external environment consists of external pressure (Matta and Moberg, 2007), government (Matta and Moberg, 2007; Zhu et al. 2003), external information sources (Jeyaraj et al. 2006; Matta and Moberg, 2007), and industry-wide standardization and cost (Brown and Russell, 2007; Cheng and Yang, 2007; Juban and Wyld, 2004).

External pressure

External pressure consists of government or regulatory pressure (Kuan and Chau, 2001) and market or competitive pressure (Chang et al. 2008; Ranganathan and Jha, 2005). Organisations across various sectors are subjected to different government policies and regulations. For example, a growing number of animal exporting countries have introduced legislation on compulsory RFID-based livestock management systems. Therefore, farmers are compelled to adopt RFID technology. Another reason for livestock farmers to adopt RFID is because of the increasing market pressure for RFID-based animal tracking systems (Li and Visich, 2006).

Government

Government can play an important role in RFID adoption and diffusion through information provision, research and development policies and facilities, incentives for adopters, and infrastructural development and enhancement (Scupola, 2003).

External information sources

Organisations interested in RFID can acquire information from external information sources, including technology vendors, NGOs, government agencies (Kettinger, 1994), and through business collaborations (Ghadim and Pannell, 1999). External information sources are a good platform for acquiring RFID knowledge and staying updated with latest RFID developments.

Industry-wide standardization

The lack of industry-wide standardization is considered one of the major constraints of RFID adoption (Schmitt et al. 2008). Although the RFID standards are defined by the International Standards Organisation (ISO), there is a great deal of variety in terms of components, tags, and architectures. Some issues regarding compatibility, readability and interoperability are still unaddressed. Therefore, adopters are looking for an industry-wide standards that would ease their operations (Brown and Russell, 2007; Cheng and Yang, 2007; Juban and Wyld, 2004; Sharma and Citurs, 2005).

2.5.2 Implementation phase

After the decision to adopt RFID technology has been made, numerous factors need to be considered in order to implement the proposed system. The RFID implementation phase includes the methods, designs, and specifications involved in the deployment of RFID systems. The implementation of an RFID system is a complex task that involves both technical and human factors.

As RFID technology becomes more widely applicable, numerous researchers develop models or frameworks for the implementation of RFID systems. Developments in that regard include the development of a 4-step practical guide for implementing RFID (in plant and warehouse operations), consisting of business case justification and return on investment (ROI) analysis, design and architecture, software and system integration, and maintenance and support (Rockwell Automation, 2004); development of RFID deployment strategies consisting of preliminary planning, pilot, technical integration, and rollout phases after business justification (Brown, 2007); development of a 4-phase framework that involves the identification of business processes, piloting, system design and deployment, and sustenance and improvement (Bhuptani and Moradpour, 2005); definition of steps and critical success factors to ensure the proactive implementation of RFID systems (Jones and Chung, 2008); and the development of deployment strategies for RFID implementation consisting of three phases, namely, business, infrastructure, and deployment environments. They also develop phase transition motivators as indicators for the implementing organisation of their progression at each stage (Lutton et al., 2008).

In order to capture the various frameworks for RFID implementation, Ting et al. (2013) propose a 6-step generic framework for the implementation of RFID systems synthesizing the frameworks discussed above and those published in the literature of various industrial applications. Table 2.3 summarizes the 6-step generic framework for the implementation of RFID systems by Ting et al. (2013). The various steps of the framework are discussed in the succeeding paragraphs.

Table 2.3: Generic framework for the implementation of RFID systems

Steps	Description	Reference(s)
Project scoping	Understand the potential and limitations of RFID technology Define the project objectives	Angeles (2005); Vijayaraman and Osyk (2006); Wu et al. (2006); Attaran (2007); Reyes and Jaska (2007); Sellitto et al. (2007); Ngai et al. (2010)
Analysis of existing systems	Collect information Information analysis	Soylemezoglu et al. (2006); Attaran (2007); Jaska (2007); Pålsson (2007); Huang and Tang (2008); Hellström (2009); Kim and Garrison (2010); Ngai et al. (2010)
System design	Requirement analysis Hardware/ software selection Develop a new process	Soylemezoglu et al. (2006); Reyes and Jaska (2007); Huang and Tang (2008); Hellström (2009); Ngai et al. (2010)
Prototype testing	Debug System Adaptation	Reyes and Jaska (2007); Soylemezoglu et al. (2006); Ngai et al. (2010)
Implementation	System deployment Training	Soylemezoglu et al. (2006); Spekman and Sweeney (2006); Attaran (2007); Reyes and Jaska (2007); Ngai et al. (2010)
Continuous improvement	Monitoring Collect feedback from users	Ngai et al. (2010)

2.5.2.1 Project scoping

The project scoping phase involves the definition of project objectives, assessment of potentials and limitations of the proposed system, and general project planning. This phase enables the management of expectations and provision of a clear direction for the project implementation team.

Understand the potential and the limitations of RFID technology

Organisations are prone to overestimating on minunderstanding the potentials of a new RFID system, thereby creating unrealistic expectations about the system (Hardgrave and Miller, 2006). Although multiple benefits can potentially be derived from RFID technology, it is paramount that organisations become aware of achievable targets and limitations before forging ahead to implement an RFID system.

Define the project objectives

It is important for the RFID implementation team to focus on identifying areas or processes that need to be improved by the proposed system. This enables the clear definition of the project scope and objectives. A clear scope and objectives in implementing the system will guide the organisation towards a productive programme and enable decision makers to develop well-defined boundaries for the implementation of the project (Ngai et al., 2010).

2.5.2.2 Analysis of existing systems

This phase involves information gathering, evaluation, and analysis of existing systems, in order to identify the processes and procedures that will be redesigned for the proposed system.

Gathering information

Data on existing systems, operation of the proposed system, and activities and processes will need to be gathered. This can be done using a variety of methods including interviews with employees and other key stakeholders, observation of front-line employees, etc.

Information analysis

After data collection, the information collected will be analyzed using multiple techniques and methodologies such as diagramming and workflow diagrams. In that way, areas for improvement can be identified and prioritized (mostly according to their impact on the organisation’s performance). Those processes that are more likely to bring about more potential benefits to the organisation are thus given higher priority in implementation.

2.5.2.3 System design

This stage involves requirement analysis, hardware and software selection, and the development of the new processes that match the needs and requirements of the proposed system.

Requirement analysis

Requirement analysis involves assessing which processes need to be modified, redesigned, or optimized to improve process flow.

Hardware/Software selection

Selection of appropriate hardware and software is paramount to the success of RFID implementation as it directly determines the performance of an RFID system. This stage involves the identification, selection, and testing of hardware and software to be used in the proposed system. Typically, an RFID system comprises hardware items such as RFID tags, antenna and readers; which should be carefully selected to avoid interference and maximize performance. The software architecture, including the RFID middleware and the application level software also need to be selected and tested carefully. The testing of the hardware gives decision-makers a clearer picture of how the hardware and software items function in an integrated system, as well as providing data for measuring the reliability of the system.

Developing new processes

This stage is builds on findings from the requirement analysis stage. It involves either the modification or elimination of existing processes or the development of new ones. This is done in line with the project objectives.

2.5.2.4 Prototype Testing

This phase involves demo testing, debugging the technical system, and collecting feedback from users after the demo testing in order to aid users in understanding the system. The testing can be conducted in simulated environments or in the actual work environment.

Debugging

Any bugs and/or system collisions in the hardware and software tests are detected in this stage. Scenario testing is conducted to assess the flexibility and capability of the system (Ting et al., 2013).

System adaptation

This stage involves reviewing and documenting problems encountered during the demo testing in order to fine- tune the system and resolve issues. This is necessary in order to ensure that the proposed RFID system will deliver the expected performance results.

2.5.2.5 Implementation

This phase takes place after system adaptation. It typically involves the installation and commissioning of hardware and software systems, change management, training, and system deployment. This stage is critical to the success of the implementation. Sometimes, implementation might not involve a clean changeover to the new system; the new RFID system may run side-by-side with an existing system, and the latter will phase out only when the performance of the new system is assured.

System deployment

System deployment includes the installation and commissioning of hardware and software systems, and the development of new procedures. This stage considers hardware and software issues such as antenna and tag positioning, and middleware configuration and deployment.

Training

This stage involves the provision of basic and technical training of users of the newly deployed RFID system. The training typically includes basic knowledge of operating the system, hands-on training in using the new system and the changed processes (Ting, et al., 2013). This is done in order to provide users with opportunities to understand the guidelines and precautions regarding using the new system.

2.5.2.6 Continuous improvement

This phase includes system monitoring and the collection of user feedback. It involves continuously evaluating the system's performance in line with pre-set objectives, enhancing the system with emergent technologies and/or adapting it to match the changing needs of the market.

Monitoring

This stage involves observing the performance of the newly deployed system addressing problems encountered. The actual performance of the system should be compared with the targets set during the system design stage.

Collecting feedback from users

This stage involves monitoring system performance, collecting user feedback, and tracking the development of new technology. Feedback from the different stakeholders of the newly deployed system is collected and analysed in order to highlight potential technical and operational problem areas.

2.5.3 Post-implementation phase

The RFID post-implementation phase involves the processes after the launch of the RFID system. This phase primarily involves managing the benefits derived from the system.

2.5.3.1 Benefits derivable from RFID implementation

RFID benefits are defined as the advantages/profits that a firm derives, that are attributable to its use of RFID technology. Over the years, numerous cost-benefit analyses have been conducted to establish the feasibility and profitability of RFID investments.

RFID technology can improve various processes in numerous business operations (Roy et al., 2004; Bolan, 2005). Major benefits of RFID include its unique capability to share information with business partners, allowing collaboration on inventory management, planning, forecasting, and replenishment (Vijayaraman and Osyk, 2006). Multiple studies attest to the potential of RFID in building supply chain relationships, synchronizing supply and demand, and process optimization and improvement (Angeles, 2005; Michael and McCathie, 2005; Tracy, 2005; Bose & Pal, 2005; Arnold and Bures, 2003). Other studies such as Lin and Ku (2009), Zelbst et al. (2008a), Tzeng et al. (2007), and Hou and Huang (2006) have investigated the impact of RFID technology utilization and benefits derived on operational performance and/or supply chain performance. Table 2.4 provides a summary of RFID benefits derived from numerous studies conducted in recent years. The majority of the studies attempt to derive the economic benefits of RFID and/or ascertain the value of an RFID investment.

Table 2.4: Summary of benefits derivable from RFID implementation

Benefits derivable from RFID	References	Main results/findings
Obtaining timely and accurate information	[1, 2, 11, 13, 214, 215, 224]	Frameworks and systematic approaches to reduce information distortion, amplification, and inventory inaccuracies.
Reducing shrinkage, misplaced inventory and transaction errors	[3, 4, 5, 6, 7, 8, 9, 10, 142, 179, 161, 187, 188, 189, 191, 212, 219, 222, 242, 250]	Characterization of the major causes of inventory inaccuracy and analyses of the potential of RFID to eliminate the causes.
Improving replenishment of supplies	[21, 14, 15, 17, 18, 19, 20, 22, 12, 6, 16, 10, 220]	Design of RFID-based models and frameworks for the management of product replenishment.

Tackling product counterfeiting	[83, 85, 75, 79, 21, 74, 81, 82, 162]	Use of RFID for product authentication, tracking and tracing. Studies of the viability of RFID-based anti-counterfeiting systems.
Improving product flow	[135, 117, 148]	Use of RFID to enhance the responsiveness of logistics workflow and synchronize supply and demand in supply chains.
Improving forecasting	[136, 137]	Use of RFID-enabled inventory models to track, dispatch and forecast materials.
	[143, 147, 168, 172, 175, 192, 193, 244, 255, 256]	Development of RFID-enabled real-time monitoring systems to improve visibility, control and operation of manufacturing equipment and routines.
Improving distribution planning and fleet management	[144, 146, 170, 195, 196, 213, 216, 232]	Use of RFID for accurate, secure and reliable product distribution and fleet management through the provision of automatic identification of objects, asset tracking, geofencing (i.e., restricting products and assets to specific geographical areas or locations or denying access to premises).
Enabling in-transit product visibility, including condition monitoring	[180, 156, 159, 160, 161, 173, 176, 194]	Use of RFID to facilitate the capture of accurate and timely data in mobile environments and/or about products in transit (including for monitoring the physical conditions of products and dynamic routing of vehicles).
Improving warehouse management	[138, 167, 174, 176, 180, 199]	Design and implementation of RFID-enabled systems for effectively determining optimal storage spaces and conditions, and for improving quality assurance of inventory receiving and dispatching processes.
Improving reverse logistics	[43, 66, 67, 68, 169, 231, 247]	Tracking and controlling of reusable products and assets; inventory management of recycled products; return centre/warehouse management; enhancing the user value of recovered products. See also "closed-loop product lifecycle management" below.
	[23, 24, 25, 26, 27, 28, 143, 175, 31, 32, 140, 151, 154, 163, 198, 201, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 155, 172, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 139, 149, 153, 165, 197, 202, 203, 200, 209, 210, 211, 218, 229, 245, 246, 248, 252, 257]	Use of RFID to plan, monitor and reconfigure the flow of information, production processes and product so as to increase the overall system throughput, efficiency, responsiveness and effectiveness. Use of RFID to improve (a) the integration of timely and accurate data flows into information systems, (b) system-to-system communication, and (c) better intra- and inter-organizational business process integration.
Enabling product tracking	[69, 169, 71, 72, 73, 145, 166, 177, 204, 205, 221]	Impact of RFID on product lifecycle management in closed-loop supply chains. Development of RFID-based models to process and meet recycled product and component demand. Design of RFID-based systems for

		collecting product usage data for the sake of proactive product maintenance.

1-Dai and Tseng (2012), **2**-Rekik (2011), **3**-Camdereli and Swaminathan (2010), **4**-Uckun et al. (2008), **5**-Sahin et al. (2008), **6**-Rekik et al. (2007), **7**-Heese (2007), **8**-Sari (2008), **9**-Fleisch and Tellkamp (2005), **10**-Kang and Gershwin (2004), **11**-Bottani and Rizzi (2008), **12**-Wang et al. (2008), **13**-Bottani et al. (2010), **14**- Chew et al. (2013), **15**-Su and Roan (2013), **16**-Kok et al. (2008), **17**-Duan and Liao (2013), **18**-Poon et al. (2011), **19**-Wang et al. (2010), **20**-Bendavid et al. (2010), **21**-Bendavid and Boeck (2011), **22**-Gaukler (2010), **23**-Balocco et al. (2011), **24**-Zhang et al. (2010), **25**-Lee and Park (2008), **26**-Sari (2010), **27**-Hong et al. (2010), **28**-Bhakoo and Chan (2011), **29**-Brintrup et al. (2010), **30**-Wang et al. (2010), **31**-Hellström and Wiberg (2010), **32**-Chen et al. (2013), **33**-Zelbst et al. (2010), **34**-Ustundag and Ikcan (2008), **35**-Liu et al. (2008), **36**-Yang et al. (2013), **37**-Swartz et al. (2010), **38**-Liu and Chen (2009), **39**-Shin et al. (2011), **40**-Yuksel and Yuksel (2011), **41**-Dash (2011), **42**-Zhang et al. (2012), **43**-Zhou and Piramuthu (2013), **44**-Ko et al. (2011), **45**-Chatziantoniou et al. (2011), **46**-Brusey and McFarlane (2009), **47**-Wang et al. (2011), **48**-Mehrjerdi (2013), **49**-Zelbst et al. (2012), **50**-Wamba (2012), **51**-Bendavid et al. (2012), **52**-Hong et al. (2011), **53**-Kvarnström and Vanhatalo (2010), **54**-Ngai et al. (2009), **55**-Ngai et al. (2008), **56**-Wamba and Boeck (2008), **57**-Wang et al. (2007), **58**-Chow et al. (2007), **59**-Costa et al. (2013), **60**-Zhang and Li (2012), **61**-Azevedo and Carvalho (2012), **62**-Bjork et al. (2011), **63**-Curran and Porter (2007), **64**-Jaselskis et al. (2003), **65**-Klundert et al. (2008), **66**-Nativi and Lee (2012), **67**-Vishwa and Felix (2010), **68**-Visich and Khumawala (2007), **69**-Ondemir et al. (2012), **70**-Thoroe et al. (2009), **71**-Cao et al. (2009), **72**-Stankovski et al. (2009), **73**-Jun et al. (2009), **74**-Kwok et al. (2010), **75**-Catarinucci et al. (2012), **76**-Alomair et al. (2011), **77**-Revere et al. (2010), **78**-Shi et al. (2012), **79**-Rahman and Ahamed (2012), **80**-Juels (2006), **81-**Kwok et al. (2010), **82**-Coutasse et al. (2010), **83**-Li (2013), **84**-Baldini et al. (2012), **85**-Schapranow et al. (2011), **86**-Muir (2007), **87**-Szmerekovsky et al. (2011), **88**-Miragliotta et al. (2009), **89**-Langer et al. (2007), **90**-Gaukler et al. (2007), **91**-Lee and Ozer (2007), **92**-Choi (2011), **93**-Gaukler (2011), **94**-Ustundag and Tanyas (2009), **95**-Hozak and Collier (2008), **96**-Amini et al. (2007), **97**-Caridi et al. (2013), **98**-Vlachos (2013), **99**-Anand and Wamba (2013), **100**-Mehrjerdi (2010), **101**-Wen et al. (2009), **102**-Wen and Chang (2008), **103**-Miragliotta et al. (2009), **104**-Visich et al. (2009), **105**-Whitaker et al. (2007), **106**-Vijarayaman and Osyk (2006), **107**-Hou and Houang (2006), **108**-Lai et al. (2005), **109**-Karkkainen (2003), **110**-Veronneau and Roy (2009), **111**-Ross et al. (2009), **112**-Azevedo and Ferreira (2009), **113**-Kumar et al. (2009), **114**-Gaukler and Hausman (2008), **115**-Cannon et al. (2008), **116**-Delen et al. (2007), **117**-Karaer and Lee (2007), **118**-Jones et al. (2007), **119**-Yu (2007), **120**-Wang et al. (2006), **121**-Higgins and Cairney (2006), **122**-Angeles (2005), **123**-Asif and Mandviwalla (2005), **124**-Jones et al. (2005), **125**-Srivastava (2004), **126**-Page (2000), **127**-Lee and Lee (2012), **128**-Ustundag (2010), **129**-Bosona and Gebresenbet (2013), **130**-Smart et al. (2010), **131**-Bendavid et al. (2009), **132**-Li et al. (2006), **133**-Attaran (2007), **134**-Barut et al. (2006), **135**-Lee et al. (2011), **136**-Saygin (2007), **137**-Baars et al. (2009), **138**-Yoon and Zhou (2011), **139**-Garcia et al. (2007), **140**-Bureau et al. (2011), **141**-Bottani et al. (2009), **142**-Hardgrave et al. (2009), **143**-Brintrup et al. (2010), **144**-Schmidt et al. (2013), **145**-Singh and Midha (2008), **146**-Will and Blecker (2012), **147**-Huang et al. (2012), **148**-Kvarnstrom et al. (2011), **149**-Bendavid and Cassivi (2010), **150**-Veeramani et al. (2008), **151**-Meiller et al. (2011), **152**-Jeong and Lu (2008), **153**-Chong and Chan (2012), **154**-Castro et al. (2013), **155**-Safari et al. (2013), **156**-Angeles (2013), **157**-Wei and Zhang (2013), **158**-Mirza and Brohi (2013), **159**-Nguyen et al. (2013), **160**-Grunow and Piramuthu (2013), **161**-Bertolini et al. (2013), **162**-Chen et al. (2012), **163**-Yan et al. (2012), **164**-Bhattacharya (2012), **165**-Memon and Khoja (2012), **166**-Maleki and Meiser (2011), **167**-Lao et al. (2011), **168**-Ferrer et al. (2011), **169**-Thoroe et al. (2011), **170**-Ngai et al. (2011), **171**-Sandhya and Rangaswamy (2011), **172**-Zhang et al. (2011), **173**-Shi et al. (2010), **174**-Dimitropoulos and Soldatos (2010), **175**-Wang (2010), **176**-Zeimpekis et al. (2010), **177**-Luttropp and Johansson (2010), **178**-Ngai et al. (2010), **179**-Hardgrave et al. (2013), **180**-Singh et al. (2008), **181**-Lee et al. (2012), **182**-Yazici (2014), **183**-Leung et al. (2014), **184**-Tsekrekos et al. (2014), **185**-Roper et al. (2014), **186**-Gastaldi et al. (2014), **187**-Lam et al. (2014), **188**-Fan et al. (2014), **189**-Thiesse and Buckel (2015), **190**-Fan et al. (2015), **191**-Wang et al. (2014), **192**-Zelbst et al. (2014), **193**-Zhong et al. (2015), **194**-

Mejjaouli and Babiceanu (2015), **195**-Zhong et al. (2015), **196**-Jagga et al. (2014), **197**-Chen et al. (2014), **198**-Yang et al. (2014), **199**-Sooksaksun and Sudsertsin (2014), **200**-Eksioglu and Shin (2015), **201**-Chung et al. (2014), **202**-Choi et al. (2015), **203**-Kapoor et al. (2014), **204**-Kumar and Rahman (2014), **205**-Glock and Kim (2014), **206**-Ray et al. (2014), **207**-Ding et al. (2014), **208**-Ma and Saxena (2014), **209**-Gertts and O'leary (2014), **210**-Kapoor et al. (2011), **211**-Zhou et al. (2012), **212**-Chan et al. (2012), **213-**Ngai et al. (2012), **214-**Zhou and Piramuthu (2015), **215-**Zhou and Piramuthu (2015), **216-**Ngai et al. (2007), **217-**Zhou et al. (2009), **218**-Oztekin et al. (2010), **219**-Çakıcı et al. (2011), **220-**Condea et al. (2012), **221-**Bottani et al. (2014), **222**- Bertolini et al. (2013), **223-**Rinaldi and Bandinelli (2015), **224-**Hinkka et al. (2015), **225**-Yan et al. (2012), **226**-Bertolini et al. (2012), **227-**Hinkka (2012), **228-**Vecchi and Brennan (2010), **229-**Nummela et al. (2009), **230-**Bottani et al. (2009), **231**-Uckelmann et al. (2009), **232**-Meyer-Larsen et al. (2012), **233**-Maffia et al. (2012), **234-**Whang (2010), **235-**Thiesse et al. (2009), **236**-Hsiaoping (2013), **237**-Wamba and Chatfield (2009), **238**-Cheon-pyo and Shim (2007), **239**-Kapoor et al. (2009), **240**-Kasiri et al. (2012), **241-**Bose et al. (2009), **242**-Kök and Shang (2014), **243-**White et al. (2008), **244**-Piramuthu et al. (2013), **245-**Jimenez et al. (2013), **246**-Chongwatpol and Sharda (2013), **247-**Ondemir and Gupta (2014), **248**-Zhou (2009), **249**-Kim and Sohn (2009), **250**-Xu et al. (2012), **251-**Zhou and Piramuthu (2012), **252**-Cinicioglu and Shenoy (2012), **253**-Cui et al. (2016), **254**-Yang et al.(2016), **255**-Barenji et al. (2016), **256**-Appelhanz et al. (2016), **257**-Kim et al. (2016)

2.6 Review implications

The findings of this review illustrate the determinants of RFID adoption. In particular, the importance of technological, organisational and environmental factors on determining RFID adoption is highlighted. However, the effects of these factors on RFID adoption vary across different cultural and industrial contexts. Thus, there is a need to analyze the determinants of RFID adoption and how they interact with organisational and industrial culture in order to obtain a better understanding of RFID adoption.

Although various studies have explored how RFID can provide benefits to businesses, the high cost, to the firm, of implementing RFID calls for an optimal decision to be made on whether or not to adopt the technology. Therefore, it is necessary for researchers to study and quantify the achievable benefits of RFID and balance them against the cost of adopting RFID. In this regard, a framework is needed, which takes as input some key quantifiable firm and/or supply chain characteristics and yields an advisory concerning the benefit versus the cost of implementing RFID. In other words, simple rules of thumb on the benefits of RFID are needed. This would enable practitioners to meaningfully and affordably examine the relationship between RFID adoption and its benefits. There is equally a need to concretely characterize what "benefits" imply. For example, in the case of business benefits, it is necessary to map the dimensions and sub-dimensions that may be used to define business benefits.

The benefits of RFID are likely to be moderated by factors such as firm size, business/industrial sector of the firm, product line, business structure and strength of culture, existing information technologies and systems, the business process re-engineering that must accompany RFID adoption, external environment, etc. The external environment is determined by elements such as the available basic infrastructure, present communication systems, economic conditions, regulatory policies, taxation, culture, skills market, manpower costs, and climate. The extents to which these factors influence the benefits derivable from RFID investments have not been well studied in the extant literature.

Numerous studies highlight the contribution of RFID in supporting more responsive and efficient logistics activities, improving product quality, customer satisfaction, and hence overall supply chain efficiency (Mehrjerdi, 2013; Zelbst et al. 2012; Wang et al. 2011; Brusey and McFarlane, 2009). However, realizing these benefits is dependent on the nature, efficiency and effectiveness of intra- and inter-organisational culture, processes and information systems. Therefore, further research is needed, on the one hand, to explore the impact of RFID on legacy information systems and intra- and inter-organisational setups and processes, and, on the other hand, to identify and understand how these processes can be optimized by RFID.

In a survey of RFID user community, Musa et al. (2014) found that users prefer open and interoperable systems to proprietary systems (tags, readers, middleware, and data exchange infrastructure and formats between RFID and legacy backend ERP systems). However, the development of compatible RFID platforms and systems seems is still far behind expectation. Full compatibility between RFID systems, and between RFID and other sensor types and communication protocols, is needed if RFID is to play the roles that have been projected for it in the era of Internet of Things (IoT). Fortunately, industry and government directives are gradually leading to common standards across industries and technologies, permitting future interoperability across devices (Wu et al., 2013; Farris et al., 2013; Xu and Chen, 2013; Gao et al., 2012).

2.7 Summary

This chapter provides a comprehensive review of RFID application in different industrial settings. The review highlights the importance of numerous factors in influencing RFID adoption decisions, implementation processes, and benefits. These factors can be classified under technological, organisational, or environmental contexts. Therefore, the decision to utilize the TOE framework to explore the aims and objectives of this study is justified.

The review also highlights that multiple benefits can be derived from RFID implementation. However, RFID system implementation is complex and not only relates to the technical aspects of system development and deployment but also involves human, organisational, and environment issues, business processes, project management skills and knowledge, and support and commitment from management and staff. Therefore, the next chapter proposes a research framework for RFID system adoption and implementation that consists of a multi-stage process and takes these factors into account. The next chapter aims to meet the need for a more comprehensive approach into investigating drivers and barriers of RFID adoption; one which should include investigating organisational, environmental and technological aspects of RFID adoption.

CHAPTER 3 – RESEARCH FRAMEWORK

3.1 Introduction

As highlighted in the previous chapter, numerous studies provide evidence that a variety of factors influence decisions to adopt RFID. However, most of the studies simply focus on the technology itself, often disregarding broader societal, organisational, cultural, and economic factors that often determine how a new technology is adopted (Baker, 2011). Thus, the studies have fallen short of drawing important conclusions that can be applied in practice (Hsu et al., 2006). Thus, RFID adoption and benefits remain the key focus for organisations.

This chapter proposes a research framework to investigate and understand key factors that influence RFID adoption, and its subsequent implementation processes and benefits. It aims to meet the need for a more comprehensive approach into investigating drivers and barriers of RFID adoption; one which should include investigating privacy, security, regulatory, and cultural aspects of RFID adoption. The extant literature on RFID, along with the technology–organisation–environment (TOE) framework derived by Tornatzky and Fleischer (1990) and the Diffusion-Of-Innovation (DOI) theory of Rogers (1995), were used as the theoretical models to identify and group the factors investigated into 3 main categories: technological determinants, organisational determinants, and environmental determinants. The TOE and DOI frameworks provide a good starting point when analysing appropriate factors for understanding the selection process of auto-ID technologies (Wang et al., 2010b).

For each category, the key factors that influence RFID adoption, implementation, and benefits were identified based on a comprehensive review of the literature on IS implementation, RFID in supply chain management, and RFID implementation reports. This allows factors investigated to be based not only on theoretical technological adoption models but on social and industrial processes by which diffusion of innovation/technology occurs.

The main aim of the proposed framework is to enable a structured and systematic investigation into our research questions (section 1.3); explain the critical issues within the decision making process of RFID technology adoption; and determine the interaction of technological, organisational, and environmental characteristics with RFID adoption and implementation processes, and with benefits derived subsequently. The framework is expected to offer an effective guide to better understanding RFID adoption decisions and benefits. The framework requires empirical validation by the researcher, which is reported in Chapters 5 of this thesis.

3.2 Developing the framework

A research framework is a written or visual presentation that "explains either graphically, or in narrative form, the main issues to be studied – the key factors, concepts or variables and the presumed relationship among them" (Huberman and Miles, 1998). It consists of concepts and, together with their definitions and reference to relevant literature, existing theory that is used for a particular study. According to Swanson and Richard (2013), a research framework must demonstrate an understanding of theories and concepts that are relevant to the research aim and questions and relate to the broader areas of knowledge being considered.

A research framework is also used to limit the scope of the relevant data by focusing on specific variables and defining the specific viewpoint (framework) that the researcher will take in analyzing and interpreting the data to be gathered. It also facilitates the understanding of concepts and variables according to given definitions and builds new knowledge by validating or challenging theoretical assumptions.

Trochim (2006) and Swanson and Richard (2013) suggest strategies to develop of an effective research framework. These include

- **Identification of research problem and key research variables** – The research problem should be clearly stated as it anchors the entire study and forms the basis from which the research framework is constructed. This is followed by the identification of the key variables in the research.
- **Review relevant literature and key social science theories –** Investigate how previous works have addressed the/a related research problem. Identify the assumptions from which the researcher(s) addressed the problem. Identify and choose the theory that can best explain the relationships between the key variables in the study.
- **Develop constructs and propositions** – Group variables into independent and dependent categories. Proceed to review the theories, assess their relevance to your research, and formulate hypotheses to be investigated.

Although RFID is often considered simply as an input device to an Information System (IS) (Stair and Reynolds, 2008), many practitioners consider and treat the technology to be an IS in its own right and therefore reap more benefits from its implementation (Doerr et al., 2006). Consequently, this study adopts the strategies suggested by Trochim (2006) and Swanson and Richard (2013) in developing a research framework and reviews relevant IS literature and literature on RFID.

Extant literature on IS implementation has been categorised into either factor or process research (Sambamurthy and Kirsch, 2000; and Newman and Robey, 1992). Factor research involves adopting survey research methodologies in identifying the factors or determinants that are critical for the successful adoption and deployment of IS systems (Aladwani, 2001). Using the factor approach, this framework derives a set of factors and sub-factors that influence RFID adoption decisions through the synthesis and analysis of extant IS and RFID literature. On the other hand, process research involves sequencing of discrete and collective activities and events in order to achieve an outcome of particular interest (Pettigrew, 1997). For example, some studies under the process approach have investigated the adoption of IS in supply chains and found that the interaction between the strategic analysis (for instance network structure, business processes and management component) and the technological analysis is crucial in the technology adoption process (Ilie-Zudor et al., 2011).

Although factor research is valuable for advancing understanding of the IS adoption process, it adopts a static view (Aladwani, 2001), which limits its adequacy in explaining the dynamics of the technology adoption process. Aladwani (2001) suggests a process research approach or a combination of factor and process approaches in order to improve research in IS topics. Therefore, this study adopts both factor and process approaches to investigate RFID adoption, implementation, and benefits within organisations. This study does that by first using the factor approach to identify, from the synthesis and analysis the extant IS and RFID literature, a comprehensive set of factors and sub-factors that influence RFID adoption decisions. Building on the technology–organisation–environment (TOE) framework of Tornatzky and Fleischer (1990) and the Diffusion of Innovation model of Rogers (1995), this study develops a research framework that categorises the identified factors into three categories: (1) technological; (2) organisational; and (3) environmental factors. On the other hand, using the process approach, this research identifies all the key steps and activities in the RFID implementation process. These include project scoping; analysis of existing systems; system design; prototype testing; implementation; and continuous improvement.

The proposed research framework, guided by relevant theories and literature, provides a platform to investigate and understand the key factors and sub-factors that influence RFID technology adoption decisions, implementation processes and benefits. In doing so, it gives the basis for hypotheses formulation and choice of research methods in Chapter 4. It also enables the researcher to specify which key variables influence RFID adoption decisions, implementation processes, and benefits and highlight the need to examine how those key variables might differ and under what circumstances. Finally, it supports the researcher to investigate the hypotheses enacted with empirical findings in Chapter 5. This enables the researcher to address the research questions of the study.

3.3 The research problem

Despite RFID being considered the prime technology of 21st century management (Chao et al., 2007; Wyld, 2006), its adoption is still being weighed down by a variety of issues including technological uncertainties, competition with established auto-ID technologies (e.g. bar code), costly software and services, data management challenges, unclear Return-On-Investments (ROIs), and global standardization issues (Dortch, 2008; Bose and Lam, 2008; Vijayaraman and Osyk, 2006; Li et al., 2006; Wu et al., 2006). Consequently, organisations still struggle to make informed, optimal decisions on whether or not to adopt the technology.

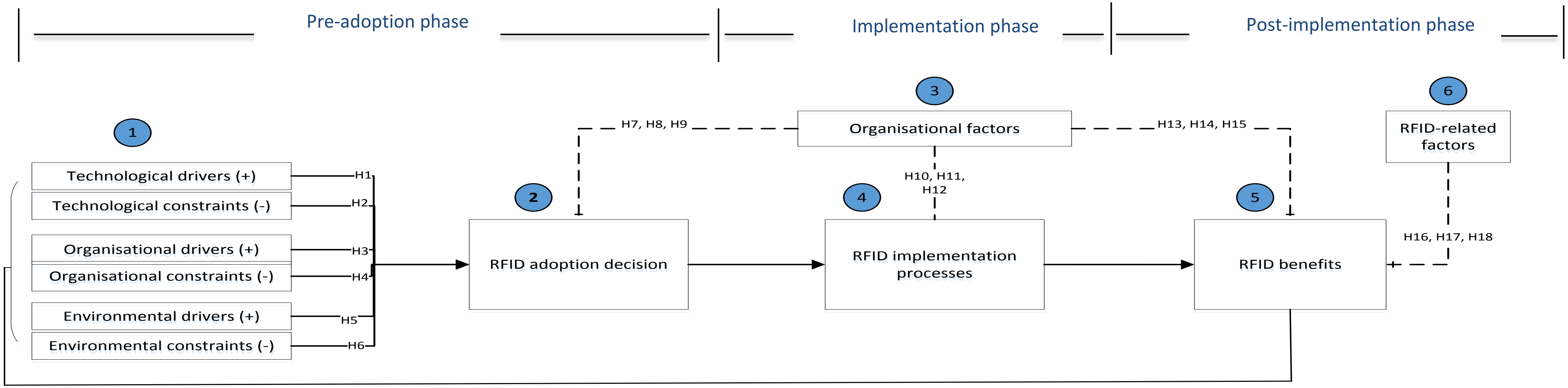
Numerous studies on factors that influence the adoption and diffusion of RFID (Alqahtani and Wamba, 2012; Wang et al., 2010; Li et al., 2010; Lin, 2009; Schmitt and Michahelles, 2009; and Sharma et al., 2007) have been conducted. However, the majority of these studies fail to draw important conclusions that can be applied in practice, as they are limited to simply focusing on the technology itself, often disregarding complex organisational, cultural, and environmental factors that determine how a new technology is adopted, its diffusion within organisations, and how benefits derived from its implementation interact with organisation characteristics (Oliveira and Martins, 2011; MacVaugh and Schiavone, 2010). Thus, there remains a need to develop an advisory framework, one which considers quantifiable firm characteristics and the costs and benefits of implementing RFID, in guiding organisational decisions on RFID adoption. For example, it is necessary to determine how RFID adoption decisions, RFID implementation processes, and derivable RFID benefits interact with factors such as business size, business structure and culture, existing information technologies and systems, and business process re-engineering. The extents to which these factors influence the organisational decision to adopt RFID, the RFID implementation process, and benefits derivable from RFID investments have not been well studied in the extant literature. Therefore, the proposed framework seeks to provide a platform and a guide to investigate the impact of technological, organisational and environmental factors on organisational decision to adopt RFID, and its subsequent implementation processes and benefits. It is expected that findings from this research will aid in clearing the ambiguity surrounding factors that influence RFID adoption decisions and their interactions with organisational characteristics.

3.4 Key variables/constructs

Six key constructs make up the research framework. These are: Determinants of RFID adoption; RFID adoption decision; Organisational factors; RFID implementation processes; RFID benefits; and RFID-related factors. The constructs were developed from the Diffusion of Innovation (DOI) theory (Rogers, 1995) and the Technology-Organisation-Environmental (TOE) framework (Tornatzky & Fleischer, 1990), extant literature on RFID implementation in organisations, and RFID implementation reports from industry. Further details of how each variable/construct was derived are given in the succeeding section.

Figure 3.1 illustrates key constructs of the research framework. The headed arrows signify the direction of movement in an RFID system deployment process. An encircled number refers to a particular construct discussed in this chapter. As illustrated in the figure, the drivers and constraints (①) influence the decision to adopt RFID (②). When the decision to adopt RFID is made, the process continues to implementation (③), and finally to benefits (④). A key determinant of RFID is perceived benefits, therefore the benefits derived can influence the further implementation of RFID systems. For example, benefits from pilot projects can lead to full/wider implementation.

Details of all key constructs of the research framework are explained in sections 3.4.1 to 3.4.6, including how they were derived.



Key:

1. Determinants of adoption include factors derived from the DOI model (Rogers, 1995), TOE framework (Tornatzky and Fleischer, 1990), & RFID literature. They include:

- ***Technological determinants:*** perceived RFID benefits, perceived RFID standards convergence, availability of IT/IS infrastructure, capital and recurrent costs, technical issues, security
- ***Organisational determinants:*** financial readiness, global expansion, manpower availability, requirements for business process change
- ***Environmental determinants:*** industrial and competitive pressure, government support, privacy, regulatory pressure

2. RFID adoption decision is considered as a binary option: YES or NO. The organisations to be surveyed include those that have adopted RFID and those that are yet to adopt RFID.

3. RFID implementation processes were derived from Ting et al. (2013) and Ngai et al. (2013) who propose a 6-step generic framework for the implementation of RFID systems based upon the synthesis of the frameworks discussed above and those published in the literature of various industrial applications. The processes include: project scoping, analysis of existing systems, system design, prototype testing, implementation, and continuous improvement.

4. RFID benefits investigated were derived from numerous RFID literature (Srivasta, 2007; Jarugumilli and Grasman, 2007; Lee and Ozer, 2007; Wamba et al., 2006; Hou and Houang, 2006) and were categorised into four categories of the Balance Scorecard (BSC) proposed by Kaplan and Norton (2004). These are: financial, internal processes, customer, and learning and growth.

5. Organisational factors: Three pertinent factors that influence RFID adoption, implementation, and benefits were considered. These are strength of culture, business size, and BPR; and were derived from IS Literature, Culture and performance literature, and RFID literature.

6. RFID-related factors: Three factors were considered.
- Product Unit Level of Tagging (PULT): container level, pallet level, case level and Item level
- Organisational pedigree in RFID: "fully conversant with all aspects of RFID", "understand most of the concepts of RFID", "understand the principles of RFID", or "Little Knowledge of RFID but system works for us"
- RFID implementation stage: pilot stage, partial implementation stage, or full implementation stage

→ Arrow signifies direction of movement in RFID system deployment. The adoption decision is informed by determinants. When the decision to adopt is made, the process continues to implementation, and finally to benefits. A key determinant of RFID is perceived benefits, therefore the benefits derived can influence the further implementation of RFID systems. For example, benefits from pilot projects can lead to full/wider implementation.

N – Each circled number refers to a particular construct discussed in this chapter

- - - - Dashed arrow signifies relationship between variables

Figure 3.1: *The research framework*

3.4.1 Determinants of RFID adoption ①

One of the most popular topics in technology adoption research is the identification of factors that influence the adoption process, with the aim of facilitating or guiding the way to achieving best adoption procedures (Loraas and Wolfe, 2006). Ngai et al. (2008) advocate the importance of understanding the concepts of RFID adoption and identifying and analyzing drivers and barriers affecting RFID adoption decisions. Thus, with a view to understanding how individuals, organisations, and groups may perceive the viability of adopting RFID, numerous studies (Alqahtani and Wamba, 2012; Schmitt and Michahelles, 2009; Huber et al., 2007; Eckfeldt, 2005; Swanton, 2005; Asif and Mandviwalla, 2005; Walker, 2004) have adopted the TOE framework, DOI model, and various other technology adoption models as platforms on which to study the adoption and diffusion of RFID. These studies provide evidence that a variety of factors influence decisions to adopt RFID. However, most of the studies simply focus on the technology itself, often disregarding broader societal, organisational, cultural, and economic factors that often determine how a new technology is adopted (Baker, 2011). Thus, the studies have fallen short of drawing important conclusions that can be applied in practice (Hsu et al., 2006). In that regard, there still remains a need for a more comprehensive approach into investigating drivers and barriers of RFID adoption; one which should include investigating privacy, security, regulatory, and cultural aspects of RFID adoption. Consequently, this study investigates factors adopted from technology adoption frameworks, extant literature, and from interactions with industry experts and practitioners. This allows factors investigated to be based not only on theoretical technological adoption models but on social and industrial processes by which diffusion of innovation/technology occurs.

At the organisational level, a firm is motivated by its objectives, challenges, and/or environment. Thus, it sets out to gain necessary information and knowledge to inform its decision on technology adoption. In this research framework, the factors that encourage or compel organisations to adopt RFID are regarded to as ‘drivers’.

Despite advancements in efforts for global standardization, lower costs of components, and widening applicability supporting the growth of RFID, there still remain a number of challenges that prevent the technology from widespread adoption. In this research framework, these challenges are referred to as ‘constraints’.

Both drivers and constraints are termed “determinants” in this framework, and were derived from and categorised under the three contexts of the TOE framework of Tornatzky and Fleisher (1990).

Table 3.1 details the literature from which the determinants of RFID adoption (those constituting the research framework) were derived. This table is then followed by a more detailed discussion of the determinants.

Table 3.1: Publications from which the determinants (drivers and constraints) of RFID adoption were derived

Classification	Determinant(s)	Reference(s)
Technological determinants	Relative advantage/perceived benefits	Paydar (2013), Attaran (2012); Goethals and Newlands (2011); Srivastava (2004); Wamba et al. (2006); (Jarugumilli and Grasman (2007); Lee and Ozer (2007); Hou and Huang (2006); Rogers (1995)
	Perceived RFID standards convergence	Huber et al. (2007); GS1 Australia (2006); Ngai (2007); Cheng and Yang (2007); Juban and Wyld (2004)
	Availability of IT/IS infrastructure	Mitchell and Zmud (1999); Rogers (1995); Tornatzky and Fleischer (1990)
	Capital and recurrent costs	Ngai et al. (2007); Park and Rim (2011)
	Technical issues	OECD (2006); Zhu et al. (2003); Zhu et al. (2006)
	Compliance issues	Rogers (1995); Huber et al. (2007); Borecki (2005)
	Security issues	Ngai et al. (2007); Finkenzeller (2003); Ngai (2007)
Organisational determinants	Top management initiative	Rogers (1995); Tornatzky and Fleischer (1990); Park and Rim (2011)
	Financial readiness	Walczuch et al. (2000); Ghobakhloo et al. (2011b); Nguyen (2009); Rangone (1999); Rogers (1995)
	Global expansion	Zhu et al. (2004); Wang (2010)
	Organisational technical capability	Rogers (1995); Tornatzky and Fleischer (1990);
	Manpower (skills) shortages	Walczuch et al. (2000); Thong (1999); Morgan et al. (2006); Nguyen (2009); Ghonakhloo et al. (2011b); Rogers (1995); Tornatzky and Fleischer (1990)
	Requirements for business process change	Park and Rim (2011); Rogers (1995); Tornatzky and Fleischer (1990)
Environmental determinants	Industrial, regulatory, media, dominant partner, professional and trade association, and competitive pressures	Nguyen (2009); Drew (2003); Mole et al. (2004); Premkumar (2003); Premkumar and Roberts (1999); Riemenschneider et al. (2003); Tornatzky and Fleischer (1990); Rogers (1995)
	Government support	Ahuja et al. (2009); Southern and Tilley (2000); Tan et al. (2009); Yap et al. (1994)
	Industrial sector/ transactional climate	Ghobakhloo et al. (2011a); Seyal (2000); Rogers (1995); Tornatzky and Fleischer (1990)
	Regulatory environment	Deloite (2005); Tornatzky and Fleischer (1990); Ngai (2007)
	Wider society/privacy	Barut et al. (2006); Ngai (2007)
	Unwillingness to use RFID	RFID Journal Report (2014); Hossain and Prybutok (2008)
	Lack of industry standards	Huber et al. (2007); Ngai et al. (2007); Finkenzeller (2003); Cheng and Yang (2007); Juban and Wyld (2004)

3.4.1.1 Technological drivers and constraints of RFID adoption

The technological factors include equipment, component and process-related factors that drive and constrain RFID adoption. These include:

- **Relative advantage/Perceived RFID benefits** – These represent the benefits derivable from RFID technology adoption. Paydar (2013), Attaran (2012) and Goethals and Newlands (2011) state that organisations which implement RFID are driven to adoption by the promise of achieving benefits, particularly achieving higher efficiency, better supply chain monitoring and better collaboration with partners. Some researchers have used empirical methods to identify which RFID benefits are achievable in real-life settings (Srivastava, 2004; Wamba et al., 2006). Others have used analytical models to estimate the amount of quantifiable benefits, such as labour cost savings, operation time savings, shrinkage reduction, and increased order fulfilment rates (Jarugumilli and Grasman, 2007; Lee and Ozer, 2007; Hou and Huang, 2006). Overall, perceived RFID benefits generally stem from the following:

    (i) *Visibility* – through the capture of real-time, accurate and timely data, RFID increases equipment, inventory, and business process visibility. It also increases efficiency by optimizing business processes and automating asset and inventory management.

    (ii) *Automation* – reducing manual processes through automated scanning and data entry improves productivity, thus allowing resources to be reallocated to higher value activities.

    (iii) *Integrity* – improving the integrity of real-time supply-chain information, with increased authentication and security and tracking capabilities, thereby reducing errors, shrinkage and counterfeiting while improving customer satisfaction.

    (iv) *Speed and accuracy* – minimizing the time spent finding and tracking needed assets, in turn increasing product flow and handling speeds.

    (v) *Insight* – providing the real-time information needed to make faster, better-informed decisions and the ability to be more responsive to the customer.

    (vi) *Capability* – providing new applications and quality to meet supply-chain partner demands and enhance customer experiences.

- **Perceived RFID standards convergence** – Numerous organisations adopt RFID having already invested large amounts of time and capital into refining existing legacy systems (Huber et al., 2007). Consequently, organisations are interested in the convergence of RFID and their existing systems, often demanding RFID vendors integrate both technologies into their supply chain processes. Technology standards need to converge if RFID and legacy systems such as barcodes are to coexist (Ngai, 2007). Developments in the convergence of Universal Product Code (UPC), European Article Number (EAN) and Electronic Product Code (EPC) standards have driven organisations towards adopting RFID without having to worry about potential system and component incompatibility between RFID and legacy systems (Huber et al., 2007).
- **Availability of IS/IT infrastructure** – Broadly, IT infrastructure refers to enabling technologies, outsourcing arrangements, and policies (Mitchell and Zmud, 1999). IT infrastructure, according to Mitchell and Zmud (1999), includes both technical and organisational capabilities that enable organisations to share and effectively leverage IT resources. The availability of adequate IT infrastructure enables clear definition and design of RFID system architecture, and linkages between tags, readers, edge-of-network middleware, and an organisation's various IT systems, and thus drives organisations towards adopting RFID.
- **Capital and recurrent costs** – A major challenge organisations face with RFID system deployment is that of high cost of implementation. Organisations often struggle to develop a viable business case or work out a favourable return on investment (ROI). Cost-benefit analyses are critical to the successful implementation of RFID systems. The cost of RFID adoption is the major investment in hardware, application software, middleware, tags and the cost of integrating RFID-based system with the legacy systems, consultancy fees and employee training (Ngai et al., 2007). The financial burden of RFID systems hinders organisations, mainly SMEs, from adopting the technology (Park and Rim, 2011), whereas the availability of sufficient financial resources drives organisations towards adoption.
- **Technical issues** – Numerous technical challenges arise from the use of RFID systems. As radio waves can pass through most objects, the combination of materials, operating frequencies, associated power and environment can prove to be

problematic and thus must be managed effectively (Zhu et al., 2003; Zhu et al., 2006). Interference is a main issue. Indeed, there are multiple sources of potential background interference as tags and readers attempt two-way communication. The first source of interference is that data signals of one reader can collide with those of another (reader collision). Furthermore, a proliferation of wireless devices (mobile phones, consumer electronics devices, etc.), also creates potential for electromagnetic interference with RFID systems (OECD, 2006). As RFID does not have its own dedicated frequency band in most jurisdictions, but rather, operates in bands that are shared with other users, interference becomes a significant problem by deteriorating the accuracy of RFID systems. Interference can lead to poor tag read-rates or complete tag failure. If they are to become widespread, RFID applications will increasingly need to take radio magnetic interference from other devices into account in RFID component design and use (OECD, 2006).

- **Compliance issues** – There are some regulatory matters of which RFID manufacturers, designers, and operators should be aware. Key RFID regulatory issues include compliance with the Federal Communications Commission's (FCC) rules and regulations, and the probability of multiplying state privacy laws. Ignorance of the law could impede deployment of even the most efficient and well-designed RFID systems (Ronald et al. 2005).

- **Security issues** – RFID technology has proven to be reliable, especially in supply chains, and is already showing tremendous advantages. But an automated supply chain mandates the necessity for data privacy, identity and non-refutability, and organisations should ensure the RFID technology they adopt supports their security requirements. Organisations need to be aware of the security risks, such as profiling, eavesdropping, denial of service attacks and inventory jamming (Ngai et al., 2007). Consequently, security is yet another technological challenge that RFID faces, particularly because current secure protocols developed include cryptographic features which increase cost and often reduce speed of RFID systems.

3.4.1.2 Organisational drivers and constraints of RFID adoption

The organisational factors refer to the characteristics and resources of the firm, including the firm's size, degree of centralization, degree of formalization, managerial structure, human resources, amount of slack resources, and linkages among employees. Numerous organisational characteristics influence the adoption processes of RFID systems. These include organisational strategies, business size, information intensity, organisational culture and technological maturity (Acar et al., 2005; Caldeira and Ward, 2003; De Burca et al., 2005; Drew, 2003; Levy et al., 2001; Love et al., 2005; Mole et al., 2004). Strategically, IT tools are employed within organisations in order to achieve pre-determined business strategy, therefore, organisational investments in IT are strongly affected by their strategic context such as cost reduction versus value added strategies (Levy et al., 2001). According to Nguyen (2009), some organisations adopt RFID just to rival/match up to competitors that have implemented the technology. Nguyen (2009) further argues that under such circumstances, lack of definition or strategy of the purposes of RFID adoption may lead to project failure. Key organisational determinants RFID adoption include:

- **Top management initiative** – Top management initiative has an influence on the adoption of technological innovation. It includes the development of clear strategies around re-design, restructuring, and promoting a shared vision about the innovation to be adopted or introduced. It also involves creating change programs around these strategies in order to ensure successful deployment of the innovation (Rogers, 1995; Tornatzky and Fleischer, 1990; Park and Rim, 2011).
- **Financial readiness** – The implementation of RFID systems and their components require long term investment (Nguyen, 2009) to develop IT infrastructure and cover capital and recurrent expenditures (Walczuch et al., 2000; Ghobakhloo et al., 2011b). Financial resources are critical for RFID project scoping, analysis of existing systems, and determining performance requirements and subsequent critical success factors (Rangone, 1999). Adequate availability and access to financial resources through equity, partnerships, and/or government incentives drives organisations towards RFID adoption.
- **Global expansion** – The importance of global expansion as a growth opportunity has enabled smaller organisations to compete with larger ones - sometimes with the advantage of being nimbler and quicker to seize opportunities. In that regard, **many organisations,** when considering ways to grow internationally, adopt RFID in order to improve communication tools, and supply chain coordination and integration (Zhu et al., 2004; Wang, 2010).

- **Organisational technical capability** – The technical capability of an organisation determines its potential to acquire new technologies and technical resources for operational practices and processes. The availability of adequate technical resources influences the deployment of RFID technology and determines performance requirements and subsequent critical success factors of the RFID system (Rogers, 1995; Tornatzky and Fleischer, 1990).
- **Manpower availability** – The availability of adequate manpower and expertise remain one of the most important aspects of IT adoption process within organisations (Ghonakhloo et al, 2011b). The lack of internal expertise has been found to hinder IS sophistication and evolution within organisations, therefore, they organisations must overcome this problem through either seeking help from external sources or developing their own internal manpower (Walczuch et al., 2000; Thong, 1999; Morgan et al., 2006; Nguyen, 2009).
- **Requirements for business process change** – Business process change is often required in order to integrate RFID systems with existing legacy systems. This can include partial or total redesign of processes including re-routing, shortening, and/or elimination of certain processes. Depending on the complexity of the existing and incoming system, business process change can be a lengthy and expensive venture. Therefore, some organisations view this as a disadvantage when considering RFID adoption (Park and Rim, 2011).

3.4.1.3 Environmental drivers and constraints of RFID adoption

Organisations are increasingly confronted by numerous social and ecological issues within the environments in which they operate (Deuten *et al.*, 1997). The nature of the environment in which an innovation has to survive is essential for its success. Environmental determinants of RFID adoption include:

- **External and competitive pressure** – Many organisations adopt IT in order to become more competitive, provide a means to enhance survival and/or growth, manage changes, promote services to customers, and stay competitive and/or enhance innovation abilities (Nguyen, 2009; Drew, 2003; Mole et al., 2004; Premkumar, 2003; Premkumar and Roberts, 1999; Riemenschneider et al., 2003). Extant literature suggests that as organisations (particularly smaller ones) are susceptible to customer pressure, and therefore adopt IT as a result of demand from customers to develop the efficiency of their inter-organizational dealings (Levy et al., 2003). Hence, it has become an indispensable strategy for firms to adopt IT (Premkumar and Roberts, 1999). In the case of RFID, media pressure, dominant partner pressure, regulatory pressure, and trade association pressure also drives organisations towards adopting the technology. However, some researchers have dismissed the role of the aforementioned factors suggesting that the main driving forces to move toward IT tools in organisations are internal factors including industry changes and trends, maintaining current market, finding new market, opportunities for growth and the necessity to keep up with competition (Drew, 2003; Southern and Tilley, 2000). Nguyen (2009) argues that firms move toward adoption of IT for dissimilar reasons due to various functions of firms in different environments and their operation in different ways. According to Nguyen (2009), organisations adopt IT in order to (i) respond or react to an event; (ii) respond to pressure from the internal and external environment; and (iii) respond to pressure from customers to improve efficiency.

- **Government support** – Many studies have found that a significant positive relationship exists between IT adoption and government support (Ahuja et al., 2009; Southern and Tilley, 2000; Tan et al., 2009). SMEs in particular, are limited by a shortage or lack of resources, hence are generally more dependent on external resources and support (Sarosa and Zowghi, 2003). Therefore, government initiatives and policies could directly and/or indirectly stimulate the development of RFID infrastructure and information provision to energize faster technology diffusion (Ghobakhloo et al., 2011a).
- **Wider Society/Privacy** – The operation of RFID has been subject to scrutiny from privacy protection organisations. Consumer organisations are prosecuting against the possible use of RFID by retailers to track consumer behavior. Although consumer perceptions and privacy issues receive a great deal of media attention, majority of organisations don't view them as significant barriers to implementation (Accenture, 2004). Nevertheless, some organisations have delayed or canceled their implementation of RFID due to privacy concerns (Barut et al., 2006). According to Barut et al. (2006), educating organisations and the public on these issues will help overcome skepticism.

- **Unwillingness to adopt RFID** – Resistance from employees to use proposed system or from top management to approve deployment of RFID systems can delay RFID implementation within organisations (RFID Journal Report, 2014; Hossain and Prybutok, 2008).
- **Regulations/Industry standards** – There is lack of global standards for RFID adoption. Practitioners believe that the development and adoption of official standards, enabling interoperability between applications or devices, can significantly accelerate the adoption of RFID technology. Global standards are required in order to ensure end-to-end interoperability of RFID systems to track goods through the global supply chain (Finkenzeller, 2003).

3.4.2 RFID adoption decision ②

In this study, "decision to adopt RFID" simply means the verdict to acquire and use an RFID system. Studies of Paydar and Endut (2013), Wu (2011), Matta (2008) and Wamba et al. (2016) have predicted the adoption of RFID in different organisational settings, using a dichotomous variable to model the decision to adopt RFID – with outcome as "Yes" and "No". Consequently, the proposed research framework also considers the outcome values for the "decision to adopt RFID" variable to be binary i.e. Yes or No.

Organisations that have implemented RFID systems or have plans of adopting RFID systems are to be surveyed, with the results presented in Chapter 5.

3.4.3 Organisational *factors* ③

In addition to the organisational factors considered as part of the TOE framework, three other pertinent factors were derived from IS literature. These three factors are further considered because they are seen to have an influence on not just the decision to adopt RFID but on the subsequent implementation processes and benefits. The three factors investigated are strength of culture, business size, and business process re-engineering (BPR). These factors and their measures were derived from a multitude of publications within IS, RFID, and innovation literature. A number of RFID implementation and industry reports were also used to derive some of the measures. Table 3.2 details the publications from which the factors and their measures were derived to constitute the research framework.

Table 3.2: Organisational factors and their measures

Factor	Measures	Reference(s)
Strength of culture	Organisational goals and objectives Organisational focus on its performance relative to its competitors Organisational focus on customer satisfaction Effective decision-making Management cooperation and involvement Drive to introduce new technologies into business processes Creating strong internal and external motivation for improvement Developing a clear RFID strategy Innovation Provision of training and support for employees Top management support and commitment from leadership Organisational knowledge accumulation	Bruque and Moyano (2007); Riolli and Savicki (2003); Tushman and O'Reilly (1997); Tornatzky and Fleischer (1990); Gordon and DiTomaso (1992); Burt et al. (1994); Kotter and Heskett (1992); Peters and Waterman (1982); Deal and Kennedy (2000); Brown and Russell (2007); Huyskens and Loebbecke (2007); Krasnova and Weser (2008); Ranganathan and Jha (2005); Schmitt et al. (2007); Sharma and Citurs (2005); Sharma et al. (2007); Sahinidis and Kanellopoulous (2010)
Business size	Number of employees Annual turnover International reach IT/IS infrastructure Range of products/services Number of office locations, retail outlets, warehouses, and service centres	Fink (1998); Love et al. (2005); Premkumar (2003); Premkumar and Roberts (1999); Tornatzky and Fleischer (1990); Rogers (1995); Thong (1999); Premkumar (2003); Mole et al. (2004)
Business process re-engineering	Data standardization and integration Restructuring and streamlining activities Decentralization of consolidated resources and processes Provision of decision-support tools Synchronization of IT resources and business processes Adoption of flexible deployment architecture Continuous review and improvement of procedures Integration and management of large amounts of data	Ganesh (2000); Tornatzky and Fleischer (1990); Kimberly and Evanisko (1981); Goodhue et al. (1992); Goodhue et al. (1998); Hammer (1990); Davenport & Short (1990)

Strength of culture – Organisational culture in another significant determinant of IS/IT implementation in organizations (Bruque and Moyano, 2007; Riolli and Savicki, 2003).

Strong cultures, defined as “a set of norms and values that are widely shared and strongly held throughout the organization” (O’Reilly and Chatman, 1996), have been found to enhance organisational performance by influencing employee motivation, achievement of common goals, and teamwork (Kotter and Heskett, 1992; Peters and Waterman, 1982). In particular, the performance benefits of a strong organisational culture stem from three consequences of having widely shared and strongly held norms and values: enhanced coordination and control within the organisation, alignment to common organisational goals by employees and stakeholders, and increased employee motivation. In support of this argument, numerous quantitative studies find that firms with strong cultures outperform firms with weak cultures (Kotter and Heskett, 1992; Gordon and DiTomaso, 1992; Burt et al., 1994).

However, the strength of organisational cultures influences not just performance benefits but the decision to adopt innovative technology also. Sahinidis and Kanellopoulous (2010) investigated the effects of strong cultures on organisational innovation. The study found that there is a significant relationship between the strength of culture and organisational innovation. Strong cultures were found to be associated with higher rates of administrative, technological and cultural innovations and exhibited higher performance in the long-run, than organisations with weak cultures. In similar regard, Borkovich et al. (2015) conducted a secondary review of technology adoption literature and philosophies from cultural theorists, social scientists, and business management experts, and found that strong organisational culture has a significant influence and impact on technology adoption. The study found that attributes of strong organizational cultures influence the success or failure of technology adoption in the workplace. The study concluded that understanding and incorporating strong organizational culture attributes into the technology implementation process favourably increases successful technology adoption.

With regards to RFID, numerous studies have found strong culture attributes such as top management initiative towards adoption of RFID, employee coordination and cooperation, and the provision of adequate funding and technical expertise to be factors that influence RFID adoption (Brown and Russell 2007; Huyskens and Loebbecke 2007; Krasnova and Weser 2008; Ranganathan and Jha 2005; Schmitt et al. 2007; Sharma and Citurs 2005; Sharma et al. 2007).

In this research framework, the strength of culture is determined by the following measures:

- *Organisational goals and objectives* – These define what an organisation is trying to accomplish, both in terms of operations and functionality. These are usually a collection of related programs, and a reflection of major actions of the organisation, that provide a rallying point for managers. An organisation's culture has a bi-directional relationship with its goals and objectives. An organisation can encourage a culture that aligns with its objectives, thereby making employees more likely to succeed in reaching those objectives. In a similar manner, the goals and objectives of the organisation can influence what organisational culture is adopted, and how it evolves over time.
- *Organisational focus on performance relative to competitors* – This is an essential aspect of organisational culture. It helps organisations gauge their relative standings against their competition. This is paramount in identifying ways to improve organisational ranking and performance.
- *Organisational focus on customer satisfaction* **–** This is essential in understanding and managing customers' interaction and perceptions about the organisations' products/services. This usually involves using customer experience metrics to track and identify improvement opportunities in order to increase customer loyalty. It constitutes an essential aspect of organisational culture.
- *Management cooperation and involvement* – Involvement and support of top management is considered to have high influence on innovation plans, project execution and success, and organisational performance. Top management initiative practices vary across industries and organisations, depending on their cultures. The support and encouragement of top management, along with financial availability and readiness are considered essential factors for the development of innovation strategies because the resources required for the implementation of new technologies will be more readily available if the management responsible for these resources support the plans.
- *Effective and timely decision-making* – Business performance is increasingly dependent on an organisation's agility and its ability to improve business operations by timely, high-quality decisions based on relevant and accurate information. The culture of a business influences its ability to generate insights regarding the business

environment and to make decisions that make it more adaptable to market changes, thus having a better chance of gaining market share from its competitors.

- *Innovation* – The culture of innovation in an organisation has an influence on the organisational structure and operating systems in that organisation, and vice versa (Armstrong, 1995). Innovation thrives under flexible and free corporate cultures that support and encourage cooperative teamwork. On the other hand, innovation is thwarted by rigid, predictable, and unstable corporate cultures (mostly associated with hierarchical structures) (Arad et al., 1997).
- *Drive to introduce new technology into business processes* – This is usually influenced by the innovative culture of an organisation. The adoption of new technology results from a series of decisions which are often a result of a comparison of the perceived benefits with the perceived costs of adopting the technology.
- *Creating strong internal and external motivation for improvement* – This involves educating and encouraging employees to focus on the procedures and coordination of a system or business process in order to understand when improvements are desired, monitor optimization processes, and report yielded improvements.
- *Developing a clear implementation strategy* – The approach an organisation employs towards RFID deployment is vital towards achieving desired benefits. A clearly articulated RFID strategy will bring discipline and focus to the deployment. It's easy for the engineers and operation managers overseeing the installation of RFID equipment to see myriad potential uses for the technology. The only way to make sure that everyone is going after the most important opportunities first—the ones that will provide a return on investment and further the organisation's long-term goals—is to have a strategy that defines which opportunities are most important.
- *Team orientation and capability development* – This involves encouraging teamwork so that creative ideas are captured and employees support one another in accomplishing work goals. Capability development is practiced in a variety of ways, including training, coaching, and exposing employees to new roles and responsibilities.
- *Organisational learning and knowledge accumulation* **–** This is the organisation-wide continuous process that enhances its collective ability to accept, make sense of, and respond to internal and external change.

Business Size – According to extant literature on IT adoption in organisations, business size definable by turnover and/or number of employees is one of the most important determinants of IT adoption (Fink, 1998; Love et al., 2005; Premkumar, 2003; Premkumar and Roberts, 1999; Thong and Yap, 1995). The importance of firm size is partly because of its role as the source of firms' capabilities (Mole et al., 2004). Another reason however is the fact that firms' resources including financial and human capital can be an approximation of firm size (Thong, 1999). Premkumar (2003) posits that business size is an important determinant between adopters and non-adopters of RFID systems within organisations. The study further finds that larger firms have a higher inclination to adopt RFID technologies than smaller ones. In extant literature on RFID adoption, organisational size has been defined by the following factors:

(i) *Number of trained/skilled employees* – This is the most common metric for measuring organisational size. It gives an idea of workforce available, scale of organisational operations, and firm activities.

(ii) *Annual turnover* – This is the total revenue of a business in a year. It is also a common metric of measuring organisational size.

(iii) *International reach/Global expansion* – Due to globalization, businesses have supply chains spanning across continents. The global outreach of a business can be an indicator of the scale of its operations, global impact, and size.

(iv) *IT/IS infrastructure* – Organisations employ varying networking strategies and practices to connect employees, promote information discovery, and improve knowledge sharing. The scale of such networks, both in-house and cross-company, can be an indicator of organisational size. Large organisations usually have highly automated processes, and operate large-scale or complex IT systems. On the other hand, smaller businesses tend to have simpler processes and IT systems.

(v) *Range of products/services* – Although quite arbitrary, the range of products and/or services offered by a business can be an indicator of its size.

(vi) *The number of office locations, retail outlets, warehouses, and service centres deploying RFID* – This can be an indicator of the size of the business and how widely RFID has been implemented within its scale of operations.

(vii) *Range of products/services using RFID* – This refers to the range of products and/or services using RFID.

Business process re-engineering (BPR) – BPR precedes or accompanies technological innovation implementation and is thus expected to play a role in the decision to adopt, the implementation process, and benefits derived from technological innovation (Ganesh, 2000; Tornatzky and Fleischer, 1990; Kimberly and Evanisko, 1981). In extant literature, BPR has been defined by the following factors:

(i) *Data standardization and integration* – In coordinating the activities of an organisation, different business units require access to consistent data about the activities of different departments (Goodhue et al., 1992). Data standardization helps organisations to effectively manage their IT activities and assess their performance against comparable functional units (Goodhue et al., 1988).

(ii) *Restructuring and streamlining activities* – After establishing the need for reengineering, processes are mapped out and analyzed. The main objective of this is to identify disconnects (anything that prevents a process from achieving desired results and in particular information transfer between organisations or people) and non-value-adding processes. This is succeeded by the restructuring and streamlining of activities to achieve total re-invention or redesign of business processes.

(iii) *Decentralization of consolidated resources and processes* – This is the redistribution or dispersion of an organisation's consolidated resources. Decentralization initiatives are often initiated when it becomes apparent that allowing individual departments or branch offices provision of their own resources (usually IT systems and services) would help the organisation meet its goals and objectives. Decentralization of resources can simplify administrative tasks, improve security, make data management easier, and save costs.

(iv) *Provision of decision support tools* – Decision support tools assists organisations in making management, operations, and planning decisions, which may be rapidly changing and not easily specified in advance. Decision support systems can be either fully computerized, human or a combination of both. They specifically focus on features, making them easy to use by 'non-computer' or non-technical people. Consequently, decision-support tools are put in place when a new technology is deployed, so to improve ease-of-use and enhance effectiveness.

(v) *Synchronization of IT resources and business processes* – Integrating business processes with IT resources improves supply chain efficiency by utilizing standardized information formats and communication points between trading partners. Business process and IT resource synchronization can eliminate costs associated with inefficient movement of goods, redundant processes and excess inventory; thereby promoting a dedicated collaboration of all supply chain partners. When adopting new technology like RFID, synchronization of business processes and IT resources is a crucial stage of BPR, so as to realize the benefits of a more integrated supply chain.

(vi) *Adoption of flexible deployment architecture* **–** This is a method of minimizing IT infrastructure costs by enabling organisations to deploy RFID on existing premises and enterprise servers. This enables organisations to leverage existing IT architecture and reduce costs of RFID deployment.

(vii) *Continuous review and improvement of procedures* **–** This refers to efforts put in place to continuously improve operational procedures and processes in order to achieve "incremental" improvements over time or "breakthrough" improvement all at once.

(viii) *Integration and management of large amounts of data* **–** This refers to data mining techniques in place in order to deal with the large data generated from RFID applications.

3.4.4 *RFID implementation processes* ④

RFID implementation processes refer to the methods, designs, and specifications involved in the deployment of RFID systems. The implementation of an RFID system is a complex task that involves both technical and human factors. Several studies have identified factors that contribute to the success or failure RFID projects (Attaran, 2012; Ngai et al. 2010; Visich et al., 2009; Huang and Tang, 2008; Reyes and Jaska, 2007; Soylemezoglu et al. 2006; Angeles, 2005). Based on these studies, critical implementation factors have been chosen to represent the prominent influences of RFID adoption by organisations. Generic frameworks for the implementation of RFID systems have also been developed. Nevertheless, a systematic and holistic RFID implementation framework that has been validated by academic and practitioners is lacking.

The proposed research framework aims to provide the platform to study the various steps of the RFID system deployment and determine how each step interacts with organisational characteristics such as culture, size and BPR. This would enable practitioners to make informed decisions and essential considerations of implementing RFID while taking into cognisance their organisational characteristics.

Table 3.3 details the literature from which RFID implementation processes and procedures (those constituting the research framework) were derived. The RFID implementation processes were primarily derived from Ting et al. (2013) and Ngai et al. (2015) who propose a 6-step generic framework for the implementation of RFID systems based upon the synthesis of RFID implementation frameworks published in extant literature.

Table 3.3: Publications from which RFID implementation processes were derived

Factor	Measures	Reference(s)
RFID implementation processes	Project scoping	Angeles (2005); Vijayaraman and Osyk (2006); Wu et al. (2006); Attaran (2007); Reyes and Jaska (2007); Sellitto et al. (2007); Ngai et al. (2010); Ting et al. (2013); Ngai et al. (2015)
	Analysis of existing systems	Soylemezoglu et al. (2006); Attaran (2007); Jaska (2007); Pålsson (2007); Huang and Tang (2008); Hellström (2009); Kim and Garrison (2010); Ngai et al. (2010); Ting et al. (2013); Ngai et al. (2015)
	System design	Soylemezoglu et al. (2006); Reyes and Jaska (2007); Huang and Tang (2008); Hellström (2009); Ngai et al. (2010); Ting et al. (2013); Ngai et al. (2015)
	Prototype testing	Reyes and Jaska (2007); Soylemezoglu et al. (2006); Ngai et al. (2010); Ting et al. (2013); Ngai et al. (2015)
	Implementation	Soylemezoglu et al. (2006); Spekman and Sweeney (2006); Attaran (2007); Reyes and Jaska (2007); Ngai et al. (2010); Ting et al. (2013); Ngai et al. (2015)
	Continuous improvement	Ngai et al. (2010); Ting et al. (2013); Ngai et al. (2015)

The RFID implementation processes constituting this research framework are as follows:

- *Project scoping:* This involves defining the project objective and scope, investigating the feasibility of using an RFID system, and securing support from top management.

The typical tasks in this step are to understand the potential and the limitations of RFID systems and to define a given project's objectives.

- *Analysis of the existing system:* This involves the evaluation of an existing system in order to identify the vital procedures in the process – i.e., the vital inputs to the subsequent redesign stage.
- *System design:* This consists of designing a new process that matches the organisation's needs and requirements. The system design stage includes requirement analysis, hardware and software selection, and the development of the new process.
- *Prototype testing*: Before the actual implementation of an RFID system, pilot testing is required to ensure that the technology is ready for deployment. This includes technical debugging and tracing and eliminating errors in the analyses, and collecting feedback from users after the demo testing. This is designed as such in order to elicit comments on the various user interfaces and in order to fine tune their design.
- *Implementation:* Implementation typically involves the installation and commissioning of hardware and software systems, change management, training, and system deployment.
- *Continuous improvement:* This involves the continuous evaluation of a system's performance in comparison to preset objectives. This stage is necessary in enhancing the system with emergent technologies, or adapting it to match the changing needs of the market.

3.4.5 RFID benefits ⑤

RFID benefits are defined as the advantages/profits that a firm derives, that are attributable to its use of RFID technology. In this study, the benefits are considered to be proxies of organisational performance indicators, and are hence categorized and analyzed according to the Balanced Scorecard (BSC) approach of Kaplan and Norton (2004). The Balanced Scorecard (BSC) is a technique for measuring organisational performance. Under this technique, both financial and non-financial indicators are comprehensively evaluated to achieve a balanced measurement method (Kaplan and Norton, 2004; Kaplan and Norton, 1993; Kaplan and Norton, 1992). In addition to assessing general organisational performance, the BSC has been adopted in measuring to measure the impacts of IT deployment on organisational performance. The BSC considers four perspectives, namely, financial; internal business process; learning and growth; and corporate/customer, that are derived from an organisation's vision and strategy.

Numerous studies have adopted and adapted the BSC to measure organisational performance in a variety of research fields. Some researchers such as (Papalexandris et al. 2004) adopted the BSC unmodified to measure the performance of organisations. Others adapted the BSC in order to measure organisational performance. In that regard, Michalska (2005) replaced the learning and growth perspective of the BSC the "development perspective", and derived appropriate performance indicators for the readapted perspectives. Similarly, Olson and Slater (2002), in their measurement of performance among service and manufacturing companies, used a BSC framework consisting of the customer, internal business process, innovation and growth, and the financial perspective.

In this research, the four categories of the BSC will be adopted, unmodified. These are financial, internal business process, learning and growth, and corporate/customer.

RFID technology can improve various processes in numerous facets of supply chain management (Bolan, 2005 and Roy et al., 2004). Major benefits of RFID include its unique capability to share information with business partners, allowing collaboration on inventory management, planning, forecasting, and replenishment (Vijayaraman and Osyk, 2006). Multiple studies attest to the potential of RFID in building supply chain relationships, synchronizing supply and demand, and process optimization and improvement (Angeles, 2005; Michael and McCathie, 2005; Tracy, 2005; Bose & Pal, 2005; Arnold and Bures, 2003). Other studies such as Lin and Ku (2009), Zelbst et al. (2008a), Tzeng et al. (2007), and Hou and Huang (2006) have investigated the impact of RFID technology utilization and benefits derived on operational performance and/or supply chain performance.

However, majority of these studies were limited in the following ways.

(i) They were either country-specific or industry-specific or both, thereby limiting the generalizability of findings obtained
(ii) They highlighted RFID benefits that were mostly anecdotal, therefore fail to develop valuable business cases
(iii) They did not consider interactions between organisational characteristics and benefits derived from RFID implementation

Consequently, the proposed research framework investigates the relationship between RFID adoption and benefits using data obtained across a variety of countries and industrial sectors i.e. this study is neither country nor industry specific. This allows for better generalizability of findings. Additionally, the impact of organisational factors (culture, size, and BPR) on benefits derived from RFID is investigated.

Table 3.4 details the literature from which RFID benefits (those constituting the research framework) were derived.

Table 3.4: Publications from which RFID benefits investigated in this research framework were derived

Factor	BSC Category	Reference(s)
RFID benefits	Financial	Jarugumilli and Grasman (2007); Lee and Ozer (2007); Hou and Huang (2006); Vijayaraman and Osyk (2006); Angeles (2005); Michael and McCathie (2005); Tracy (2005); Bose and Pal (2005); Arnold and Bures (2003) Lin and Ku (2009); Zelbst et al. (2008a); Tzeng et al. (2007); Hou and Huang (2006); Srivastava (2007); Wamba et al. (2006);
	Internal business process	
	Learning and growth	
	Corporate/customer	

3.4.6 RFID-*related factors* ⑥

Some researchers have used empirical methods to identify which RFID benefits are achievable in real-life settings (Srivastava, 2004; Wamba et al., 2006). Others have used analytical models to estimate the amount of quantifiable benefits, such as labour cost savings, operation time savings, shrinkage reduction, and increased order fulfilment rates (Jarugumilli and Grasman, 2007; Lee and Ozer, 2007; Hou and Huang, 2006). However, little is explicitly known on how these benefits can be achieved, and how they are moderated by RFID-related characteristics such as RFID implementation stage, Product Unit Level of Tagging (PULT), and organisational pedigree in RFID.

Product Unit Level of Tagging (PULT) refers to the product level at which an organisation is implementing RFID. RFID implementation stage refers to the stage of RFID adoption within the organisation, i.e., whether the implementation is at pilot stage (where the technology is implemented as an experimental project), partial implementation (where RFID is deployed in only select processes of the business), or full implementation (where RFID and all its features are fully deployed across the organisation). Organisational pedigree in RFID refers to the organisation's experience in deploying RFID.

Consequently, this study investigates:

(i) Whether implementing RFID at item, case, pallet or container level impacts the benefits derived from RFID. While the ultimate desire of the supply chain is to implement RFID at product or item level, all cost-benefits analyses have so far demonstrated the commercial unviability of item tagging, except for high value goods.

(ii) How implementation stage (full, partial, or pilot) affects benefits derived from RFID implementation

(iii) How staff experience in RFID deployment affects the smooth implementation of RFID and the benefits derived from the technology. Four levels of experience investigated are:

- Fully conversant with aspects of RFID
- Understand most of the concepts of RFID
- Understand the principles of RFID
- Little knowledge of RFID but operating a working system

3.5 Research hypotheses

From the five research questions specified in section 1.3, eighteen (18) hypotheses were formulated in order to investigate the relationships enumerated in the research framework (depicted in figure 3.1). The eighteen hypotheses studied the relationships between the following factors (all of which were derived/measured from extant literature):

- Drivers and constraints of RFID adoption
- Organisational and RFID-related factors and their effects on RFID adoption and implementation;
- Benefits derived from RFID implementation

Table 3.5: List of research hypotheses

Research question(s)	Description	Hypothesis
1	What factors drive and constrain organisational decision to adopt RFID technology?	H1: Technological drivers of RFID adoption have a significant positive influence on the decision to adopt RFID
		H2: Technological constraints of RFID adoption have a significant negative influence on the decision to adopt RFID
		H3: Organisational drivers of RFID adoption have a significant positive influence on the decision to adopt RFID

		H4: Organisational constraints of RFID adoption have a significant negative influence on the decision to adopt RFID
		H5: Environmental drivers of RFID adoption have a significant positive influence on the decision to adopt RFID
		H6: Environmental constraints of RFID adoption have a significant negative influence on the decision to adopt RFID
2	How is the decision to adopt RFID enhanced or constrained by an organisation's underlying culture, the size of the organisation, and business process re-engineering?	H7: A strong organisational culture has a significant positive influence on the decision to adopt RFID
		H8: Organisational size has a significant positive influence on the decision to adopt RFID
		H9: Business process re-engineering (BPR) has a significant positive influence on the decision to adopt RFID
3	If the decision to adopt RFID is taken, how is the implementation process affected by an organisation's underlying culture, the size of the organisation, and business process re-engineering?	H10: A strong organisational culture has a significant positive influence on the implementation processes of RFID
		H11: Organisational size has a significant positive influence on the implementation processes of RFID
		H12: Business process re-engineering (BPR) has a significant positive influence on the implementation processes of RFID
4	What benefits are derived from RFID implementation and how are they affected by an organisation's underlying culture, the size of the organisation, and business process re-engineering?	H13: A strong organisational culture has a significant positive influence on the benefits derivable from RFID implementation
		H14: Organisational size has a significant positive influence on the benefits derivable from RFID implementation
		H15: Business process re-engineering (BPR) has a significant positive influence on the benefits derivable from RFID implementation
5	How are the benefits derived from RFID implementation affected by the implementation stage of RFID, the Product Unit Level of Tagging (PULT), and the organisational pedigree in RFID?	H16: An organisation's internal capacity for implementing the technology has a significant positive influence on the benefits derivable from RFID
		H17: Lower Product Unit Level of Tagging (PULT) has a significant positive influence on the benefits derivable from RFID implementation
		H18: Higher implementation stage of an RFID system has a significant positive influence on the benefits derivable from RFID implementation

3.6 Summary

Firstly, this chapter presents the research framework which investigates the impact of organisational and technological factors within pre-adoption, implementation, and post-implementation phases of RFID system deployment. In the pre-adoption phase, the framework examines factors that drive and hinder organisations' decision to adopt RFID. In the implementation phase, the framework investigates the impact of organisational factors (business size, strength of culture, and business process re-engineering) on influencing the implementation processes of RFID. In the post-implementation phase, the study investigates how the benefits derived from RFID implementation interact with organisational factors (business size, strength of culture, and business process re-engineering) and RFID-related factors (product unit level of tagging, RFID implementation stage, and organisational pedigree in RFID). The development of this research framework was motivated by the lack of (i) a an advisory framework which considers quantifiable firm characteristics and the costs and benefits of implementing RFID, in yielding advice to guide decisions on RFID adoption, and (ii) a framework that covers the complete processes of RFID project deployment (from adoption decision to benefits derived) in yielding advice to guide decisions on RFID adoption.

Secondly, discussions on the different elements that make up the research framework and their inter-relationships are also presented. Justification for the research framework was used to give account of the relationships between the research constructs, the factors and dimensions of each of the construct, and the hypotheses enacted to investigate the relationships between the constructs.

The next chapter presents an overview and justification of research methodologies adopted in this research. The method of data collection is also highlighted, alongside an outline of the statistical tools and techniques adopted.

CHAPTER 4 – METHODOLOGY

4.1 Introduction

Research methodology is considered a strategy, plan of action, process and/or design that shapes the choice of specific methods, and the use of those methods to achieve desired results (Crotty, 1998). It comprises a process of data collection, data analysis, and interpretation (Creswell, 2011). For this research, the methodology focusses on adopting appropriate techniques to address the research aim and questions, and to test the hypotheses enacted after the literature review. In order to choose the appropriate research method, Meredith et al. (1989), Newman and Benz (1998), and Creswell (2009) advocate that the methodology in contention should attempt to integrate both quantitative and qualitative research paradigms. Accordingly, this research achieves methodological triangulation through the combination of the two research paradigms. Through this, the advantages of both research methods are realized and their individual limitations mitigated. To gather data to investigate the research questions, survey by questionnaire and case study were adopted.

This chapter describes the methodologies employed in addressing the research aims and objectives, presents the philosophical basis of the study, justifies the chosen research paradigm, outlines and discusses empirical methodologies used to collect data, analyse results, and validate the research framework presented in chapter 3.

4.2 Research Philosophy

Research philosophy is a belief about how data about a phenomenon should be gathered, analysed, and used. It is important to fully understand the philosophical underpinnings of a research project because it enhances a researchers' ability to select appropriate methodology (Holden and Lynch, 2004). The terms Ontology and Epistemology, define the nature of reality, and how that reality is captured, respectively (Carson et al., 2001). There are two major ontological and epistemological ideologies: (i) Positivism and (ii) Interpretivism (Galliers, 1991).

4.2.1 Positivism

Positivism is a philosophy that believes only information gathered from sensory experience and/or interpreted through rational or logical mathematical procedures, forms an authoritative and exclusive source of knowledge. In other words, positivism advocates that reality is stable and thus can be studied and described from objective viewpoints, without interfering with the studied phenomena (Levin, 1988). Positivist researchers adopt a controlled and structured approach to conducting research by outlining a research topic, formulating appropriate hypotheses, and adopting a suitable research methodology. Additionally, a neutral stance between the studied phenomena and the researcher is maintained by making a clear distinction between reason and feeling (Carson et al., 2001).

Positivism has a successful historical association with the physical and natural sciences. Alavi and Carlson (1992) reviewed 902 Information System (IS) publications, finding that all the empirical studies had a positivist approach. It is due to such trends that Hirschheim (1985) posits that "Positivism is so embedded in our society that knowledge claims not grounded in positivist thought are simply dismissed as ascientific and therefore invalid". However, there has been extensive debate on the suitability of the positivist paradigm in social science research, with multiple researchers advocating for a more pluralist approach towards IS research methods (Remenyi and Williams, 1996). This is relevant to this study as IS research deals with the interaction of people and technology, and is categorized under the social sciences (Hirschheim, 1985). Indeed, limitations encountered in IS research, such as the inconsistency of results, may be as a result of inappropriateness of the positivist paradigm for the domain. Additionally, some variables of reality might have been rendered unmeasurable in the past – and have hence not been researched (Galliers, 1991).

4.2.2 Interpretivism

Interpretivism is a philosophy that believes in the study of phenomena in their natural environment, and contend that it is only through subjective interpretation that reality can be fully understood (Hudson and Ozanne, 1988). The position of Interpretivism in relation to ontology and epistemology is that reality is multiple and relative, and that these multiple realities are interrelated with other systems of meanings, thereby making it difficult to interpret in terms of fixed realities (Neuman, 2000).

Interpretivist researchers adopt flexible and more personal research structures than the rigid structural frameworks of positivist research. These are receptive to making sense of what is perceived as reality and for interpreting meanings in human interaction (Carson et al., 2001;

Black, 2006). The major goal of interpretivist research is to understand meanings, motives, reasons, and other subjective experiences that are time and context bound (Neuman, 2000.)

4.2.3 Justification for choice of approach

Selecting a research paradigm is often the choice between positivist or interpretivist philosophies. Many researchers (Collis and Hussey, 2009; Bryman & Bell, 2003; Saunders et al., 2000) have highlighted that the main elements of this choice of research philosophies can be characterised through their ontology, epistemology, and methodology. These characteristics create a holistic view of the methodological strategies used to discover, interpret, and interact with knowledge. The key features of the two philosophy paradigms are detailed in Table 4.1.

Table 4.1: *Key features of Positivist and Interpretivist philosophical paradigms (Guba, 1990)*

Paradigm	Positivism	Interpretivism
Ontology	Reality is considered objective and singular (knowledge governed by the laws of nature)	Reality is considered subjective and multiple (knowledge is socially constructed and interpreted by individuals)
Epistemology	Objectivist approach is adopted where researcher does not interfere with the study	Subjectivist approach adopted where researcher collaborates with participants in the field
Methodology	Experimental approach is adopted where research questions and/or hypotheses are formulated in advance, subject to empirical investigations	Investigative approach where the researcher elicits individual constructions and refines them hermeneutically, with the aim of generating constructions on which there is substantial consensus
	Researcher adopts a deductive approach, uses a predetermined research design, and attempts to position the research to a generalizable state	Researcher adopts an inductive approach, studies the topic within its context, and uses an emerging design

However, Benbasat et al. (1987) observed that no single research methodology is inherently better than the other, with researchers such as Kaplan and Duchon (1988) advocating for a combination of research methods, in order to improve the quality of research. Nevertheless, the key determinant of the choice of research paradigm(s) adopted should be its relevance to the research questions.

In this research, the positivist research paradigm is adopted. This is because Supply Chain Management (SCM) is a normative science, whereby reality is perceived to be objective and quantifiable. This makes the positivist approach suitable for this research. Taking into account our research questions, it is clear that the underlying philosophy for these questions has been based upon the positivist philosophical paradigm. This is because they focus on the theories, concepts, and practices involved in the adoption of RFID in supply chain management. In other words, they aim to evaluate the components and characteristics that influence the RFID adoption and implementation processes based on theories and concepts gathered from the literature. These components and characteristics can be categorized either as resources-related, operational, organisational, technological, or environmental. Therefore, adopting a positivist approach helps investigate these factors, and their relative importance, to develop a comprehensive adoption framework. This framework will address the factors that drive RFID adoption within organisations and how these factors interact with organisational and technological parameters. In view of that, the positivist‘s emphasis on evidence of formal propositions, quantifiable measures of variables, hypothesis testing and/or question addressing, and drawing of predictions about a phenomenon from the previously observed and explained realities and their inter-relationships (Orlikowski & Baroudi, 1991), is met.

4.3 Research Strategy

Researchers can adopt elements of non-empirical approach, empirical approach, or a combination of the both approaches (Avison et al., 2008; Chen and Hirschheim, 2004).

4.3.1 Non-empirical approach

Non-empirical research is primarily based on conceptual and analytical reasoning, rather than on specific data (Avison et al., 2008; Alavi and Carlson, 1992). It can be divided into three categories (Alavi and Carlson, 1992): Illustrative, Conceptual, and Applied concepts. Illustrative research is concerned with developing guideline and advisory frameworks for practice. These frameworks may come in the form of recommendations for action, rules and warnings, or steps and procedures to be followed in given circumstances. On the other hand, conceptual studies synthesize pre-existing knowledge to develop frameworks, theories, or models, while providing interpretations and reasons. Lastly, applied concepts studies adopt elements of both conceptual and illustrative studies (Alavi and Carlson, 1992).

4.3.2 Empirical approach

Empirical research utilises data gathered by means of direct or indirect observation or experiment. This data can be quantitative, qualitative, or both (Avison et al., 2008). There are two primary dimensions which can be evaluated for use in empirical research (Collis & Hussey, 2009). These are (i) Quantitative/Qualitative and (ii) Deductive/Inductive

4.3.2.1 Quantitative/Qualitative

Quantitative research adopts a logical and data-led approach to provide a measure of a studied phenomenon, from a numerical and statistical point of view (Neuman, 1997). It involves testing and verifying theories by investigating hypotheses and/or research questions derived from the research (Creswell, 2009). Quantitative research methods include surveys, experiments, and mathematical and computational methods (Myers, 1997).

- *Survey Research* **-** Survey research entails any measurement procedures that involves asking questions of respondents. The basic methodology of survey research involves sampling, question design and data collection activities (Forza, 2002). Survey research can be exploratory (initial research into a hypothetical or theoretical idea), descriptive (exploring and explaining a studied phenomenon), or confirmatory (connecting ideas to understand cause and effect) (Forza, 2002).

  The instrument for data collection in surveys is the questionnaire. The questionnaire is administered to a population sample. Sampling entails choosing a percentage of the population to be representative of the demographic characteristics of the whole population. The basic premise in sampling is that resource constraints make it impossible to survey the whole population.

- *Experiments* **–** These are research design techniques that employ variable manipulation and testing to investigate causal relationships and processes. Experiments are conducted to be able to predict phenomena.

On the other hand, qualitative research covers a variety of naturalistic and interpretive approaches and methods concerned with understanding the meanings that people attach to actions, decisions, beliefs, and values within the social world (Ritchie and Lewis, 2003). Qualitative research methods include the following:

- *Action research* **–** Action research is a form of participatory research where the researcher, being a principal member, effects change on the environment under study and monitors the results of that change (Mumford, 2001). In other words, the researcher purposefully engages with the research setting rather than remaining independent from it. The main advantage of action research is its ability to produce immediate results and assess their relevance to a specific problematic situation. In doing so, action research offers the opportunity to study a system and to concurrently collaborate with members of the system to guide it in the desirable direction (Coughlan and Coghlan, 2002). However, there are demerits associated with action research and questions about its academic rigor. These primarily stem from the close collaboration required between the researcher and the study organisation. Thus, some instances of action research are seen as mere “problem-solving” or “consultancy projects” (Adler and Adler, 1998).

- *Ethnographic research* **-** *Ethnographic research* is aimed at observing target users in natural, real-world settings with the primary aim of understanding and gaining insights on how a people live. The main method of data collection in ethnography is through participant observation, where the researcher becomes a full working member of the group studied (Collis and Hussey, 2003). This involves the researcher having to negotiate access, and build trust in those to work with, so as to ensure data collection is adequately undertaken. Ethnographic research is particularly advantageous in providing insights into real life behaviour, thereby being useful in identifying new and unmet user needs. This approach is predominantly employed at the beginning of a project when there is a strong need to fully understand real end user needs, or to appreciate the challenges of using a new product or service by a particular target market (Klein & Myers, 1999).
- *Grounded theory* **-** Grounded theory consists of a set of rigorous research procedures that lead to the development of theory from systematic research. It is an inductive approach that allows the researcher to develop a theoretical account of the general features of a topic while simultaneously grounding the account in empirical observations or data (Eisenhardt, 1989). Grounded theory is particularly advantageous because it combines the inductive and deductive approaches. On the other hand, it is considered difficult and complex to implement when processing a considerable amount of data and when generalizing findings outside the studied setting (Collis and Hussey, 2003).
- *Longitudinal design* **-** Longitudinal design concerns the collection and analysis of data over time. This often involves taking repeated measures of the same respondents at

several time intervals (Oppenheim, 1992). Longitudinal studies are essential for measuring social change, or changes associated with a variable or group of subjects, by allowing a diachronic analysis of the incidence of conditions and events This contrasts with cross-sectional design, in which data are collected at one point in time and unrelated groups are compared (Huberman and Miles, 1998). Several data types may be referred to as longitudinal, including repeated cross-sectional studies, retrospective studies, and prospective studies. Although longitudinal studies provide a unique opportunity to study subjects over a long period of time, there are some drawbacks associated with the methodology. These include subject attrition (where a participant drops out of the study), large sample size requirements, and length of period it takes to gather results (Myers, 2003; Martin and Turner, 1986).

- *Case study research* **-** Case studies are in-depth investigations and systematic analyses of real life situations aimed at gaining new and creative insights, and the development of new theory. It has high validity with practitioners - the ultimate users of research (Yin, 2003). Case study data collection techniques include interviews and observations. Case studies allow the researcher to investigate a topic or subject in great detail than might be possible, if they were dealing with a large sample size or large number of participants (Yin, 2003). Case studies and surveys are the dominant approaches adopted in operations and supply chain management research (Forza, 2002). Voss and Frolich (2002) note major findings in Operations Management such as the Lean Manufacturing concepts and theories in manufacturing strategy were developed through case studies. Additionally, case studies can be used as follow-up research, in an attempt to examine more deeply and validate previous empirical results (Voss and Frolich, 2002).

4.3.2.2 Deductive/Inductive

Deductive research advocates for theory testing by empirical observation. Deduction involves deducing logical conclusions from a set of input propositions and the available information. The propositions might be assumptions that the researcher is investigating or those that the researcher believes (Bryman and Bell, 2007; 2003). Deductive reasoning is associated with positivism and natural science models of social research, and quantitative research (Bryman and Bell, 2003).

On the other hand, inductive research develops theory from the observation of empirical evidence (Hussey and Hussey, 1997). Inductive reasoning moves from specific observations to broader generalisations and theories. Qualitative research is based on inductive reasoning (Bryman & Bell, 2003).

4.3.3 Justification for choice of research strategy

This research adopts the positivist view, and a deductive approach. The research develops research questions and enacts hypotheses from existing theories and extant literature (Forza, 2002). This is based on the assumption that RFID attributes investigated can be measured and manipulated. Accordingly, when a research involves quantifiable attributes, survey by questionnaire is particularly suitable (Collis and Hussey, 2003). As a result, survey by questionnaire is used for data collection. In addition, four case studies are conducted to validate the survey results. Thus, methodological triangulation is achieved through the combination of the two research methods (Scandura and Williams, 2000). By using methodological triangulation, the advantages of both research methods are realized and their individual limitations mitigated.

4.4 Research Design

Research design is the logical sequence of an action plan to collect, analyse and interpret data (Yin, 2009). There are three classifications of research design – exploratory, descriptive, or explanatory research (Saunders et al., 2012). It is also possible to have a combination of all the three classifications. Exploratory research typically involves the use of literature review or focus group interviews in order to identify critical issues and key variables, or to develop hypotheses for further research (Pizam, 1994). Descriptive research seeks to provide an accurate description of observations of phenomena. Lastly, explanatory/confirmatory research looks to provide an understanding of relationships between variables (Saunders et al., 2012).

In this section, the systematic plan for data collection, the dependent and independent variables used, and the plan for statistical analysis are outlined. The key stages of the research design phase include the design, testing and administration of questionnaires, outlining a plan for statistical analysis, and testing the statistical techniques using software programmes (SPSS and Amos). Key stages of the research design are discussed in greater detail in sections 4.4.1.-4.4.4.

4.4.1 Questionnaire design

Exploratory survey research was adopted in this research. Thus, in designing the questionnaire, a thorough review of the literature on RFID applications in supply chain management, adoption drivers and constraints, benefits and drawbacks, and impact on business performance was carried out. The aim of the literature review was to collect information about the adoption of RFID and its application in supply chain management.

The main research instrument used to collate data was the questionnaire. The questionnaire was mostly made up of close-ended questions where the respondents choose their answers from a given number of options. The response options for the closed-ended questions were exhaustive and mutually exclusive. The survey questions captured perceptual data using relative scores on a 1-5 Likert Scale (Oppenheim, 1992). For the questions, One (1) stood for "None", Three (3) represented "Moderate", whilst Five (5) meant "Very high".

Although rating scales have been extremely popular in social science research questionnaires, they are susceptible to a host of biases and limitations. In particular, they are susceptible to acquiescence response bias (Krosnick, 1991). Some respondents agree with the statement offered regardless of its content. Given the popularity of this measurement approach, researchers must decide the number of points to offer on a rating scale. There has been much debate about the appropriate number of points to be used on a rating scale.

Psychometric literature suggests that having more scale points is better but there is a diminishing return after around 11 points (Nunnally, 1978). Likert (1932) proposed that these scales should offer five points, but Dawes (2008) recently argued that comparable results are obtained from 7- to 10-point scales, which may yield more information than a shorter scale would. However, majority of research confirms that data from Likert items (and those with similar rating scales) becomes significantly less accurate when the number of scale points drops below five or above seven (Johns, 2010). Therefore, the majority of discourse has been over the use of 5-point versus 7-point scales.

Symonds (1924) was the first to suggest that reliability is optimized with seven response categories, and other early studies generally agreed (Colman et al., 1997). In that regard, Miller (1956) argued that the human mind has a span of absolute judgment that can distinguish about seven distinct categories, therefore any increase in number of response categories beyond seven might be counterproductive

While some studies advocate the use of 7-points (or higher) in order to increase the variance in a measure, others have cautioned that increasing measures are liable to being distorted due to extreme score bias (many respondents are not inclined to respond to high and low points). In that regard, some researchers have reported higher reliabilities for five-point scales (Lissitz and Green, 1975; Jenkins and Taber, 1977; McKelvie, 1978**).**

A five-point scale rather than a seven-point scale was chosen in this study for a number of reasons, one being due to practical considerations (e.g., ease of item preparation, speed of administration, and reduced administration costs). Previous research has found that a five-point scale is readily comprehensible to respondents and enables them to express their views (Marton-Williams, 1986**).** The literature suggests that five-point scale appears to be less confusing and to increase response rate (Babakus and Mangold, 1992). Another reason for choosing 5 point scales is that they present a good balance between having enough points of discrimination without having to maintain too many response options. With a 5-point scale, it is quite simple for the interviewer to read out the complete list of scale descriptors ('1 equals strongly disagree, two equals disagree …') (Dawes, 2008).

4.4.2 Pilot testing of questionnaires

In social science research, pilot studies can refer to feasibility studies conducted prior to a major study (Polit et al., 2001) or the pre-testing of a research instrument (Baker, 1994). The main objective of pilot studies is to present the researcher with advance insights into the feasibility of the research/survey, and to assess whether proposed methods or instruments are appropriate. Pilot studies can be based on quantitative and/or qualitative methods and can also be conducted to test a research process, e.g. the different ways of distributing and collecting the questionnaires.

Peat et al. (2002) has suggested pilot study procedures to improve the internal validity of a questionnaire. These include:

- Administering the questionnaire to pilot subjects in exactly the same way as it will be administered in the main study

- Requesting feedback from pilot subjects regarding ambiguities and complex questions
- Keeping record of time taken to complete the questionnaire and decide whether it is reasonable
- Discarding all unnecessary, complex or ambiguous questions
- Assessing the range of responses given for each question and decide whether they are adequate
- Checking that all questions are answered and re-word or re-scale those questions that are not answered as expected
- Shortening and revising questionnaire
- Repeat pilot (if possible)

In line with the procedures proposed by Peat et al. (2002), the questionnaire used in this study was pilot tested upon the completion of its design. This was done by distributing the questionnaires to a sample of 20 people including industry experts, academics, and the IT staff in the library of the University of Central Lancashire. A response rate of 100% was achieved because the researcher chose only those respondents who had promised to carefully complete and return the questionnaire. Feedback about the questionnaire design was received both in writing and verbally. The highlights from the feedback received were as follows:

- 100% of respondents believed the survey wording was clear and straight forward
- 100% of the respondents believed the survey made use of appropriate headings and had suitable multiple choices of answers
- 40% of the respondents believed the questionnaire was too lengthy and hence took more time to complete than indicated in the introduction (in the cover letter)
- 40% of the respondents believed the accompanying cover letter could have provided a more concise introduction into RFID use and adoption

Accordingly, the survey instrument was updated in line with the recommendations from the pilot study, before the commencement of the next stage of the survey.

4.4.3 Sample selection

A sample is defined as a collection of units from a population that is considered to be a true representation of that population" (Field, 2005).

Probability and non-probability sampling are the two sampling approaches in Social Science. In Probability sampling, all elements in the population have some opportunity of being included in the sample, and the mathematical probability that any one of them will be selected can be calculated. Types of probability sample include simple random sampling and systematic sampling. Simple random sampling represents a fraction population in which each member of the subset has an equal probability of being selected (Bryman and Bell, 2003). Systematic samples are drawn by starting at a randomly selected element in the sampling frame and then taking every nth element (e.g. starting at a random location in a telephone book and then taking every 50th name).

On the other hand, non-probability sampling involves selecting population elements based on the researcher's personal judgement or on the basis of their availability (e.g. because they volunteered). The consequence is that an unknown portion of the population is excluded (e.g. those who did not volunteer). One of the most common types of nonprobability sample is called a convenience sample – not because such samples are necessarily easy to recruit, but because the researcher uses whatever individuals are available rather than selecting from the entire population. Due to the fact that some elements of the population have no chance of being sampled, the extent to which a convenience sample – regardless of its size – actually represents the entire population cannot be calculated.

Many strategies can be used to create a probability sample. Each starts with a sampling frame, which is the list from which the potential respondents are drawn. The sampling frame operationally defines the target population from which the sample is drawn and to which the sample data will be generalized.

In this study, Financial Analysis Made Easy (FAME) and RFID Journal were the two directories used in selecting respondent organisations from sample frames. It was noted that a sample should be selected as randomly as possible in order to control bias (Saunders et al, 2003).

Simple random sampling was adopted in this research in order to give every organisation an equal chance of being included in the sample. However, convenience sampling techniques were also employed in selecting respondents from the sampled companies. Convenience sampling is a non-probability sampling method where subjects are selected because of their convenient accessibility or proximity (Bryman and Bell, 2003). In this case, convenience sampling involves choosing the most convenient person(s) to act as respondents. Supply chain managers, IT directors, and main RFID contacts within the organisations were chosen as respondents of this research because they are in better position to explain the operations of RFID within their organisations. It has been suggested that samples must be true representatives of the population (Walliman, 2011). As the aim of this research is to make generalisation from sample to population, representativeness of sample has been of primary importance.

In this study, organisations that had adopted RFID and those with plans to adopt RFID are surveyed. This ensures the generalizability and extension of research findings and conclusions to include a greater number of organisations in the population. Bryman and Bell (2003) advocate that sound generalizability should include all the variations available within the population and generally in the same proportions as in the population. . Therefore, this study has collected information from organisations that had adopted RFID and those with plans to adopt RFID in order to account for the possible variations, and thus improve generalizability.

Another reason for including organisations that had adopted RFID and those with plans to adopt RFID in the sample is to reduce framing effects or general cognitive bias, and thus improve the accuracy and reliability of information obtained. For example, in this study, information on the drivers and constraints of RFID adoption is solicited in the questionnaire. Although the information can be provided by organisations that have already adopted RFID, it is important that organisations intending to adopt RFID are surveyed on that as well because they could be potentially more likely to provide unbiased information on factors hindering their adoption of RFID. This is because they are at a potentially neutral position and are devoid of pressure of trying to justify or defend their adoption of the technology.

4.4.4 Questionnaire administration

There are various modes of collecting data by questionnaire. These modes vary in the method of contacting respondents, means of delivering of the questionnaire, and the method of administering the questionnaire. These variations can have different effects on the accuracy and quality of the data obtained.

Although scholars have not agreed on one standard definition of data quality, it is often characterized in terms of survey response rates, questionnaire item response rates, the accuracy of responses, absence of bias, and completeness of the information obtained from respondents. Mode of questionnaire administration has effects on elements of data quality.

There are a number of ways of administering questionnaire. These include post, telephone, and online. The choice of a method depends on several factors including efficiency, speed, cost, and sensitivity of questions. Postal questionnaire is considered an easy, and a relatively low cost option. However, a drawback of postal questionnaires is that they suffer from low response rates (Saunders et al., 2003). Although, good questionnaire design in terms of layout, formatting and question styling all go to improve response rate.

After several factors including efficiency, speed, response rate, and cost were carefully considered, postal questionnaires were ruled out. The decision to distribute the questionnaires by email was taken. However, questionnaires sent by email could be perceived as unsolicited e-mails by the recipients and could easily be deleted or filtered out (Walliman, 2011; Saunders et al., 2003). To mitigate this problem, the questionnaires were emailed out by a contact at RFID Journal (an independent media company devoted solely to RFID and its business applications). This was done to increase credibility of the research and to stimulate the interest of the recipients.

4.5 Data

Questionnaire survey was the primary method of data collection.

4.5.1 Response rate

The response rate describes the extent to which the final data set includes all sample members. Regardless of the mode of data collection, a high response rate is paramount when generalizing results to a larger population. High survey response rates help to ensure that survey results are representative of the target population. A survey must have a good response rate in order to produce accurate, useful results.

Response rates are widely reported to have decreased for many types of surveys over the past decade (Curtin et al. 2005; Steeh et al. 2001). One consequence of this major decline of response rates is the anxiety among social scientists about the validity of analysis of data from surveys with low response rates.

In this study, several methods were applied to boost the response rate. The "*funnel approach*" of starting survey questions from wider issues at market and industry levels before narrowing it down to company level details was used (Walliman, 2011). Also, the "total design method" was deployed. It consists of an 18-step process for avoiding bad formatting, illogical sequence, and repetition (Walliman, 2011). In order to further improve on the response rate, email reminders were sent at the end of the third and sixth and eighth week of sending out the questionnaire. Further details on the response rate obtained are discussed in section 5.3 of the next chapter (Survey by Questionnaire).

4.5.2 Data analysis

Data analysis involves the processing and modelling of data with the objective of deriving useful information, insightful conclusions, and supporting decision-making. Key data analysis processes including data inspection and cleaning, transformation, and presentation. Data analysis has multiple facets and approaches, encompassing diverse techniques under a variety of names, in different business, science, and social science domains.

4.5.2.1 Data types

The type of data collected is very important in determining the methodology of analysis that would be employed and consequently ensuring that conclusions are valid. In this study, data obtained from the questionnaire survey was scrutinised and the data types categorized accordingly. This was done using a software statistical package called SPSS. SPSS is the acronym of Statistical Package for the Social Science. SPSS is one of the most popular statistical packages which can perform highly complex data manipulation and analysis. Data was categorized into the following types:

- **Nominal Data:** This is data that classifies or categorizes a given attribute in no default or natural order. Example: Male or Female
- **Ordinal Data:** This is data that can be put in an order, but doesn't have a numerical meaning beyond the order. Ordinal scales are typically measures of non-numeric concepts like satisfaction, approval, etc.
- **Interval Data:** Interval scales are numeric scales where the order and exact differences between the values are known. Example: The difference between 40 and 30 degrees is a measurable 10 degrees, so is the difference between 10 and 20 degrees
- **Ratio Data:** Ratio scales give the order and exact value between units, but also have an absolute zero–which allows for a wide range of both descriptive and inferential statistics to be applied. Example: Height and Weight.

4.5.2.2 Data coding

Firstly, all variables were named and their format (numerical, string, etc.) specified. Data was then entered as numbers. If observations were recorded in textual format, for example Male or Female, they were coded as 1 and 2, respectively. Lastly, the "measure" of all entered variables was defined, choosing from options of nominal, ordinal, or scale.

4.5.2.3 Parametric vs Non-parametric

Parametric analysis procedures assume that data follow a specific distribution and hence rely on data about which the underlying parameters of its distribution is known (typically data that is normally distributed). On the other hand, nonparametric tests don't assume that data follow a specific distribution. Nonparametric tests are usually used when data being analysed is not normally distributed (this might be due to the distribution or the presence of outliers). Scores would typically be treated as nonparametric as would ordinal and nominal data.

In this study, parametric tests are used because:

1. They can perform well with skewed and non-normed data. For example, parametric tests can perform well with continuous data that are non-normal if you satisfy the sample size guidelines. For example, to conduct a one-way ANOVA between 2-9 groups with non-normed data, the sample size in each group should be greater than 15.
2. Parametric tests usually have more statistical power than nonparametric tests. Thus, the researcher is more likely to detect a significant effect where one exists. Nonparametric tests are generally less sensitive and so have lower statistical power.

4.6 Data analysis outline

This section outlines how statistical tools and techniques were used to address the research questions. Descriptive statistical methods were used to describe the basic features of the data in this study. Means and standard deviations were used to provide simple summaries about the sample and the measures. Tables were used to present the results.

Aside from the descriptive statistical techniques mentioned, three main inferential statistical techniques were used to address the research questions. These are (i) Binary Logistic Regression and (ii) Structural Equation Modelling (SEM), and (iii) Analysis of Variance (ANOVA). In addition, a Chi-square test is produced as part of both Logistic regression and

SEM. These particular inferential techniques were chosen because they presented the best methods and conditions for analysing the results obtained from our questionnaire survey, taking into consideration the variable types (categorical, ordinal, nominal, etc.), data patterns, sampling method adopted, and the assumptions associated with the statistical techniques in deliberation. Sections 4.6.1 – 4.6.4 provide details on how the statistical tests are derived mathematically and how they are applied and interpreted. The abbreviation "Eq" stands for equation, and is numbered in order to keep track of the formulae used in this section. Section 4.7 provides the justification for choice of statistical techniques in context of our research questions (section 1.3).

4.6.1. Descriptive statistics

Means, standard deviations, skewness and kurtosis tests are used to analyze the spread and distribution of the data. The formulae for the statistical techniques to be used are detailed below.

- The sample mean is denoted as $\bar{x}$

$$\textit{Sample mean} = \bar{x} = \Sigma x / n \qquad \text{....Eq (1)}$$

where ***Σx*** is the sum of all the sample observations, and ***n*** is the number of sample observations.

- The standard deviation of a sample is known an ***S*** and is calculated using:

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}} \qquad \text{....Eq (2)}$$

where ***x*** represents each value in the population, ***x*** is the mean value of the sample, ***Σ*** is the summation (operator), and ***n-1*** is the number of values in the sample minus 1.

- *The skewness of a sample* is used for describing or estimating symmetry of a distribution (relative frequency of positive and negative extreme values). It is represented as ***S.***

$$S = \frac{n}{(n-1)(n-2)} \frac{\sum_{i=1}^{n}(X_i - X_{avg})^3}{s^3} \qquad \text{....Eq (3)}$$

where ***n*** is the sample size, ***s*** is the sample standard deviation, and X_{avg} is the sample mean

- *The kurtosis of a sample* is used for describing or estimating a distribution's 'peakedness' and frequency of extreme values. It is represented as ***K***

$$K = \frac{n(n+1)}{(n-1)(n-2)(n-3)} \frac{\sum_{i=1}^{n}(X_i - X_{avg})^4}{s^4} \qquad \text{....Eq (4)}$$

where ***n*** is the sample size, ***s*** is the sample standard deviation, and X_{avg} is the sample mean.

4.6.2 Chi-square test of goodness of fit

A chi-square goodness of fit test is applied when you have one categorical variable from a single population. It is used to determine whether sample data are consistent with a hypothesized distribution. The chi-square goodness of fit test is produced as part of both logistic regression and SEM (explained in sections 4.6.3 and 4.6.4 respectively) and is appropriate when the following conditions are met:

i. The sampling method is simple random sampling.
ii. The variable under study is categorical or ordinal.
iii. The expected value of the number of sample observations in each level of the variable is at least 5.

The degrees of freedom, expected frequency counts, test statistic, and the p-value associated with the test statistic are the main outputs obtained.

- Degrees of freedom - The degrees of freedom (***DF***) is equal to the number of levels (***k***) of the categorical variable minus 1:

$$DF = k - 1 \qquad \text{....Eq (5)}$$

- Expected frequency counts - The expected frequency counts at each level of the categorical variable are equal to the sample size times the hypothesized proportion from the null hypothesis

$$E_i = np_i \qquad \text{....Eq (6)}$$

where E_i is the expected frequency count for the ***ith*** level of the categorical variable, n is the total sample size, and p_i is the hypothesized proportion of observations in level i.

- Test statistic - The test statistic is a chi-square random variable (χ^2) defined by the following equation.

$$\chi^2 = \Sigma [(O_i - E_i)^2 / E_i] \quad \text{....Eq (7)}$$

where O_i is the observed frequency count for the ***ith*** level of the categorical variable, and E_i is the expected frequency count for the ***ith*** level of the categorical variable. Greater differences between expected and actual data produce a larger chi-square statistic value. The larger the chi-square value, the greater the probability that there really is a significant difference

- P-value - The ***p-value*** is the probability of observing a sample statistic as extreme as the test statistic.

The p-value is a function of the observed sample results that is used for testing the statistical hypothesis. Before the test is performed, a threshold value is chosen, called the significance level of the test, traditionally 5% or 1% and denoted as α. In this study, 5% (0.05) is the significance level adopted. Formally, α is the maximum acceptable level of risk for rejecting a true null hypothesis (Type I error) and is expressed as a probability ranging between 0 and 1. The smaller the significance level, the less likely you are to make a Type I error, and the more likely you are to make a Type II error (failure to reject a false null hypothesis). Therefore, 5% level of significance is chosen as an alpha that balances these opposing risks of error based on their practical consequences in this study.

For a chi-square goodness of fit test, hypotheses take the following form.

H_0: The data are consistent with a specified distribution.
H_a: The data are not consistent with a specified distribution.

Typically, the null hypothesis (H_0) specifies the proportion of observations at each level of the categorical variable. The alternative hypothesis (H_a) is that at least one of the specified proportions is not true. For example, in SEM, when a structural model is built, the null hypothesis states that the model fits the data collected. Therefore, a chi-square statistic with a p-value > .05 will indicate good model fit.

4.6.3 Binary Logistic Regression

Binary logistic regression is a statistical method for analysing a dataset in which there are one or more independent variables that determine an outcome. The outcome is measured with a dichotomous variable (in which there are only two possible outcomes). The goal of binary logistic regression is to find the best fitting model to describe the relationship between the dichotomous characteristic of interest (dependent variable/response or outcome variable) and a set of independent (predictor or explanatory) variables. Logistic regression generates the coefficients (and its standard errors and significance levels) of a formula to predict a logit transformation of the probability of presence of the characteristic of interest:

$$logit(p) = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + ... + b_kX_k \qquad \text{....Eq (8)}$$

where ***p*** is the probability of presence of the characteristic of interest, b_0 is the intercept from the linear regression equation (the value of the criterion when the predictor is equal to zero), and b_1X is the regression coefficient multiplied by some value of the predictor.

The logit transformation is defined as the logged odds:

$$odds = \frac{p}{1-p} = \frac{probability\ of\ presence\ of\ characteristic}{probability\ of\ absence\ of\ characteristic} \qquad \text{....Eq (9)}$$

and

$$logit(p) = \ln\left(\frac{p}{1-p}\right) \qquad \text{....Eq (10)}$$

where ***ln*** is the natural logarithm.

4.6.3.1 Assumptions and data type requirements

Logistic regression is used in this study because of the following reasons.

- It does not need a linear relationship between the dependent and independent variables. Logistic regression applies a non-linear log transformation to the predicted odds ratio, and thus can handle various types of variable relationships.
- The independent variables and error terms (the residuals) do not need to be multivariate normal
- Logistic regression does not need variances to be heteroscedastic for each level of the independent variables.
- Logistic regression can handle ordinal and nominal data as independent variables. The independent variables do not need to be metric (interval or ratio scaled)

However, some other assumptions still apply.

- Binary logistic regression requires the dependent variable to be binary
- Logistic regression assumes that P(Y=1) is the probability of the event occurring, it is necessary that the dependent variable is coded accordingly. That is, for a binary regression, the factor level 1 of the dependent variable should represent the desired outcome.
- The error terms need to be independent. Logistic regression requires each observation to be independent. That is that the data-points should not be from any dependent samples design. Also the model should have little or no multicollinearity. That is that the independent variables should be independent from each other
- Logistic regression assumes linearity of independent variables and log odds. Whilst it does not require the dependent and independent variables to be related linearly, it requires that the independent variables are linearly related to the log odds. Otherwise the test underestimates the strength of the relationship and rejects the relationship too easily, that is being not significant (not rejecting the null hypothesis) where it should be significant.

4.6.3.2 Model fit assessment

After running a binary logistic regression model, the model fit is assessed. This is done using a chi-square test (section 4.6.2)

Another method used to assess the fit of the binary logistic model is to examine how 'likely' the sample results are, given the parameter estimates. The probability of the observed results given the parameter estimates is known as the **'Likelihood'**. Since the likelihood is a small number less than 1, it is customary to use -2 times the log likelihood (**-2LL**) as an estimate of how well the model fits the data. A good model is one that results in a high likelihood of the observed results.

4.6.3.3 Hypothesis testing

The final part of the binary logistic regression model involves hypothesis testing. This is done using the Wald statistic. Under the Wald statistical test, the maximum likelihood estimate $\hat{\theta}$ of the parameter(s) of interest θ is compared with the proposed value θ_0, with the assumption that the difference between the two will be approximately normally distributed. In the univariate case, the Wald statistic is:

$$\frac{(\widehat{\theta}-\theta_0)^2}{\operatorname{var}(\hat{\theta})} \quad \text{....Eq (11)}$$

Binary logistic regression is ideal for testing models to predict categorical outcomes with two categories. The predictor (independent variable) can be either continuous, categorical or both. For example, the categorical dependent variable that was used in research questions 2 has values “respondent has adopted RFID” and “respondent has not adopted RFID”. This allowed us to split the data into two sets and examine the relationships between the dependent variable and the covariates (and between the covariates themselves). Covariates are variables that are possibly predictive of the outcome under study.

4.6.4 Structural Equation Modelling (SEM)

Structural equation modeling, or SEM, is a very general, primarily linear and cross-sectional statistical modeling technique. It is a combination of factor analysis and multiple regression analysis, and it is used to analyze the structural relationship between measured variables and latent constructs. This method is preferred by researchers because it estimates the multiple and interrelated dependence in a single analysis, and it provides analyses for latent constructs (variables not observed or measured directly).

In SEM, interest usually focuses on latent constructs – abstract variables like "culture" or "attitude towards a brand" – rather than on the manifest variables used to measure these constructs. In empirical research, measurement is recognized as difficult and error-prone. By explicitly modeling measurement error, SEM users seek to derive unbiased estimates for the relations between latent constructs. To this end, SEM allows multiple measures to be associated with a single latent construct. Thus, SEM, to date, is the most effective tool for determining and interpreting the relationships between variables involving latent and observed constructs, like those set out in research questions 1, 2, 3, 4 and 5 of section 1.3.

The concept of the latent variable from confirmatory factor analysis and structural equation modeling can be viewed in parallel to the classical test theory formulation. The latent variable is like a true score that is not directly observed, the observed variable is the measurement that is directly observed, and some degree of random measurement error may exist such that the observed score does not perfectly match the true score. In these terms, it is assumed that the true score causes a portion of the observed score typically with some unaccounted variance remaining. This causal hypothesis suggests a regression or path model that can be graphically depicted with ellipses that stand for latent variables and square boxes that stand for measured variables, as shown in Figure 4.1.

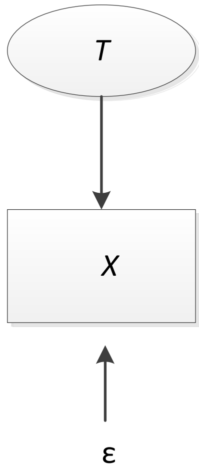


Figure 4.1: *Path model in SEM*

The general SEM notation is:

$$\mathbf{Xi = \Lambda X\ \xi k + \theta\delta} \qquad \text{....Eq (12)}$$

where: $\boldsymbol{Xi}$ = a column vector of observed variables;

$\boldsymbol{\xi k}$ = *ksi,* a column vector of latent variables;

$\boldsymbol{\Lambda X}$ = lambda*, an* $\boldsymbol{i\ X\ k}$ matrix of coefficients defining the relations between the manifest *(X)* and latent *(ξ)* variables; $\boldsymbol{\vartheta\delta}$ = theta-delta, an i $\boldsymbol{X}$ i variance/covariance matrix of relations among the residual terms of $\boldsymbol{X}$

SEMs consist of a series of multiple regression equations – all equations are fitted simultaneously. SEMs produce several statistics, including an overall test of model fit and tests of individual parameter estimates. In addition, SEMs produce unstandardized regression coefficients, standard errors for those coefficients, a standardized version of the regression coefficients, and a squared multiple correlation or R^2 for the regression equation. Structural equation modeling (SEM) is now a regularly used method for representing dependency relations in multivariate data in the behavioural and social sciences.

AMOS (Analysis of Moment Structures), an add-on module for SPSS is used in this study. It is designed primarily for structural equation modeling, path analysis, and covariance structure modeling, and was used for analyses in all our research questions. It features an intuitive graphical interface that allows the analyst to specify models by drawing them. It also has a built-in bootstrapping routine and handling of missing data. It reads data from a number of sources, including MS Excel spreadsheets and SPSS databases.

This study uses SEM for causal modeling, or path analysis, which hypothesizes causal relationships among variables and tests the causal models with a linear equation system. Causal models to be tested will involve either manifest variables, latent variables, or both. Sound guidelines for the reporting of SEM results have been offered previously by Steiger (1988), Breckler (1990), Raykov, Tomer, and Nesselroade (1991), Hoyle and Panter (1995), and Boomsma (2000) were followed in this study.

4.6.4.1 SEM fit assessment

The chi-square statistic tests the overall fit of the structural model to the data. The null hypothesis under test is that the model fits the data, therefore researchers hope to obtain a small, non-significant chi-square value. A small, non-significant chi-square value indicates good model fit thus suggesting that the model fits the data acceptably in the population from which the researcher drew the sample.

However, as the chi-square (χ^2) test is not only sensitive to sample size but also sensitive to the violation of the multivariate normality assumption (West et al., 1995), it should not serve as the sole basis for judging model fit. Bollen and Long (1993) and Mueller (1996) recommend the evaluation of several indices simultaneously which represent different classes of goodness-of-fit criteria. There are three classes of descriptive fit indices developed by SEM:

i. Descriptive measures of overall model fit – These are the Root Mean Square Error of Approximation (RMSEA) and the Root Mean Square Residual (RMR).

ii. Descriptive measures based on model comparisons – These are the Normed Fit Index (NFI), the Non-Normed Fit Index (NNFI), the Comparative Fit Index (CFI), the Goodness-of Fit Index (GFI), and the Adjusted Goodness-of-Fit Index (AGFI)

iii. Descriptive measures of model parsimony – These are the Parsimony Goodness-of-Fit Index (PGFI), and the Parsimony Normed Fit Index (PNFI)

<u>*Descriptive measures of overall model fit*</u>

Measures of overall model fit indicate to which extent a structural equation model corresponds to the empirical data. These criteria are based on the difference between the sample covariance matrix and the model-implied covariance matrix.

- ***Root Mean Square Error of Approximation (RMSEA) –*** The Root Mean Square Error of Approximation (RMSEA) is a measure of approximate fit in the population and is therefore concerned with the discrepancy due to approximation (Steiger, 1990). RMSEA is estimated by:

$$\hat{\varepsilon}_a = \sqrt{\max\left\{\left(\frac{F(\mathbf{S},\mathbf{\Sigma}(\hat{\theta}))}{df} - \frac{1}{N-1}\right), 0\right\}} \qquad \text{....Eq (13)}$$

where

$F(\mathbf{S},\mathbf{\Sigma}(\hat{\theta}))$ is the minimum of the fit function,

$df = s - t$ is the number of degrees of freedom, and

N is the sample size.

An RMSEA value of or less than 0.05 is considered a good fit (Steiger, 1990; Browne and Cudeck, 1993). Hu and Bentler (1999) suggest an RMSEA of less than .06 as a cut-off criterion.

- ***Root Mean Square Residual (RMR) –*** The Root Mean Square Residual index (RMR) of Jöreskog and Sörbom (1981; 1989) is an overall goodness-of-fit measure that is based on the fitted residuals. RMR is defined as the square root of the mean of the squared fitted residuals:

$$RMR = \sqrt{\frac{\sum_{i=1}^{p}\sum_{j=1}^{i}(s_{ij} - \hat{\sigma}_{ij})^2}{p(p+1)/2}} \quad \text{....Eq (14)}$$

where

s_{ij} is an element of the empirical covariance matrix $\mathbf{S}$,

$\hat{\sigma}_{ij}$ is an element of the model-implied matrix covariance $\mathbf{\Sigma}(\hat{\theta})$, and

p is the number of observed variables.

RMR values less than 0.05 are considered a good fit (Jöreskog and Sörbom, 1989; Hu & Bentler, 1995).

<u>Descriptive fit measures based on model comparison</u>

Comparison indices compare the fit of a model of interest to the fit of a baseline model. Commonly used comparison indices include Normed Fit Index (NFI), the Non-normed Fit Index (NNFI), the Comparative Fit Index (CFI), the Goodness-of-Fit Index (GFI), which will be explained below in more detail.

- **Normed Fit Index (NFI) and Non-normed Fit Index (NNFI) –** The Normed Fit Index (NFI) proposed by Bentler and Bonnett (1980) is defined as:

$$NFI = \frac{\chi_i^2 - \chi_t^2}{\chi_i^2} = 1 - \frac{\chi_t^2}{\chi_i^2} = 1 - \frac{F_t}{F_i}, \quad \text{....Eq (15)}$$

where

χ_i^2 is the chi-square of the independence model (baseline model),

χ_t^2 is the chi-square of the target model, and

F is the corresponding minimum fit function value.

NFI values of greater than .95 are indicative of good fit relative to the baseline model (Kaplan, 2000), whereas values greater than .90 are typically interpreted as indicating an acceptable fit (Marsh and Grayson, 1995; Schumacker and Lomax, 1996). A disadvantage of the NFI is that it is affected by sample size. In order to mitigate this problem, the Non-normed Fit Index (NNFI), also known as the Tucker-Lewis Index (TLI), was developed. The NNFI is defined as:

$$NNFI = \frac{(\chi_i^2 / df_i) - (\chi_t^2 / df_t)}{(\chi_i^2 / df_i) - 1} = \frac{(F_i / df_i) - (F_t / df_t)}{(F_i / df_i) - 1/(N-1)}, \quad \text{....Eq (16)}$$

where

χ_i^2 is the chi-square of the independence model (baseline model),

χ_t^2 is the chi-square of the target model,

F is the corresponding minimum fit function value, and

df is the number of degrees of freedom.

NNFI values between .95 and .97 are indicative of good fit. An advantage of the NNFI is that it is one of the fit indices less affected by sample size (Bentler, 1990; Bollen, 1990; Hu & Bentler, 1995, 1998).

- **Comparative Fit Index (CFI)** – The Comparative Fit Index (CFI) is defined as:

$$CFI = 1 - \frac{\max[(\chi_t^2 - df_t), 0]}{\max[(\chi_t^2 - df_t), (\chi_i^2 - df_i), 0]} \quad \text{....Eq (17)}$$

where

max denotes the maximum of the values given in brackets,

χ_i^2 is the chi-square of the independence model (baseline model),

χ_t^2 is the chi-square of the target model, and

df is the number of degrees of freedom.

CFI values of .95 to .97 is indicative of good fit. Comparable to the NNFI, the CFI is one of the fit indices less affected by sample size (Bentler, 1990; Bollen, 1990; Hu & Bentler, 1995, 1998, 1999).

- **Goodness-of-Fit-Index (GFI)** – The Goodness-of-Fit-Index (Jöreskog & Sörbom, 1989) measures the relative amount of the variances and covariances in the empirical covariance matrix that is predicted by the model-implied covariance matrix. The GFI is defined as:

$$GFI = 1 - \frac{F_t}{F_n} = 1 - \frac{\chi_t^2}{\chi_n^2}, \quad \text{....Eq (18)}$$

where

χ_n^2 is the chi-square of the null model (baseline model),

χ_t^2 is the chi-square of the target model, and

F is the corresponding minimum fit function value.

GFI values between .90 and .95 are considered a good fit (Marsh & Grayson, 1995; Schumacker & Lomax, 1996).

Descriptive measures of model parsimony

Parsimony is considered to be important in assessing model fit (Hu & Bentler, 1995) and serves as a criterion for choosing between alternative models. The Parsimony Goodness-of-Fit Index (PGFI), the Parsimony Normed Fit Index (PNFI) adjust for model parsimony when assessing the fit of structural equation models.

- **Parsimony Goodness-of-Fit Index (PGFI) and Parsimony Normed Fit Index (PNFI) –** The Parsimony Goodness-of-Fit Index (PGFI; Mulaik et al., 1989) and the Parsimony Normed Fit Index (PNFI; James, Mulaik, & Brett, 1982) are modifications of GFI and NFI:

$$PGFI = \frac{df_t}{df_n} GFI \qquad \text{....Eq (19)}$$

where

df_t is the number of degrees of freedom of the target model,

df_n is the number of degrees of freedom of the null model, and

GFI is the Goodness-of-Fit Index,

and

$$PNFI = \frac{df_t}{df_i} NFI \qquad \text{....Eq (20)}$$

where

df_t is the number of degrees of freedom of the target model,

df_i is the number of degrees of freedom of the independence model, and

NFI is the Normed Fit Index.

PGFI and PNFI both range between zero and one, with higher values indicating a more parsimonious fit.

4.6.4.2 SEM fit evaluation

Although SEM provides several fit indices after running the analysis, to explain and discuss all the indices will be superfluous. Hair et al. (2006) observe that it will be adequate to provide evidence of model fit based on three to four indices. However, not all of the suggested three or four should be reported due to overlap between the different indices. In this thesis, all model fit indices generated when running our models were observed, however, corroborating evidence of model fit is provided by the RMSEA fit statistic, and the NNFI (also known as TLI). RMSEA and NNFI were selected because they are sensitive to model misspecifications and do not depend on sample size as strongly as the chi-square test χ^2 (Fan et al., 1999; Hu and Bentler, 1998). GFI and AGFI were not used because simulation studies suggest that they are not independent of sample size (Hu and Bentler, 1995, 1998, 1999).

Having obtained a model that fits well, the parameter estimates and individual tests of significance of each parameter estimate are then interpreted. Path diagram outputs provide visual display of the parameter estimates. The values associated with each path are standardized regression coefficients. These values represent the amount of change in the *dependent (outcome) variable* given a standard deviation unit change in the *independent (predictor) variable*. R-square values ranging between 0 and 1 are also displayed, with 0 meaning that the independent variable (***X***) has no predictive ability on the dependent variable (***y***) and 1 meaning that an independent variable (***X***) perfectly predicts the dependent variable (***y***). Finally, individual tests of significance of each parameter estimate are interpreted.

4.7 Justification for choice of statistical techniques for research questions

Binary logistic regression, SEM and ANOVA are the main techniques to be used for the research questions. Binary logistic regression was adopted because it was ideal for analysing a dataset in which there are one or more independent variables that determine an outcome, specifically for an outcome measured with a dichotomous variable (in which there are only two possible outcomes). Accordingly, in research questions 1 and 2, the outcome variable investigated is binary (decision to adopt RFID: “Yes” or “No”).

Additionally, binary logistic regression was chosen because of its robustness – independent variables don’t have to be normally distributed, or have equal variance between them; it does not assume a linear relationship between the independent and outcome variables, and it does not require the independent variables be interval.

SEM was used to address research questions 3 and 4 and was also used as a follow-up technique to validate the results of the binary logistic regression in research question 2. SEM’s ability to deal with latent constructs makes it an ideal tool for assessing relationships between variables that are not directly observed. Additionally, SEM accounts for measurement error for individual parameter estimates, allowing us to obtain unbiased relationships estimates between variables.

Finally, ANOVA was chosen to address research question 5. As this question concerns comparing means of multiple continuous independent variables against one dependent continuous variable, ANOVA was chosen as the most appropriate technique to address the question. ANOVA allows for analysing the differences between groups and their associated procedures. However, it falls short in providing estimates as to how individual parameters differ across groups, particularly in relation to latent constructs. Therefore, SEM is used as a follow up technique to determine the coefficient estimates of individual parameters.

4.8 Summary

In this chapter, an overview of research methodologies adopted in this research was given and a case was made for the chosen methodologies. Thereafter, an outline of the statistical techniques used for data analysis was also given.

The next chapter reports the result of a survey by questionnaire. The survey was designed to collect responses of key actors responsible for RFID operations within the surveyed organisations. Top management, supply chain/operations managers, and IT specialists were the target respondents due to the fact that they are concerned with decisions on key strategic and operational issues relating to RFID within their organisations. Specifically, the survey elicited perceptual information in respect of the decision to adopt RFID and the role organisational characteristics played in that regard; the implementation processes of RFID and how they were affected by organisational and technological factors; and the benefits derived from RFID. Questionnaires were designed and distributed to collect data, and the data was used to test the validity of the hypotheses proposed earlier, with the aim of answering the research questions.

The next chapter also seeks to validate the research model through survey by questionnaire. Additionally, in chapter 6, case studies of selected firms that participated in the survey by questionnaire are presented as part of the validation of the survey results and testing of relevant hypotheses.

CHAPTER 5 – SURVEY BY QUESTIONNAIRE

5.1 Introduction

This chapter reports the planning, design and administration of a survey by questionnaire, and presents the results of descriptive and inferential statistics from which findings were made. The primary aim of the survey was to generate data for the purpose of exploring and testing the relationships specified in the research framework and research hypotheses presented in chapter 3. To test the hypotheses proposed in chapter 3, the relationships between the main research constructs of strength of culture, business size, and business process re-engineering (BPR) were determined. In doing so, logistic regression and structural equation models were used to assess the role these constructs play in influencing organisations' decision to adopt RFID, RID implementation processes, RFID benefits.

This study has two main research themes; the first determines the factors that drive and hinder the adoption of RFID, in the context of the theories of Diffusion of Innovation (DOI) and Technology-Organisation-Environment (TOE) framework, which offer a robust perspective for analyzing organisational adoption and usage of technology. The second theme of the study empirically establishes the effects of organisational characteristics (business size, strength of culture and BPR) on RFID adoption, implementation processes, and on realizing and moderating benefits derived from RFID. Consequently, a survey was designed to undertake the study and gain understanding of the two research themes. A survey by questionnaire, being a deductive research method, was deemed appropriate for this. The survey was designed to provide the basis for testing the research hypotheses. The survey was complemented with case studies (in chapter 6) to mitigate the limitations of a single method approach and to gain insights through the in-depth study of cases.

5.2 Questionnaire Design

As advocated by Nachmias and Nachmias (1992), a comprehensive approach to designing questionnaires was adopted. The Total Design Method (TDM), developed by Dillman (1978), uses social exchange theory to identify ways to improve the quantity and quality of survey responses by organizing the data collection process in a way that attempts to convince respondents that the merits of responding outweigh the costs of doing so. The TDM is considered to be a general framework for designing online, mixed-mode surveys, and postal surveys and was thus adopted in the research instrument design phase of this study. TDM entails a broad set of questions to be asked, taking into account data types, analysis and research questions to be addressed.

The questionnaire was designed and distributed to various organisations across a variety of industrial sectors. It was designed to assess the interactions of organisational characteristics such as business size, strength of culture, and business process re-engineering with RFID adoption decision, implementation processes, and benefits. The questionnaire was mostly made up of close-ended and Likert-scale driven questions, where the respondents pick an answer from a given number of options, or rank their responses according to a scale, respectively. The response options for the closed-ended questions were exhaustive and mutually exclusive. A cover letter soliciting for participation of organisations accompanied the questionnaire when distributed.

The questionnaire consisted of 30 questions. It was divided into two sections, namely, “Company details” and “RFID technology”. The first section collated the demographic characteristics of the responding company. Background information obtained includes the names of the responding company and respondent, the position or post held by the respondent, the estimates of the number of employees in the company and the company’s annual turnover, the year the company was established, and the business sector the company operates in. Thus, in this section both textual and numeric data were generated.

The second part of the questionnaire solicited the views of industry experts concerning (a) the drivers of RFID adoption, where a list of corporate, supply chain, and product/service-related factors were listed and respondents were asked to rate the extent to which the listed factors influenced their company’s decision to adopt RFID; (b) the hindrance factors of RFID adoption, where a list of financial, manpower and technical issues were listed and respondents were asked to rate the extent to which the listed factors hindered their organisation’s decision to adopt RFID; (c) the effect of organisational characteristics (strength of culture, business size and BPR) on a company’s decision to adopt RFID, where respondents were given a list of factors and asked to rate the extent to which the factors affected their organisation’s adoption of RFID; (d) the effect of organisational characteristics (strength of culture, business size and BPR) on a company’s RFID implementation processes, where respondents were given a list of factors and asked to rate the extent to which the factors affected their company's implementation of RFID; (e) the effect of organisational characteristics (strength of culture, business size and BPR) on benefits derived from RFID technology, where respondents were given a list of factors and asked to rate the extent to which the factors affected the benefits their organisations derived from RFID implementation; and (f) the impact of PULT, RFID implementation stage, and pedigree in RFID on benefits derived from RFID implementation.

A copy of the questionnaire used is attached in Appendix A.

5.3 Questionnaire administration and response rate

In this study, organisations that had adopted RFID and those with plans to adopt RFID are surveyed. This ensures the generalizability and extension of research findings and conclusions to include a greater number of organisations in the population. Bryman and Bell (2003) advocate that sound generalizability should include all the variations available within the population and generally in the same proportions as in the population. . Therefore, this study has collected information from organisations that had adopted RFID and those with plans to adopt RFID in order to account for the possible variations, and thus improve generalizability.

Another reason for including organisations that had adopted RFID and those with plans to adopt RFID in the sample is to reduce framing effects or general cognitive bias, and thus improve the accuracy and reliability of information obtained. For example, in this study, information on the drivers and constraints of RFID adoption is solicited in the questionnaire. Although the information can be provided by organisations that have already adopted RFID, it is important that organisations intending to adopt RFID are surveyed on that as well because they could be potentially more likely to provide unbiased information on factors hindering their adoption of RFID. This is because they are at a potentially neutral position and are devoid of pressure of trying to justify or defend their adoption of the technology.

A total of 750 questionnaires were administered by email. 171 questionnaires were returned. This gives a response rate of 22.8%. This response rate is considered to be acceptable for studies of organisations. Earlier empirical studies of organisations have accepted lower response rates as representative of organisations. For instance, Ahmed et al. (1996) achieved a response rate of 6.5% when investigating the impact of training and development on organisational performance.

Out of the 171 questionnaires returned, 163 were fully completed with logical answers. 163 of the questionnaires were used for analysis while the remaining 8 questionnaires were rejected for missing data and excluded from further analysis. Out of the 163 respondents, 96 had already adopted RFID while the remaining 67 respondents had plans of adopting RFID.

Poorly completed questionnaires still provide some data but are excluded from further analysis in order to reduce the incidence of missing data, and hence improve the reliability of results (Creswell, 2007; Bryman and Bell, 2003).

5.4 Statistical Results

The responses of both questionnaires were coded and entered into SPSS version 22, in order to carry out statistical analysis of the data collected. The SPSS software tool enables the computation of simple descriptive statistical analyses such as frequencies, means, standard deviation, and more complex inferential statistical analyses such as Regression, Chi-square test for association or differences, Analysis of Variance (ANOVA) and much more.

5.4.1 Non-response bias analysis

The potential problem of non-response bias can be dealt with in two ways. In the first approach, Lambert and Harrington (1990) recommend sending to non-respondents a summarized version of the original questionnaire to complete. Upon receiving their responses, one-way ANOVA is conducted to test for variance between responses of the original and summarized questionnaires.

The second approach involves splitting the responses into two groups – first wave and second wave. It proceeds with testing for statistically significant differences between the first and second wave of responses. This approach was adopted over the first one recommended by Lambert and Harrington (1990) because, in the first one, there was no guarantee that the non-respondents would respond, given that they refused to participate in the first study.

Consequently, in this study, the second wave of the surveys received was considered to be representative of the non-respondents. Thereafter, t-tests were conducted on the responses of the two waves as shown in Table 5.1. The t-test result yielded no statistically significant differences among the survey items tested. This evidence is corroborated by the 2-tailed significance value and the Levene’s test. As shown in Table 5.1, the two tailed significance values are all greater than 0.05 for all the variables measured. Thus, the null hypothesis that there is no significant difference between mean values of the two waves of responses cannot be rejected. Additionally, Levene's test for the equality of variance of the measured variables indicates that the two variances are significantly different. Thus, from Table 5.1, it can be seen that for all the measured variables, the null hypothesis that there is no significant difference between mean values of the two waves of responses cannot be rejected. Thus, the research instrument can be adjudged to be valid. Therefore, there was no evidence of non-response bias impacting the study.

Table 5.1: Wave analysis to test external validity for non-response bias of the questionnaire

Variable	Mean 1st Wave	Mean 2nd Wave	Sig.	Levene's test
Demographics				
Annual turnover	3.13	2.97	.407	.064
Number of employees	4.13	3.87	.149	.089
Drivers of RFID adoption				
Top management initiative	4.77	4.62	.568	.134
Industry pressure	3.13	3.44	.342	.592
Strength of culture				
Goals and objectives	3.93	3.83	.907	.609
Innovation	4.70	4.56	.201	.249
Focus on customer satisfaction	3.90	3.21	.192	.270
RFID benefits				
Increased visibility	4.12	3.45	.179	.923
Electronic traceability	4.41	4.21	.185	.543
Reduced out-of-stocks	3.78	3.94	.170	.421

5.4.3 Validity and Reliability analysis

It is vital to assess the quality of a research instrument in order to account for the effects of measurement errors in any relationships that are being measured (Forza, 2002). Accordingly, the questionnaire used in this study was tested for reliability and validity.

5.4.3.1 Reliability analysis

Tracey et al. (2005) and Curkovic et al. (2000) recommend the assessment of the reliability of the scales used to gather responses in a research, in order to ensure that questionnaire data is devoid of random effects. Reliability tests measure the internal consistency of instruments employed to measure concepts. For instruments measuring a concept to be reliable, they should be highly correlated. Cronbach's coefficient alpha is the most widely used test of internal consistency (Ngai and Cheng, 1997; Flynn et al., 1990). Thus, Cronbach tests were computed for the main elements of the questionnaire – demographic characteristics, drivers and constraints of RFID adoption, culture strength attributes, RFID benefits, as well as the entire questionnaire. The reliability test result for the questionnaire are reported in Table 5.2. Table 5.2 shows that the Cronbach's alpha for the overall scale of the survey instrument consisting of 109 variables was found to be 0.812**.** In addition, the scale reliabilities were also computed again for each of the sub items. The results of this analysis indicate that for all the sub-items of the questionnaire, the coefficient alphas exceed 0.70; thus the scales demonstrate strong internal consistency. Swafford et al. (2006) and Forza (2002) report Cronbach alpha values of 0.6 or higher to be acceptable in establishing the reliability of a construct.

Table 5.2: The reliability test results

Variables	Cronbach's Alpha	Number of Items
The full questionnaire	.812	109
Demographics	.717	11
Technology details	.721	9
Drivers of RFID adoption	.754	15
Constraints of RFID adoption	.807	9
Strength of culture	.854	11
Business size	.796	8
BPR	.744	8
RFID benefits	.727	29
PULT	.825	4
Implementation stage	.743	3
RFID pedigree	.874	1
Additional information	.766	1

5.4.4 Descriptive statistics of respondent firms

Data obtained from the questionnaire was analysed for descriptive statistics. The research variables, their minimum and maximum scores received, and their mean and standard deviation scores are presented (refer to Table 5.3 in Appendix B).

5.4.4.1 Demographic characteristics of respondents

Descriptive statistics were used to analyse the distribution of the demographic and socio-economic characteristics of the responding organisations. In Table 5.4, demographic characteristics of the respondents are presented, including organisational size, measured by number of employees, designation of respondents, annual turnover (in millions of pounds), and business sectors of the survey respondents. As is evident in Table 5.4, the variety of industries to which the respondents belong indicates that RFID applications in supply chain management range into diverse industrial sectors.

Table 5.4: Demographic data of respondents

	Category	Frequency	Percentage of total responses
Designation of respondents			
	Director, MD, CEO	23	14.1
	Supply chain Manager	78	47.9
	IT specialist/consultant	45	27.6
	Others	17	10.4
Number of employees in the company			
	1-10	3	1.8
	11-50	3	1.8
	51-250	65	39.9
	251-500	59	36.2
	500 and above	33	20.2
Company annual turnover			
	<2 million	19	11.7
	2-10 million	60	36.8
	11-50 million	51	31.3
	51-100 million	18	11.0
	> 100 million	15	9.2
Business sector			
	Healthcare	19	11.7
	Automotive	14	8.6
	Civilian aviation	20	12.2
	Agriculture	11	6.8
	Finance and banking	5	3.1
	Consumer goods	68	41.7
	Construction	8	4.9
	Education/Publishing	18	11.0

The demographic characteristics of the respondents enumerated above are discussed in greater detail below (points 1 to 3).

1. ***Designation of respondents***

   Table 5.4 shows the designation of the respondents to the survey. A challenge with organisational-level questionnaire survey is that top management staff (who are usually identified as the target respondents) hardly respond to requests to participate due to their busy schedules. Nevertheless, amongst our respondents, top to middle management staff (MD, CEO, and Directors) constitute 14.1% of the respondents. Supply chain managers and directors constitute the majority, with 47.9% of the respondents. The second largest designation of respondents was IT specialists/consultants, accounting for 27.6% of responses. Within this study, the most sought after respondents were the supply chain managers or directors. The expectation is that supply chain managers hold the key information solicited in the study, as they possess better overview of the issues that the study hopes to address.

2. *Size of organisation*

Size of organisation was indicated by number of employees in the organisation and the annual turnover of the organisation. It can be seen in Table 5.4 that out of the sample respondents, about 39.9% of the organisations have between 51-250 employees, while about 36.2% of the organisations have between 251-500 employees. About 20.2% have a workforce in the range of over 500 employees.

Thus, the spectrum of the respondents to the survey cut across large companies, as well as small and medium size enterprises (SMEs), but the majority of the respondents to the survey are SMEs or organisations with employees between 251– 500. This is in line with an earlier study of RFID adoption by Barjis and Wamba (2010) where they found the majority (53.5%) of respondents to their survey were SMEs.

Furthermore, Table 5.4 describes size by annual turnover of the responding organisations. The table shows that there are five categories of the company annual turnover. The largest category of the firms (about 36.8%) has a turnover of between 2-10 million pounds. This was closely followed by 31.3% of organisations with a turnover of between 11-50 million pounds. However, there are large organisations with turnovers of 500 million that responded to the survey as well.

Overall, the size of the responding organisations indicates that a significant percentage (over 35%) of the respondents to the survey are small and medium scale enterprises.

3. *Business sectors of respondents*

Table 5.4 also summarizes the companies in terms of the principal business sectors in which the respondents were involved. A major characteristic of sample respondents is that organisations in the commercial goods sector are the most represented at 41.7%. This is followed by companies operating in civilian aviation at about 12.2%. Additionally, organisations in the healthcare and education sectors constitute about

11.7 and 11%, respectively. There are also several organisations that are undertaking activities classified under the business sectors reported in the table, which echoes the implementation of RFID in varied industrial backgrounds.

5.5 Inferential Statistics

As highlighted in Chapter 4, Binary Logistic regression and Structural Equation Modelling (SEM) were used to establish the relationship between the major research constructs. Binary logistic regression is a statistical method for analysing a dataset in which there are one or more independent variables that determine an outcome. The outcome is measured with a dichotomous variable (in which there are only two possible outcomes). Binary logistic regression calculates the relationship between the dichotomous characteristic of interest (dependent variable/response or outcome variable) and a set of independent (predictor or explanatory) variables. The outcome variable in this study has two categories “adopt RFID” or “do not adopt RFID”.

SEM is a statistical technique used for modelling causal relationships between constructs. It is considered as an appropriate data analysis method due to its ability to account for measurement error and derive unbiased estimates for the relations between constructs (Zhu et al., 2006a).

5.5.1 Data screening prior to SEM estimation and testing

5.5.1.1 Coding errors and missing data

The first step of the screening process involved checking the data file for coding errors. In cases where coding errors were discovered, they were corrected using the original questionnaire as advocated by Baumgartner and Homburg (1996); Churchill (1999); and Green et al. (1988).

The second step involved checking for missing data. Although the ML estimation method used in AMOS can handle missing data, cases incorporating missing values were deleted prior to data analysis, following a listwise approach. There are several approaches to deal with missing data, and all of them have their advantages and disadvantages (Hair et al. 1998). In this study, listwise case deletion was considered appropriate because the proportion of missing values was very low (Hair et al. 1998), with around 1.4% of cases containing missing values. Taking also into consideration that this study's quantitative analysis is based on a moderately sized sample, listwise deletion was the selected approach to missing values.

5.5.1.2 Sample size

While there is no consensus on an acceptable sample size for SEM, it is recommended that the sample should contain a sufficient number of cases in relation to the parameters to be estimated. This is in line with the asymptotic theory, upon which the estimation and testing methods of SEM are based (Baumgartner and Homburg, 1996). Baumgartner and Homburg (1996) posit that "the ratio of sample size to the number of free parameters should be at least 5:1 to get trustworthy parameter estimates, and higher in order to obtain appropriate significant tests'' (Baumgartner and Homburg, 1996). This criterion is satisfied in this study, given that the models estimated between 3 to 16 parameters, multiple times less than the size of the calibration sample, which contained 163 cases.

5.5.2 Data preparation for SEM analysis

Before estimating the structural equation models, the nature of the data was explored in order to make sure the chosen variables are suitable for the estimations. This section describes the SEM analysis preparation procedures, including the choice of input matrix, estimation technique, and the selection of goodness-of-fit-indices.

5.5.2.1 Covariance and Collinearity

Covariance and correlation determine how data will be presented when specifying models within a software program that implements structural equation modelling. In the context of SEM, covariance and/or correlations between variables are essential because they allow the researcher to include both causal and non-causal relationships between variables. In this study, the structural equation models used contain both causal and non-causal relationships. Obtaining correlation estimates between variables allowed the researcher to better estimate direct and indirect effects with other variables, particularly in complex models with many parameters to be estimated.

In this study, the bivariate correlations between the independent variables were examined, and values of .70 and above were highlighted as potential sources of multicollinearity (based on arbitrary rule of thumb). In such cases, the potential problems of multicollinearity between variables were dealt with by creating relationships between them (e.g. correlation or causation) and/or using a latent variable to eliminate spurious relationships. This was the basis on which the latent variables in the structural models in this study were formed.

Although the correlations of all variables were analyzed, Appendix F shows only the correlation matrix of some key constructs in order to avoid an information overload within the thesis.

5.5.2.2 Forms of Input Data

Data can be input into any SEM computer tool in one of two forms – either as a raw data file or a matrix summary of the data. In respect of the input matrix, a correlation or covariance matrix can be used. However, numerous studies tend to support the use of covariance over correlation matrix. For example, Hair et al. (1998) and Bentler et al. (2001) state that a covariance matrix should be used when the aim of a study is to test a proposed theoretical framework because most of the statistical theory behind SEM has been developed on the assumption that the analysis applies to a covariance matrix.

In AMOS, using the raw data file as input calculates test statistics that correct against inflated chi-square statistics and bias in critical values for determining coefficient significance and standard errors (Baumgartner and Homburg, 1996; Hair et al. 1998).Therefore, in this study, data was entered into AMOS in its raw form.

5.5.2.3 Estimation Technique

Maximum likelihood (ML) is the default estimation method in AMOS and indeed in most statistical packages. It is also one of the most widely used estimation methods (Anderson and Gerbing, 1988; Baumgartner and Homburg, 1996). The ML is maintained as the estimation techniques in this study because it is consistent at producing efficient estimation.

5.5.2.4 Goodness of Fit Indices

While there is no consensus on the appropriate index for assessing overall goodness-of-fit of a model (Ping, 2004), the chi-square statistic has been the most widely used fit index (Bagozzi and Heatherton, 1994; Baumgartner and Homburg, 1996; Ping, 2004). The chi-square statistic tests the estimated covariance matrix vs the empirical (i.e. the sample) matrix. Obtaining a small, non-significant chi-square value indicates that the model fits the data acceptably However, as the chi-square (χ^2) test is not only sensitive to sample size (West et al., 1995), it should not serve as the sole basis for judging model fit. Bollen and Long (1993) recommend the evaluation of several indices simultaneously which represent different classes of goodness-of-fit criteria (Bagozzi and Heatherton 1994; Baumgartner and Homburg 1996).

Although SEM provides several fit indices after running the analysis, to explain and discuss all the indices will be superfluous. Hair et al. (2006) observe that it will be adequate to provide evidence of model fit based on three to four indices. However, not all of the suggested three or four should be reported due to overlap between the different indices. The fit indices RMSEA, NNFI and CFI are sensitive to model misspecifications and do not depend on sample size as strongly as the chi-square test χ^2 (Hu and Bentler, 1998), therefore they should always be considered. Hu and Bentler (1998) recommend to use RMR, supplemented by NNFI, CFI, or RMSEA.

In this thesis, all model fit indices generated when running our models were observed, however, corroborating evidence of model fit is provided by the RMSEA fit statistic, and the NNFI (also known as TLI). RMSEA and NNFI were selected because they are sensitive to model misspecifications and do not depend on sample size as strongly as the chi-square test χ^2 (Fan et al., 1999; Hu and Bentler, 1998). GFI and AGFI were not used because simulation studies suggest that they are not independent of sample size (Hu and Bentler, 1998). Furthermore, both indices decrease with increasing model complexity, especially for smaller sample sizes.

Table 5.5 summarizes a description of the indices used and their suggested cut-offs.

Table 5.5: Descriptions and thresholds of goodness-of-fit indices used in the assessment of the structural models

Fit index	Description	Cut-off
χ^2	Indicates the discrepancy between hypothesised model and data; Tests the null hypothesis that the estimated covariance–variance matrix deviates from the sample variance–covariance matrix only because of sampling error	P < 0.05
RMSEA	Shows how well the model fits the population covariance matrix, taking the number of degrees of freedom into consideration	< 0.05: good fit;< 0.08: reasonable fit
NNFI	Shows how much better the model fits, compared to a baseline model, normally the null model, adjusted for the degrees of freedom (can take values greater than one)	>0.90

Source: Bagozzi and Yi (1988); Baumgartner and Homburg (1996); Diamantopoulos and Siguaw (2000); MacCallum et al. (1996); Ping (2004)

Section 5.6 analyses and discusses the responses obtained from the questionnaire survey in context of our research questions. In order to present the result of the statistical tests in a structured manner, the research questions (section 1.3) were addressed in ascending order (starting from research question 1). Alongside, the justification for the statistical technique adopted is given. The following format is adopted in order to comprehensively discuss the results for each research question. A “results” section, which presents the results (pertaining to that specific question) obtained from running the statistical tests is presented. A “discussion” section then follows, which discusses the results obtained in context of extant literature.

5.6 Research question 1: Drivers and constraints of RFID adoption

This research question uses binary logistic regression models and structural equation models (SEM) to establish the relationship between a binary outcome variable (RFID adoption) and a group of predictor variables (Drivers and Constraints).

5.6.1 Model definition

5.6.1.1 Binary Logistic models

Binary logistic regression models the logit-transformed probability as a linear relationship with the predictor variables. In this question, two models (A and B) are presented. Model A estimates the probability that organisations will adopt RFID given the values of the independent variables, which are in this case, **drivers** of RFID adoption. Model B estimates the probability that organisations will adopt RFID given the values of the independent variables, which are in this case, **constraints** of RFID adoption The hypotheses under investigation are on the relationship between technological, organisational, and environmental factors and the decision to adopt RFID.

Let $\boldsymbol{y}$ be the binary outcome variable indicating non-adoption/adoption of RFID with 0/1 and $\boldsymbol{p}$ be the probability of $\boldsymbol{y}$ to be 1, $\boldsymbol{p}$ = prob($\boldsymbol{y}$=1). Let $\boldsymbol{X_1}$, .., $\boldsymbol{X_k}$ be the set of predictor variables as shown in Table 5.6. Then the logistic regression of $\boldsymbol{y}$ on $\boldsymbol{X_1}$, ..., $\boldsymbol{X_k}$ estimates parameter values for $\beta_0, \beta_1, \ldots, \beta_k$ via Maximum Likelihood (ML) method of the following equation.

$$\text{logit}(p) = \log(p/(1-p)) = \beta_0 + \beta_1 * \boldsymbol{X_1} + \ldots + \beta_k * \boldsymbol{X_k}$$

In terms of probabilities, the equation above is translated into

$$\boldsymbol{p} = \exp(\beta_0 + \beta_1 * \boldsymbol{X_1} + \ldots + \beta_k * \boldsymbol{X_k})/(1+\exp(\beta_0 + \beta_1 * \boldsymbol{X_1} + \ldots + \beta_k * \boldsymbol{X_k})).$$

Table 5.6: *Set of independent variables. x_i is the observed value of the independent variables for observation i.*

Variable	Model A	Model B
X_1	Availability of IT/IS infrastructure	Capital and recurring costs
X_2	Perceived RFID benefits	Compliance issues
X_3	Perceived RFID standards convergence	Technical issues
X_4	Top management initiative	Security issues
X_5	Financial readiness/affordability	Manpower (skills) shortages
X_6	Organisational technical capability	Requirements for business process change
X_7	Global expansion	Unwillingness to use RFID
X_8	Competitive pressure	Lack of industry standards
X_9	Industry pressure	Privacy issues

X_{10}	Professional & trade association pressure	n/a
X_{11}	Favourable transactional climate	n/a
X_{12}	Regulatory pressure	n/a
X_{13}	Dominant partner pressure	n/a
X_{14}	Government support	n/a
X_{15}	Media pressure	n/a

5.6.2 Results: Binary Logistic Regression

Logistic regressions based on the models specified above were estimated. Two models were produced. Model A investigates the impact of each 'driver' of RFID adoption on the decision to adopt RFID. Model B investigates the impact of each 'constraint' of RFID adoption on the decision to adopt RFID. In each model, the outcome variable has two categories – "Yes" (adopt RFID) and "No" (do not adopt RFID). Model A contained 15 directly measured independent variables, which were found to be jointly statistically significant, χ^2 (15, N= 163) = 162.181, p < 0.050. Model B contained 9 directly measured independent variables, which were also found to be jointly statistically significant, χ^2 (9, N= 163) = 88.367, p < 0.050.

Probability calculation

- Organisations that have adopted RFID = 96
- Organisations yet to adopt RFID = 67

Total number of organisations = 163

- Probability of adoption is 96/163 = **.589**
- Probability of non-adoption is 1 – .589 or 67/163 = **.411**

Table 5.7 shows the results from running both models (A and B). Each estimated coefficient (***B***) is the expected change in the log odds of adopting RFID for a unit increase in the corresponding predictor variable, whilst holding the other predictor variables constant. Each exponentiated coefficient ***Exp(B)*** is the ratio of two odds, or the change in odds in the multiplicative scale for a unit increase in the corresponding predictor variable holding other variables constant.

The "notes" section of the table gives the chi-square (χ^2) goodness of fit of each model. The chi-square value of 162.181 at a p-value of <.05 was obtained for model A, indicating good fit for the regression model. Similarly, a chi-square value of 88.367 at a p-value of <.05 was obtained for model B. This also indicates good fit for the regression model.

Example to illustrate the interpretation of log odds used in sections 5.6.2.1 to 5.6.2.3

Each coefficient in logit model is the difference in the log(odds) (this follows directly from the model definition). This means that:

exp (beta)= q1/q0 (where **q1 and q0** are the odds for ***outcomes 1 and 0*** in the dependent variable). So For instance, if exp(beta) = 1.30, this means that **q1=1.3*q0** , so the corresponding explanatory variable makes (the meaning of which depends on how the variable is measured) having ***outcome 1*** 30% more likely than having ***outcome 0***. (1.3-1=0.3) If **exp(beta)** = 0.8, for instance, then **q1=0.8*q0**, so having an ***outcome 1*** is 20% less likely (0.8-1=-0.2).

So in general **q1=exp(beta)*q0** so

q1-q0= [exp(beta) -1]*q0

Hence **[exp(beta) -1]** gives the effect measured as this how much more likely is that 1 happens relative to 0 (i.e.) becoming 1)

Table 5.7: Variables in models A and B

Context		Factors	B	S.E.	Sig.	Exp(B)
Technological factors	Drivers	Availability of IS/IT infrastructure	1.992	.322	.000	7.332
		Perceived RFID benefits	2.227	.601	.000	9.276
		Perceived RFID standards convergence	1.738	.504	.001	5.687
	Constraints	Capital and recurring costs	-.593	.250	.018	.553
		Compliance issues	-1.132	.230	.000	.322
		Technical issues	-.875	.220	.000	.417
		Security issues	-2.569	.877	.003	.077
Organisational factors	Drivers	Top management initiative	2.158	.637	.001	8.652
		Financial readiness/affordability	1.949	.706	.006	7.022
		Organisational technical capability	1.697	.523	.001	5.455
		Global expansion	-.476	1.426	.738	.621
	Constraints	Manpower (skills) shortages	-.532	.435	.222	.588
		Requirements for business process change	-.956	.394	.015	.385
Environmental factors	Drivers	Competitive pressure	2.023	.621	.001	7.560
		Industry pressure	1.560	.536	.004	4.760
		Professional & trade association pressure	.278	.224	.214	1.321
		Favourable transactional climate	.377	.171	.027	1.458
		Regulatory pressure	.587	.574	.006	1.799
		Dominant partner pressure	1.697	.523	.001	5.455
		Government support	.385	.160	.016	1.470
		Media pressure	1.265	1.479	.392	3.542

	Constraints	Unwillingness to use RFID	-2.244	.760	.003	.106
		Lack of industry standards	-2.017	.746	.007	.133
		Privacy issues	-1.432	.652	.028	.239
Model A: χ^2 (15, N= 163) = 162.181, p < 0.050						
Model B: χ^2 (9, N= 163) = 88.367, p < 0.050						

5. 6.2.1 Technological factors

Firstly, all the technology drivers of RFID adoption have recorded a statistically significant p-value. In Table 5.7, the strongest driver that influences organisations' decision to adopt RFID is "perceived RFID benefits", which recorded an odds ratio of 9.276. This indicates that a unit increase in "perceived benefits" (while controlling for other factors in the model) results in a 8.276 (9.276-1) times increase in the odds of adoption of RFID (over odds of non-adoption). Other strong predictors include "perceived RFID standards convergence" and "availability of IS/IT infrastructure", recording odds ratios of 5.687 and 7.332, respectively. This indicates that a unit increase in efforts made towards fostering standardization, and a unit increase in the availability of necessary IT/IS infrastructure increases the odds of organisations adopting RFID (over odds of non-adoption) by 4.7 and 6.3 times, respectively.

On the other hand, all the technological constraints of RFID adoption have recorded a statistically significant p-value. The strongest constraint of RFID adoption is "security issues", which recorded an odds ratio of 0.077. This indicates that a unit increase in "security issues" decreases the odds of adopting RFID (over the odds of non-adoption) by 92% (0.077-1). Other constraints of organisational decision to adopt RFID include "compliance issues" and "technical issues", recording odds ratios of .322 and .417, respectively. This indicates that for a unit increase in either "compliance issues" or "technical issues", the odds of organisations adopting RFID decreases by 67% (0.322-1) or 58% (0.417-1), respectively. Lastly, "capital and recurring costs" recorded an odds ratio of 0.553. This indicates that a unit increase in "capital and recurring costs" (while controlling for other factors in the model) results in the odds of organisations adopting RFID decreasing by 45% (0.553-1).

5.6.2.2 Organisational factors

Secondly, all the organisational drivers of RFID adoption have recorded a statistically significant p-value with the exception of "global expansion". "Top management initiative" and "financial readiness/availability" were found to be the strongest drivers of organisational decision to adopt RFID, recording odds ratio of 8.652 and 7.022, respectively. This indicates that a unit increase in either “top management initiative” or “financial readiness/availability” (while controlling for other factors in the model) increases the odds of organisations adopting RFID (over odds of non-adoption) by 7.6 (8.652-1) or 6 (7.022-1) times, respectively. The other significant driver is “organisational technical capability”, recording an odds ratio of 5.455. The driver “global expansion” was found to be not statistically significant, recording a p-value > .05.

On the other hand, all the organisational constraints of RFID adoption have recorded a statistically significant p-value with the exception of “manpower (skills) shortages”. Some of the constraints on organisational decision to adopt RFID include “requirements for business process change”, which recorded an odds ratio of .385. This indicates that a unit increase in “requirements for business process change” (while controlling for other factors in the model) results in a decrease in the odds of adopting RFID by 61.5% (0.385-1). Also, “manpower (skills) shortages” was found to be not significant, recording a p-value > .05.

As stated in the paragraphs above, the two variables “global expansion” and “manpower (skills) shortages” recorded non-significant p-values. These two variables will be further explored using SEM and commented on in the results discussion section (5.6.3).

5.6.2.3 Environmental factors

Lastly, all the environmental drivers of RFID adoption have recorded a statistically significant p-value with the exception of “professional & trade association pressure” and “media pressure”. “Competitive pressure” and “dominant partner pressure” were found to be the strongest drivers of organisational decision to adopt RFID, recording odds ratios of 7.560 and 4.760, respectively. This indicates that a unit increase in pressure from competitors or supply chain partners increases the odds of organisations adopting RFID by 6.5 and 3.7 times, respectively. The odds ratio of 1.470 for “government support” and 1.458 for “favourable transactional climate” indicate that for a unit increase in either variable, the odds of adopting RFID increase by 47% and 46% respectively.

On the other hand, some of the constraints on organisational decision to adopt RFID include “privacy issues”, which recorded an odds ratio of .239. This indicates that for a 1-unit increase in “privacy issues”, (while controlling for other factors in the model), the odds of organisations adopting RFID falls by 76%. Also, “unwillingness to use RFID” recorded odds ratios of .106. This indicates that for a unit increase in “unwillingness to use RFID” the odds of organisations adopting RFID fall by 90%.

"Media pressure" and "professional and trade association pressure" were found to be not significant, as they recorded p-values > .05. These results will be further explored and commented on in the SEM results in section 5.5.2.

5.6.1.2 Structural equation model (SEM)

Two structural models were run. Model A included the drivers of adoption. Model B included the constraints of RFID adoption. The notation for both SEM models is shown below. X_i is the observed value of the independent variables for observation *i.*

$$Xi = \Lambda X\ \xi k + \vartheta\delta$$

where: ***Xi*** = a column vector of observed variables shown in Table 5.6*;*

ξk *= ksi,* a column vector of latent variables*;*

ΛX = lambda*, an* ***i X k*** matrix of coefficients defining the relations between the manifest ***(X)*** and latent ***(ξ)*** variables*;* ***ϑδ*** = theta-delta, an *i* ***X*** *i* variance/covariance matrix of relations among the residual terms of ***X***

All assumptions and data preparation regarding SEM analysis have already been discussed in sections 5.5.1 to 5.5.2.

5.6.3 Results: Structural Equation Modelling (SEM)

Two structural equation models were run – one for drivers of RFID adoption (model A) and the other for constraints of RFID adoption (model B).

Table 5.8 shows the results of running both models, including the parameter estimates (**β**) associated with each predictor variable, the standard errors, the p-values, and the variance (R^2). The "notes" section of the table shows the evidence of the model fit i.e. Root Mean Square Error of Approximation (RMSEA) and the Non-normed Fit Index (NNFI).

Hu and Bentler (1999) and Hair et al. (2006) recommend NNFI values above 0.90 as denotions of good model fit whereas the recommendations for RMSEA cut-off points have been reduced considerably over the last two decades. In the early nineties, RMSEA values ranging from 0.05 to 0.10 were considered an indication of satisfactory fit and values above 0.10 indicated poor fit (MacCallum et al, 1996). Later, it became widely accepted that RMSEA values ranging between 0.08 to 0.10 indicate a mediocre fit and below 0.08 indicate a good fit (MacCallum et al, 1996). However, more recently, a cut-off value close to .06 (Hu and Bentler, 1999) or a stringent upper limit of 0.07 (Steiger, 2007) seems to be the general consensus amongst researchers in this area.

As shown in Table 5.8, model A recorded an RMSEA value of .052 and NNFI value of .965. Model B recorded an RMSEA value of .063 and NNFI value of .917. Therefore, the values for both models denote acceptable model fit.

Table 5.8: Regression weights and significance tests of individual parameters

		Context	Variables	β	S.E.	P-value	R^2
			Drivers				
Decision to adopt RFID	←	Technological factors	Availability of IS/IT infrastructure	0.43	0.058	0.013	0.36
			Perceived RFID benefits	0.76	0.027	0.007	0.69
			Perceived RFID standards convergence	0.39	0.075	0.001	0.31
			Constraints				
			Capital and recurring costs	-0.73	0.047	0.000	0.64
			Technical issues	-0.73	0.051	0.034	0.48
			Security issues	-0.31	0.070	0.050	0.54
			Compliance issues	-0.53	0.053	0.050	0.43
			Drivers				
		Organisational factors	Top management initiative	0.56	0.036	0.027	0.43
			Financial readiness/affordability	0.61	0.026	0.000	0.54
			Organisational technical capability	0.53	0.045	0.010	0.43
			Global expansion	0.29	0.071	0.005	0.26
			Constraints				
			Manpower (skills) shortages	-0.33	0.076	0.019	0.55
			Requirements for business process change	-0.59	0.052	0.001	0.54
			Drivers				
		Environmental factors	Competitive pressure	0.38	0.056	0.035	0.28
			Industry pressure	0.43	0.074	0.042	0.27
			Professional and trade association pressure	0.11	0.054	0.048	0.34
			Favourable transactional climate	0.16	0.060	0.012	0.30
			Regulatory pressure	0.10	0.047	0.018	0.42
			Dominant partner pressure	0.33	0.060	0.005	0.28
			Government support	0.21	0.061	0.049	0.32
			Media pressure	0.13	0.048	0.047	0.37
			Constraints				
			Unwillingness to use RFID	-0.32	0.050	0.049	0.41
			Lack of industry standards	-0.62	0.063	0.023	0.37
			Privacy issues	-0.46	0.057	0.037	0.62
Notes: *Model A:* NNFI = .965; RMSEA = .052				*Model B:* NNFI = .917; RMSEA = .063			

<u>*5.6.3.1 Technological factors*</u>

As seen in Table 5.8, all the drivers have p-values < 0.05 and thus make a statistically significant contribution in predicting the model. All the drivers have a direct positive relationship with the "decision to adopt RFID". "Perceived RFID benefits" has the strongest association with "decision to adopt RFID", recording a **β** estimate of .76. This means for a unit standard deviation increase in "perceived benefits" (while controlling for other factors), the “decision to adopt” increases by .76. “Availability of IT/IS infrastructure” and “perceived RFID standards convergence” recorded regression estimates of .43 and .39, respectively.

In terms of constraints, all the factors have a significant ($p < 0.05$) direct negative relationship with the “decision to adopt RFID”. “Capital and recurring costs” and “technical issues” both recorded β values of -0.73 while “security issues” and “compliance issues” recorded β values of -0.53 and -0.31, respectively. This indicates that for a standard deviation increase in either “capital and recurring costs” or “technical issues” (while controlling for other variables), the “decision to adopt RFID” decreases by 0.73. Whereas a standard deviation increase in either “security issues” or “compliance issues” decreases the “decision to adopt RFID” by 0.53 and 0.31, respectively.

5.6.3.2 Organisational factors

As seen in Table 5.8, all the drivers have p-values < 0.05 and thus make a statistically significant contribution in predicting the model. All the drivers have a direct positive relationship with the “decision to adopt RFID”. “Financial readiness/availability” has the strongest association with “decision to adopt RFID”, recording a standardized regression estimate of .61. This means for a unit standard deviation increase in “financial readiness/availability” (while controlling for other factors), the “decision to adopt RFID” increases by .61. “Top management initiative” and “organisational technical capability” recorded regression estimates of .56 and .53, respectively.

In terms of constraints, all the factors have a significant ($p < 0.05$) direct negative relationship with the “decision to adopt RFID”. “Requirements for business process change” recorded β value of -0.59 while “manpower (skills) shortages” recorded β value of -0.33. This indicates that for a standard deviation increase in “requirements for business process change” (while controlling for other variables), the “decision to adopt RFID” decreases by 0.59. Whereas a standard deviation increase in “manpower (skills) shortages” decreases the “decision to adopt RFID” by 0.33.

5.6.3.3 Environmental factors

As seen in table 5.8, all the drivers have p-values < 0.05 and thus make a statistically significant contribution in predicting the model. All the drivers have a direct positive relationship with the “decision to adopt RFID”. “Industry pressure” has the strongest association with “decision to adopt RFID”, recording a standardized regression estimate of .43. This means for a unit standard deviation increase in “industry pressure” (while controlling for other factors), the “decision to adopt” increases by .43. “Competitive pressure” and “dominant partner pressure” recorded regression estimates of .38 and .33, respectively.

In terms of constraints, all the factors have a significant ($p < 0.05$) direct negative relationship with the “decision to adopt RFID”. “Lack of industry standards” recorded β value of -0.62 while “privacy issues” and “unwillingness to use RFID” recorded β values of -0.46 and -0.32. This indicates that for a standard deviation increase in “lack of industry standards (while controlling for other variables), the “decision to adopt RFID” decreases by 0.62. Whereas a standard deviation increase in “privacy issues” and “unwillingness to use RFID” decreases the “decision to adopt RFID” by 0.32 and 0.46, respectively.

5.6.4 Discussion: Binary Logistic regression and SEM results

5.6.4.1 Technological factors

The findings from both SEM and logistic regression show a statistically significant direct positive relationship between the drivers of adoption and the decision to adopt RFID. This is consistent with previous studies on technological innovation adoption such as Tonartzky and Klein (1982), Rogers (1995), Matta and Moberg (2006), and Schmitt et al. (2007). On the other hand, the findings from both SEM and logistic regression also show that there is a significant direct negative relationship between constraints of adoption and decision to adopt RFID. It can be seen from both sets of results (SEM and binary logistic regression) that each driver or constraint makes a unique contribution towards “decision to adopt RFID”.

For both set of results, “perceived RFID benefits” was found to be the strongest driver of RFID adoption. Our findings are supported by studies of Paydar (2013), Attaran (2012), and Goethals and Newlands (2011) which suggest that organisations that implement RFID are driven to adoption by the promise of achieving benefits, particularly achieving higher efficiency, better supply chain monitoring and better collaboration with partners. Our results also show “availability of IT/IS infrastructure” to be a strong driver of RFID adoption. These findings are consistent with those of Attaran (2012) which suggest that organisations require the necessary IT infrastructure in order to integrate RFID into their existing IT systems.

Paydar (2013), Smart et al., (2010), and Mehrjerdi (2010) found high capital costs and requirements for business process change, to be major factors that hinder RFID adoption and proliferation. From our results, we also found “capital and recurring costs” and “requirements for business process change” to be strong constraints of RFID adoption. Additionally, Mehrjerdi (2010) and Attaran (2012) found technical challenges such as imperfect tag read-rates, middleware uncertainty, and lack or shortage of in-house experts/skills to manage RFID systems have been identified to play a strong role in hindering RFID adoption. Our results are consistent with those findings as “technical issues” are seen to have a strong effect on organisational decision to adopt RFID (β = -0.73). “Compliance issues” (β = -0.53) were found to hinder the decision to adopt RFID. This indicates that requirements, often from dominant partners, for their partners to comply with their RFID standards, deadlines, or policies contributes to hindering adoption of the technology. “Security issues” has the lowest β value (-0.39) but still make a significant contribution in constraining decision to adopt.

Overall, the decisions on the null hypotheses formulated to investigate the impact of technological factors on RFID adoption decision are as follows (Table 5.9):

Table 5.9: Hypotheses on the impact of technological factors on decision to adopt RFID

Context	Factor	Hypothesis	Decision
Technological factors	***Drivers***		
	Perceived RFID benefits	**H1:** Technological drivers of RFID adoption have a significant positive influence on the decision to adopt RFID	Accept
	Availability of IS/IT infrastructure		
	Perceived RFID standards convergence		
	Constraints		
	Capital and recurring costs	**H2:** Technological constraints of RFID adoption have a significant negative influence on the decision to adopt RFID	Accept
	Technical issues		
	Security issues		
	Compliance issues		

5.6.4.2 Organisational factors

In general, the findings from both SEM and logistic regression show a statistically significant direct positive relationship between the drivers of adoption and the decision to adopt RFID, and also a significant direct negative relationship between constraints of adoption and decision to adopt RFID. It can be seen from both sets of results that each driver or constraint makes a unique contribution towards the outcome variable “decision to adopt RFID”. “Top management initiative” and “financial readiness/availability” were found to be the strongest drivers of RFID adoption. These findings are supported by Amabile (1988), Brown and Russell (2007), and Lin (2009), which report that management skills and top management support for innovation improve overall organisational innovation. The support and encouragement of top management, along with financial availability and readiness are considered essential factors for the decision to adopt technological innovation because the financial and managerial resources required for the adoption of innovative technologies will be more readily available if support from management is provided.

In terms of constraints, “shortages in manpower (skills)”and “requirements for business process change” were found to make statistically significant contributions in constraining RFID adoption. These findings are supported by Mehrjerdi (2010) and Attaran (2012), which report that lack of in-house experts/skills to manage RFID systems play a strong role in hindering RFID implementation.

In the logistic regression results, “global expansion” and “manpower (skills) shortages” were found to have p-values greater than .05. However, in the SEM results, those variables recorded significant p-values. Due to this difference, the researcher will use extant literature and results from the case studies in Chapter 6 in order to validate the findings and thus make decisions regarding the hypothesis concerning the two variables (“global expansion” and “manpower skills”).

In that regard, Mehrjerdi (2010) and Attaran (2012) report that lack of in-house experts/skills to manage RFID systems play a strong role in hindering RFID implementation providing support for the SEM results to be accepted with regards to the variable “manpower (skills) shortages”. For “global expansion”, results from the case studies conducted in Chapter 6, section 6.6.1.2 indicate that the variable is a significant driver of RFID adoption. In that regard, OE-3, a respondent in one of the case study organisations, stated that *“As we have multiple outlets around the world, such a decision (adopting RFID) is made solely by the CEO or other top execs of the company. Although, they do work and make decisions based on recommendations and reports from lower management, the decision of where to implement the technology is made based on where it’s required the most, size or location of outlets, expansion plans and the projected impact it would have.”* Therefore, this case study finding supports the results for the SEM with regards to the variable “global expansion”.

Overall, the decisions for the null hypotheses formulated to investigate the impact of organisational factors on RFID adoption decision are as follows (Table 5.10):

Table 5.10: Hypotheses on the impact of organisational factors on decision to adopt RFID

Context	Factor	Hypothesis	Decision
	Drivers		
Organisational factors	Top management initiative Financial readiness/affordability Organisational technical capability Global expansion	**H3**: Organisational drivers of RFID adoption have a significant positive influence on the decision to adopt RFID	Accept
	Constraints		
	Manpower (skills) shortages Requirements for business process change	**H4**: Organisational constraints of RFID adoption have a significant negative influence on the decision to adopt RFID	Accept

5.6.4.3 Environmental factors

The findings from both SEM and logistic regression indicate "competitive pressure" ($\beta = 0.38$), "industry pressure" ($\beta = 0.43$), and "dominant partner pressure" ($\beta = 0.33$), to be the strongest drivers of organisational decision to adopt RFID. These are closely followed by "government support" ($\beta = 0.21$). This indicates that organisations are driven towards adopting RFID majorly in order to be more competitive or as a result of external pressure. In other words, although support and encouragement from government (in terms of policies and regulations) drives adoption, the pressures from stakeholders has a stronger influence on organisation decision to adopt RFID.

In terms of constraints, "lack of industry standards" ($\beta = -0.62$) and "privacy issues" ($\beta = -0.46$) were found to be the biggest hindrance on decision to adopt in both sets of results. These findings are supported by Attaran (2012) which found both factors to play a role in constraining the adoption of RFID.

In the logistic regression results, "professional and trade association pressure" and "media pressure" were found to have p-values greater than .05. However, in the SEM results, those variables recorded significant p-values. Therefore, just like section 5.6.4.2 above, the decision on the hypotheses regarding these two variables is made with the support of extant literature on RFID adoption and case study results in Chapter 6.

In that regard, Makhija and Chugan (2015) find that professional & trade association pressure, media pressure, favorable transactional climate and government support drive RFID adoption. They add that these four variables correlate to form the external environment of an organization and its effect on adopting a new technology (forming environmental drivers for adoption of RFID technology within organisations). This finding supports the SEM results, which found "professional and trade association pressure" and "media pressure" to have a statistically significant direct positive relationship with the decision to adopt RFID.

Consequently, the decisions for the null hypotheses formulated to investigate the impact of environmental factors on RFID adoption decision are as follows (Table 5.11):

Table 5.11: Hypotheses on the impact of environmental factors on RFID adoption decision

Context	Factor	Hypothesis	Decision
Environmental factors	***Drivers***		
	Competitive pressure	**H5**: Environmental drivers of RFID adoption have a significant positive influence on the decision to adopt RFID	Accept
	Industry pressure		
	Dominant partner pressure		
	Professional and trade association pressure		
	Media pressure		
	Regulatory pressure		
	Favourable transactional climate		
	Government support		
	Constraints		
	Unwillingness to use RFID	**H6**: Environmental constraints of RFID adoption have a significant negative influence on the decision to adopt RFID	Accept
	Lack of industry standards		
	Privacy issues		

5.7 Research question 2: Impact of strength of culture, business size, and BPR on decision to adopt RFID

This research question uses binary logistic regression models and structural equation models (SEM) to establish the relationship between a binary outcome variable (RFID adoption) and latent constructs of strength of culture, business size, and business process re-engineering.

5.7.1 Model definition

5.7.1.1 Binary Logistic models

In this question, three models (A, B, and C) are presented to estimate the probability that organisations will adopt RFID given the values of their independent latent variables, which are in this case, strength of culture, business size, and BPR. Model A investigates the impact of strength of culture on RFID adoption. Model B investigates the impact of business size on RFID adoption. Model C investigates impact of BPR on RFID adoption.

Let ***y*** be the binary outcome variable indicating non-adoption/adoption of RFID with 0/1 and ***p*** be the probability of ***y*** to be 1, ***p*** = prob(***y***=1). Let $\boldsymbol{X_1}$, .., $\boldsymbol{X_k}$ be the set of predictor variables as shown in Table 5.12. Then the logistic regression of ***y*** on $\boldsymbol{X_1}$, ..., $\boldsymbol{X_k}$ estimates parameter values for $\beta_0, \beta_1, \ldots, \beta_k$ via Maximum Likelihood (ML) method of the following equation.

$$\text{logit}(p) = \log(p/(1-p)) = \beta_0 + \beta_1 * \boldsymbol{X_1} + \ldots + \beta_k * \boldsymbol{X_k}$$

In terms of probabilities, the equation above is translated into

$$\boldsymbol{p} = \exp(\beta_0 + \beta_1 * \boldsymbol{X_1} + \ldots + \beta_k * \boldsymbol{X_k})/(1+\exp(\beta_0 + \beta_1 * \boldsymbol{X_1} + \ldots + \beta_k * \boldsymbol{X_k})).$$

5.7.1.2 Structural equation models (SEM)

One structural equation model was developed to incorporate the three latent constructs (strength of culture, business size, and BPR) and the observed variable (RFID adoption decision), as shown in Figure 5.1 in Appendix C. The notation for the SEM model is shown below. X_i is the observed value of the independent variables for observation *i.*

$$Xi = \Lambda X\, \xi k + \vartheta\delta$$

where: $\boldsymbol{Xi}$ = a column vector of observed variables shown in Table 5.12*;*

$\boldsymbol{\xi k}$ = *ksi,* a column vector of latent variables*;*

ΛX = lambda*, an* ***i X k*** matrix of coefficients defining the relations between the manifest ***(X)*** and latent ***(ξ)*** variables***; ϑδ*** = theta-delta, an ***i X i*** variance/covariance matrix of relations among the residual terms of ***X***

The results of the structural equation model developed using the variables in Table 5.12 is presented in section 5.7.2.

Table 5.12: *Set of independent variables. x_i is the observed value of the independent variables for observation i.*

Variable	Model A – Strength of culture	Model B – Business size	Model C – BPR
X_1	Organisational goals and objectives	Number of employees	Data standardization and integration
X_2	Organisational focus on its performance relative to its competitors	Annual turnover	Restructuring and streamlining of business processes and activities including removal of non-value added tasks, controls and checks
X_3	Organisational focus on customer satisfaction	International reach	Decentralization of resources and processes
X_4	Effective decision-making	IT/IS infrastructure	Provision of decision-support tools
X_5	Top management initiative	The number of office locations, retail outlets, service centers, etc.	Synchronization of IT resources and business processes
X_6	Drive to introduce new technologies into business processes	Range of products/services	n/a

5.7.1 Results: Binary Logistic Regression

Logistic regression is used to determine the relationship of each predictor variable of strength of culture, business size, and BPR on "decision to adopt RFID".

Probability calculation

- Organisations that have adopted RFID = 96
- Organisations yet to adopt RFID = 67

Total number of organisations = 163

- Probability of adoption is 96/163 = **.589**
- Probability of non-adoption is 1 – .589 or 67/163 = **.411**

5.7.1.1 Impact of strength of culture on the decision to adopt RFID (Model A)

Direct logistic regression was performed to assess the impact of organisational culture strength on decision to adopt RFID. In this model (model A), the outcome variable has two categories – "Yes" (adopt RFID) and "No" (do not adopt RFID). The model contained 6 directly measured independent variables (organisational goals and objectives, organisation's focus on its performance relative to its competitors, organisational focus on customer satisfaction, top management involvement, decision making, drive to implement new technologies into business processes). The Full model containing all predictors was statistically significant, χ^2 (6, N= 163) = 106.275, $p < 0.001$. As shown in the "sig." column of Table 5.13, all the 6 independent variables made a unique statistically significant contribution to the model. Table 5.14 also shows the results from running the model, including the unstandardized regression coefficients (*B*) and the significance values and odds ratio *Exp(B)* of each predictor. The 'notes' section of the table shows chi-square (χ^2) goodness of fit value of the model. For this model, a chi-square value of 106.275 at a p-value of <.05 is obtained. This indicates good fit for the regression model.

Table 5.13: Variables in model A (strength of culture)

	B	**S.E.**	**Sig.**	**Exp(B)**
Organisational goals and objectives	.853	.257	.001	2.346
Organisational focus on its performance relative to its competitors	.654	.162	.000	1.924
Organisational focus on customer satisfaction	.422	.200	.035	1.525
Effective decision-making	.854	.325	.009	2.349
Top management initiative	1.130	.249	.000	3.095
Drive to introduce new technologies into business processes	.875	.229	.000	2.398
Notes: χ^2 (6, N= 163) = 106.275, p = 0.000				

Each estimated coefficient (***B***) is the expected change in the log odds of adopting RFID for a unit increase in the corresponding predictor variable, whilst holding the other predictor variables constant. Each exponentiated coefficient ***Exp(B)*** is the ratio of two odds, or the change in odds in the multiplicative scale for a unit increase in the corresponding predictor variable holding other variables constant.

As seen in Table 5.13, the strongest predictor that influences an organisation's decision to adopt RFID is "top management initiative", recording odds ratio of 3.095. This indicates that for a 1-unit increase in "top management initiative" (while controlling for other factors in the model), the odds of organisations adopting RFID (over odds of non-adoption) increases by 2.095 (3.095-1) times. Other strong predictors include "organisational goals and objectives" and "drive to introduce new technologies into business processes", recording odds ratios of 2.346 and 2.398, respectively. This indicates that organisations with a culture that encourages technological innovation and organisation's that deploy effective decision-making techniques result in a 1.3 times increase in the odds of organisations adopting RFID (over odds of non-adoption).

5.7.1.2 Impact of business size on the decision to adopt RFID

The binary logistic regression model in Table 5.14 was used to assess the impact of an organisation's size and its decision to adopt RFID. The model contained 6 directly measured independent variables (number of employees, annual turnover, international reach, IT/IS infrastructure, number of office locations, retail outlets, service centers, and range of products/services). The Full model containing all predictors was statistically significant, X^2 (6, N= 163) = 167.375, p < 0.001.

Table 5.14: Variables in the model (business size)

	B	**S.E.**	**Sig.**	**Exp(B)**
Number of employees	1.089	.376	.004	2.971
Annual turnover	1.305	.360	.000	3.687
International reach	.780	.280	.005	2.181
IT/IS infrastructure	1.304	.217	.000	3.684
The number of office locations, retail outlets, service centers, etc.	1.068	.224	.000	2.911
Range of products/services	.940	.278	.001	2.561
Notes: χ^2 (6, N= 163) = 167.375, p = 0.000				

As shown in sig. column of Table 5.14, all 6 predictor variables made a unique statistically significant contribution to the model. The strongest predictor that influences an organisation's decision to adopt RFID is "annual turnover", recording odds ratio of 3.687. This indicates that for a 1-unit increase in "annual turnover" (while controlling for other factors in the model), the odds of organisations adopting RFID increases by 2.687 (3.687-1) times. Another strong predictor is "IT/IS infrastructure", recording odds ratio of 3.684. This also indicates that having greater IS/IT usage and infrastructure increases the odds of organisations adopting RFID (over odds of non adoption) by 2.684 (3.684-1) times.

5.7.1.3 Impact of BPR on the decision to adopt RFID

The binary logistic regression model in Table 5.15 was used to assess the impact of BPR on organisational decision to adopt RFID. The model contained 5 directly measured independent variables (data standardization and integration, restructuring and streamlining of business processes and activities, decentralization of consolidated resources and processes, provision of decision-support tools, and synchronization of IT resources and business processes). The

Full model containing all predictors was statistically significant, X^2 (5, N= 163) = 149.728, p < 0.001.

Table 5.15: *Variables in model B (BPR)*				
	B	**S.E.**	**Sig.**	**Exp(B)**
Data standardization and integration	.488	.217	.024	1.629
Restructuring and streamlining of business processes and activities including removal of non-value added tasks, controls and checks	1.042	.235	.000	2.836
Decentralization of resources and processes	.376	.170	.027	1.456
Provision of decision-support tools	.707	.194	.000	2.027
Synchronization of IT resources and business processes	1.14	0.278	.000	3.126
Notes: χ^2 (5, N= 163) = 149.728, p = 0.000				

As shown in sig. column of Table 5.15, all 5 independent variables made a statistically significant contribution to the model, and have a direct positive relationship with "decision to adopt". The strongest predictor that influences "decision to adopt RFID" is "synchronization of IT resources and business processes", recording odds ratio of 3.126. This means that for a unit increase in "synchronization of IT resources and business processes", (while controlling for all other factors), the odds of organisations adopting RFID increases by 2.126 (3.126-1) times. Other strong predictors are "provision of decision-support tools" and "restructuring and streamlining of business processes and activities", recording odds ratio of 2.027 and 2.836, respectively. This indicates that a unit increase in either "provision of decision-support tools" or "restructuring and streamlining of business processes and activities", (while controlling for all other factors), the odds of organisations adopting RFID increases by 1.027 and 1.836 times, respectively.

5.7.2 Results: Structural equation modelling (SEM)

In section 5.7.1, binary logistic regression models determined the relationship of each predictor variable of strength of culture, size, and BPR on the decision to adopt RFID. In this section, business size, strength of culture, and BPR are considered as latent constructs and their relationships with "decision to adopt RFID" is determined. Table 5.16 shows the results obtained from running the structural equation model, including the β values, R^2, error variances, standard errors, and sig. values. Figure 5.1 in Appendix C shows the relationships between the constructs in the form of a path diagram. The values associated with with each path are standardized regression coefficients (β). They signify the amount of change in the dependent variable, for a standard deviation change in the independent.

The "notes" section of Table 5.16 shows the chi-square goodness of fit test along with its probability value. The chi-square statistic tests the overall fit of the structural model to the data. The null hypothesis under test is that the model fits the data; therefore the p-value of .067 ($p > .05$) is indicative of good model fit, suggesting that the model fits the data acceptably in the population from which the researcher drew the sample. Further, corroborating evidence of the model fit is provided by the RMSEA fit statistic, and the NNFI in Table 5.16. The RMSEA fit value obtained for our model was .049 and NNFI value of .987 was obtained. Both values denote good model fit. Also, the model accounts for a large proportion of the variance in the measured variables with the R^2 values ranging from .45 to .71.

Table 5.16: Regression weights and significance tests of individual parameters

Independent variable		Dependent variables	β	P-value	R^2	Error variance	S.E.
Strength of culture	←	Goals and objectives	0.61	0.050	0.51	.554	0.057
		Organisational focus on performance relative to competitors	0.52	0.013	0.49	.371	0.046
		Organisational focus on customer satisfaction	0.50	0.018	0.45	.176	0.058
		Top management initiative	0.84	0.037	0.67	.587	0.049
		Effective and timely decision-making	0.74	0.010	0.48	.183	0.053
		Drive to introduce new technologies into business processes	0.69	0.005	0.54	.639	0.042
	→	**Decision to adopt RFID**	**0.71**	**0.021**	**0.59**	**N/A**	**0.055**
Business size	←	Number of employees	0.84	0.040	0.46	.788	0.063
		Annual turnover	0.92	0.043	0.57	.846	0.036
		International reach	0.75	0.000	0.51	.277	0.048
		IT/IS infrastructure	0.59	0.021	0.52	.054	0.047
		Number of offices, retail outlets, service centres, etc.	0.66	0.000	0.65	.190	0.044
		Range of products/services	0.71	0.050	0.53	.788	0.051
	→	**Decision to adopt RFID**	**0.79**	**0.007**	**0.61**	**N/A**	**0.034**
BPR	←	Data standardization and integration	0.53	0.067	0.55	.527	0.052
		Restructuring and streamlining activities	0.67	0.014	0.73	.102	0.048
		Decentralization of consolidated resources and processes	0.85	0.010	0.61	.434	0.062
		Provision of decision-support tools	0.49	0.035	0.66	.389	0.057
		Synchronization of IT resources and business processes	0.53	0.001	0.59	.235	0.048
	→	**Decision to adopt RFID**	**0.63**	**0.029**	**0.65**	**N/A**	**0.054**
Notes: χ^2 (45) = 127.882, p = 0.067; NNFI = .987; RMSEA = .049							

The β values on the paths leading from the latent constructs to the measured variables signify the change in each measured variable per standard deviation change in the latent construct. For example, a unit standard deviation change in "strength of culture" results in a .84 change in “top management initiative”. Similarly, a unit standard deviation change in “business size” results in a .92 change in “annual turnover”. However, the most noteworthy findings from the SEM model indicate that “strength of culture”, “business size” and “BPR” all have a statistically significant positive relationship with “decision to adopt RFID”, recording β values of 0.71, 0.79, and 0.63, respectively.

5.7.3 Discussion: Binary logistic regression and SEM

From the results of the regression and structural equation model, the relationship of each factor of the independent variables (strength of culture, business size, BPR) with the dependent variable “decision to adopt RFID” was determined. Both set of results indicate that strength of culture, business size and BPR all have a statistically significant positive relationship with organisational decision to adopt RFID. Consequently, decisions regarding hypotheses H7, H8 and H9 are shown in Table 5.17.

Table 5.17: Hypotheses on impact of strength of culture, size and BPR on decision to adopt RFID

	Decision
H7: A strong organisational culture has a significant positive influence on the decision to adopt RFID	Accept
H8: Organisational size has a significant positive influence on the decision to adopt RFID	Accept
H9: Business process re-engineering (BPR) has a significant positive influence on the decision to adopt RFID	Accept

For strength of culture, each predictor variable made a unique statistically significant contribution to predicting “decision to adopt”. “Top management initiative” had the strongest influence on organisational decision to adopt RFID. This finding is supported by Park and Rim (2011) and Jeyaraj et al. (2006) which highlighted top management support as a crucial factor in IT systems adoption and implementation. “Effective decision-making” and “focus on performance relative to competitors” also play a crucial role in influencing organisational decision to adopt RFID. These findings are supported by Zhu and Weyant (2003) which suggest that technology adoption decisions are often made under strategic considerations or competitive pressure. They conclude that in many industries, particularly oligopolistic ones with multiple competitors, adopting a new technology is a strategic decision. In terms of “focus on performance relative to competitors”, Park and Rim (2011) and Attaran (2012) found competitive pressure to be an external factor that drives organisations towards RFID adoption. Consequently, organisations with high focus on their performance relative to their competitors are more driven towards RFID adoption. In the SEM model, strength of culture as a latent construct, has a statistically significant direct positive relationship with organisational decision to adopt RFID. This indicates that the logistic regression results and the SEM results are in agreement.

For business size, each predictor variable made a unique statistically significant contribution to predicting "decision to adopt". "Annual turnover" was found to be the strongest predictor that influences an organisation's decision to adopt RFID. This suggests that organisations with higher annual turnover can afford to allocate more financial resources towards technological innovation. This result is supported by Lin (2009), Zhu et al. (2004), and Wang et al. (2010), which highlight financial readiness and availability to be a critical determinant of RFID adoption. Another strong predictor of "decision to adopt" is "IT/IS infrastructure". IT infrastructure, according to Mitchell and Zmud (1999), offers an organisation the ability to effectively leverage IT resources. Broadly, IT infrastructure refers to enabling technologies, outsourcing arrangements, and policies (Mitchell and Zmud, 1999). Our results indicate that organisations with adequate IT/IS infrastructure are 2 times more likely to adopt RFID than those without. These findings are in tandem with many studies such as Teo et al., (2006), Lin and Lin (2008), and Pan and Jang (2008) which identify IT infrastructure as a crucial determinant of technological innovation. In the SEM model, business size as a latent construct, has a statistically significant direct positive relationship with organisational decision to adopt RFID. Thus, the logistic regression and SEM results are in agreement.

For BPR, each predictor variable made a unique statistically significant contribution to predicting "decision to adopt". "Synchronization of IT resources and business processes", "provision of decision-support tools", and "restructuring and streamlining of business processes and activities" were found to be the strongest predictors that influence organisational decision to adopt RFID. These findings are consistent with those of Jiao and Zhen (2008), which report that it is necessary to implement BPR with an innovative spirit on the fundamental processes before implementing RFID, in order to achieve greater synergy. Our findings are also theoretically consistent with those of Bendavid et al. (2010), which found that the restructuring and streamlining of business process, specifically the removal of non-value added activities, aided RFID-implementation in healthcare settings.

5.8 Research question 3: Impact of strength of culture, size, and BPR on RFID implementation process

This research question uses structural equation models (SEM) to establish the relationship between latent constructs of strength of culture, business size, and business process re-engineering and RFID implementation processes (project scoping, analysis of existing systems, design of RFID system, prototype testing, implementation, and continuous improvement).

5.8.1 Model definition

5.8.1.1 Structural equation models (SEM)

Three structural equation models were developed for the three latent constructs (strength of culture, business size, and BPR) and the observed variable (RFID implementation processes) Model A investigated the impact of strength of culture on RFID implementation processes. Model B investigated the impact of business size on RFID implementation proceses. Model C investigated the impact of BPR on RFID implementation processes. The notation for the three SEM models is shown below. X_i is the observed value of the independent variables for observation *i.*

$$Xi = \Lambda X\ \xi k + \vartheta\delta$$

where: ***Xi*** = a column vector of observed variables shown in Table 5.18*;*

ξk *= ksi,* a column vector of latent variables*;*

ΛX = lambda*, an* ***i X k*** matrix of coefficients defining the relations between the manifest ***(X)*** and latent ***(ξ)*** variables*;* ***ϑδ*** = theta-delta, an ***i X** i* variance/covariance matrix of relations among the residual terms of ***X***

The results of the structural equation model developed using the variables in Table 5.18 are presented in section 5.8.1.

Table 5.18: *Set of latent independent variables.* x_i *is the observed value of the independent variables for observation i.*

Variable	Model A - Strength of culture	Model B - Business size	Model C - BPR
X_1	Organisational goals and objectives	Number of employees	Data standardization and integration
X_2	Organisational focus on its performance relative to its competitors	Annual turnover	Restructuring and streamlining of business processes and activities including removal of non-value added tasks, controls and checks
X_3	Organisational focus on customer satisfaction	International reach	Decentralization of resources and processes
X_4	Effective decision-making	IT/IS infrastructure	Provision of decision-support tools

X_5	Top management initiative	The number of office locations, retail outlets, service centers, etc.	Synchronization of IT resources and business processes
X_6	Drive to introduce new technologies into business processes	Range of products/services	n/a

5.8.1 Results: Structural Equation Modelling (SEM)

In the structural equation models, Strength of culture, Business size, and BPR were considered as latent constructs and their relationships with the different stages of RFID implementation processes is determined.

Table 5.19, 5.20, and 5.21 show the results obtained from running the structural equation models (see figures 5.2, 5.3, and 5.4 in appendix C), including the β values, R^2, error variances, standard errors, and sig. values. The "notes" section of in Table 5.19, 5.20, and 5.21 show the chi-square goodness of fit test for each model, along with its probability value. The chi-square statistic tests the overall fit of the structural model to the data. The null hypothesis under test is that the model fits the data; therefore a non-significant p-value ($p > .05$) is indicative of good model fit. As explained in Chapter 4., Chi-square is very sensitive to multivariate normality deviations and to sample size changes, therefore further corroborating evidence of the model fit is provided by the RMSEA fit statistic, and the NNFI.

Table 5.19: Impact of strength of culture on RFID implementation processes

Independent variable		**Dependent variables**	**β**	**P-value**	**R^2**	**Error variance**	**S.E.**
Strength of culture	←	Goals and objectives	0.57	0.048	0.51	.532	0.047
		Organisational focus on performance relative to competitors	0.61	0.023	0.49	.341	0.036
		Organisational focus on customer satisfaction	0.53	0.017	0.45	.263	0.042
		Top management initiative	0.79	0.017	0.67	.477	0.052
		Effective and timely decision-making	0.72	0.030	0.48	.293	0.033
		Drive to introduce new technologies into business processes	0.64	0.015	0.54	.529	0.022
	→	Project scoping	0.54	0.021	0.59	.343	0.055
		Analysis of existing systems	0.57	0.013	0.61	.244	0.068
		Design of RFID system	0.67	0.018	0.46	.542	0.039
		Prototype testing of RFID system	0.64	0.001	0.57	.435	0.072
		Implementation of RFID system	0.75	0.023	0.53	.326	0.066
		Continuous improvement	0.54	0.017	0.54	.332	0.065

Notes: χ^2 (24) = 77.012, p = 0.059; NNFI = .932; RMSEA = .041

In Table 5.19, the RMSEA fit value obtained for our model was .041 and NNFI value of .932 was obtained. Both values denote good model fit. Also, the model accounts for a large proportion of the variance in the measured variables with the R^2 values ranging from .45 to .67.

Table 5.20: Impact of business size on RFID implementation processes

Independent variable		Dependent variables	β	P-value	R^2	Error variance	S.E.
Business size	←	Number of employees	0.79	0.040	0.46	.788	0.063
		Annual turnover	0.87	0.043	0.57	.846	0.036
		International reach	0.69	0.000	0.51	.277	0.048
		IT/IS infrastructure	0.64	0.021	0.52	.054	0.047
		Number of offices, retail outlets, service centres, etc.	0.70	0.000	0.65	.190	0.044
		Range of products/services	0.65	0.050	0.53	.788	0.051
	→	Project scoping	0.41	0.032	0.50	.343	0.057
		Analysis of existing systems	0.54	0.021	0.67	.653	0.048
		Design of RFID system	0.59	0.034	0.62	.463	0.063
		Prototype testing of RFID system	0.43	0.036	0.43	.354	0.057
		Implementation of RFID system	0.67	0.035	0.53	.456	0.062
		Continuous improvement	0.63	0.007	0.47	.473	0.045
Notes: χ^2 (27) = 71.092, p = 0.082; NNFI = .966; RMSEA = .057							

In Table 5.20, the RMSEA fit value obtained for our model was .057 and NNFI value of .966 was obtained. Both values denote good model fit. Also, the model accounts for a large proportion of the variance in the measured variables with the R^2 values ranging from .43 to .67.

Table 5.21: Impact of BPR on RFID implementation processes

Independent variable		Dependent variables	β	P-value	R^2	Error variance	S.E.
BPR	←	Data standardization and integration	0.63	0.037	0.58	.437	0.052
		Restructuring and streamlining activities	0.71	0.018	0.53	.232	0.048
		Decentralization of consolidated resources and processes	0.78	0.030	0.59	.454	0.062
		Provision of decision-support tools	0.59	0.025	0.64	.334	0.057
		Synchronization of IT resources and business processes	0.57	0.011	0.70	.455	0.048
	→	Project scoping	0.41	0.057	0.60	.537	0.056
		Analysis of existing systems	0.45	0.038	0.41	.450	0.061
		Design of RFID system	0.39	0.013	0.58	.462	0.058
		Prototype testing of RFID system	0.68	0.002	0.49	.352	0.074
		Implementation of RFID system	0.43	0.048	0.58	.484	0.067
		Continuous improvement	0.59	0.016	0.63	.324	0.046
Notes: χ^2 (23) = 64.038, p = 0.057; NNFI = .937; RMSEA = .039							

In Table 5.21, the RMSEA fit value obtained for our model was .039 and NNFI value of .937 was obtained. Both values denote good model fit. Also, the model accounts for a large proportion of the variance in the measured variables with the R^2 values ranging from .41 to .73.

The β values on the paths leading from the latent constructs (strength of culture, size, and BPR) to the measured variables signify the change in each measured variable per standard deviation change in the latent construct. For example, a unit standard deviation change in "strength culture" results in a .79 change in "top management initiative". Similarly, a unit standard deviation change in "business size" results in a .87 change in "annual turnover". However, the most noteworthy findings from the SEM model indicate that "strength of culture", "business size" and "BPR" all have a statistically significant relationship with the different processes of RFID implementation. For instance, BPR has a significant direct positive relationship with "project scoping", recording a standardized regression coefficient value of 0.41. This indicates that for a 1-unit standard deviation increase in BPR, project scoping increases by 0.41. Similarly, business size has a significant ($p < 0.05$) direct positive relationship with "continuous improvement", recording β value of 0.63. This indicates that for a 1-unit standard deviation increase in business size, continuous improvement increases by 0.63.

5.8.2 Discussion: SEM

From the results of the structural equation models, the relationship of each factor of the independent variables (strength of culture, business size, BPR) with the dependent variable (RFID implementation processes) was determined. The relationships observed between strength of culture, size, and BRP with the following implementation processes:

5.8.2.1 Project scoping

The culture of a business is key to the success of IS adoption and implementation (Talet and Al-Wahaishi, 2011). Thus, understanding culture is a vitally important for organisations because it affects strategic expansion, efficiency, and learning at all levels of management. The first phase of RFID implementation "project scoping" recorded a β value of .54, with a p value of 0.021. The project scoping of RFID systems typically involves defining the objectives and understanding the potential benefits and limitations of the proposed system. As seen in Table 5.19, strength of culture has a statistically significant direct positive relationship with "project scoping". Defining the project objectives can give a clear direction to the implementation team. This is important because organisations tend to create unrealistic expectations and have incorrect perceptions towards a system (Hardgrave and Miller, 2006). Consequently, organisations with a culture that clearly outlines goals and objectives can avoid unrealistic expectations towards RFID system deployment by fully understanding the potential benefits and limitations of the proposed system.

Table 5.20 shows that business size has a significant direct positive relationship with "project scoping", recording a β value of .41, with a p value of 0.032. The size of an organisation affects its financial resources and the availability of skilled workforce. The implementation of IS systems like RFID and its components requires long term investment and technical expertise (Nguyen, 2009), therefore larger organisations which have adequate financial and technical resources are more capable of making a success of RFID implementations, and developing a clear scope and objectives in implementing the system (Ngai et al., 2010).

Table 5.21 shows that BPR has a non-significant relationship with "project scoping", recording a β value of .41, with a p value of 0.057.

5.8.2.2 Analysis of existing systems

The second phase of RFID implementation "analysis of existing systems" recorded a β value of .57, with a p value of 0.013. As seen in Table 5.19, strength of culture has a statistically significant direct positive relationship with "analysis of existing systems". Data collection is an important aspect in the analysis of existing systems. The culture of an organisation affects the techniques, strategies, and efficiency of data collection. The details of the processes of an existing system are often collected by various methods, such as conducting interviews with the key individuals and front-line staff who use the present system, collecting comments from stakeholders, and eliciting experts' opinions. Additionally, support from top management influences the resources attributed to the analysis of current systems including collecting data to identify the limitations of existing systems. Leadership culture is a key to the success of IS adoption and effective leadership is the means by which the culture is created and managed (Talet and Al-Wahaishi, 2011). Thus, organisations that develop a culture that supports effective data collection and analyses, through the support of top management and allocation of financial and technical resources, are more likely to implement RFID, and make a success of it.

In Table 5.20, business size has a statistically significant direct positive relationship with "analysis of existing systems", recording a β value of .54, with a p value of 0.021. Analyzing existing systems involves collecting information about the operation processes, and the analysis and evaluation of the current processes. This is usually performed by using the diagramming techniques and tools that have been agreed upon by the key individuals who are currently using the system. By examining the current process with the aid of workflow diagrams, areas for improvement can be identified. Larger organisations have (i) greater number of employees and so could appoint the right candidates to study the existing system; (ii) greater annual turnover, so could allocate more resources to the tasks; and (iii) have better IT/IS infrastructure so have access to diagramming techniques and tools used for analysing existing systems.

In Table 5.21, BPR has a statistically significant direct positive relationship with "analysis of existing systems", recording a β value of .45, with a p value of 0.038. Analysis of existing systems involves identifying where areas for improvement exist. During BPR, processes are mapped out and analysed. The main objective of this is to identify disconnects (anything that prevents a process from achieving desired results and in particular information transfer between organisations or people) and non-value-adding processes. This is succeeded by the restructuring and streamlining of activities to achieve total re-invention or redesign of business processes. Consequently, BPR has an influence on the analysis of existing systems.

5.8.2.3 Design of RFID system

The third phase of RFID implementation is the "design of RFID system". The system design stage includes requirement analysis, hardware and software selection, and the development of the new process. As seen in Table 5.19, strength of culture has a statistically significant direct positive relationship with "design of RFID system", recording a β value of .67, with a p value of 0.018. Support from top management and clear outlining of organisational goals and objectives assist the implementation team in performing requirement analysis, so as to thoroughly understand the ways in which RFID technology can address the problems identified in the existing systems, identify and select the appropriate software and hardware for the proposed system, and map out and develop new business processes.

In Table 5.20, business size has a statistically significant direct positive relationship with "analysis of existing systems", recording a β value of .54, with a p value of 0.021. As identified in the previous paragraph, the selection of appropriate hardware and software is an essential process in the design of RFID systems. This is to understand the characteristics of each element of hardware and software and to decide which option is more suitable for the current environment. Accordingly, the financial resources and IT/IS infrastructure of organisations influences the selection and testing of hardware and software in the design of a proposed system. The financial resources and IT/IS infrastructure of organisations also influence the development of new processes (based upon the knowledge of the current processes).

In Table 5.21, BPR has a statistically significant direct positive relationship with "design of RFID system", recording a β value of .39, with a p value of 0.013. In designing an RFID system, the organisation design the way in which the readers are connected to the network and the software architecture, including the RFID middleware and the application level software. The BPR of business processes involves the restructuring and streamlining of business processes and activities. Accordingly, BPR influences the design of RFID systems as it would give decision-makers a clearer picture of how the hardware and software items function in an integrated system, as well as providing data for measuring the reliability of the proposed system.

5.8.2.4 Prototype testing

Before the actual implementation of the RFID system, it is very important to conduct a pilot test, so as to understand the system and establish its readiness for deployment. Prototype testing may be conducted in the laboratory or in the actual business environment. The key stages of prototype testing include debugging and system adaptation. As seen in Table 5.19, strength of culture has a statistically significant direct positive relationship with "prototype testing", recording a β value of .64, with a p value of 0.001. This suggests that organisations with top management initiative and effective decision making are more likely to make a success of the prototype testing phase of RFID implementation. This is because, apart from debugging the technical system and eliminating the mistakes in the analyses, prototype testing also includes collecting feedback from users after the pilot testing. This is designed as such in order to elicit comments on the various user interfaces and in order to fine tune their design. Thus, this feedback collection process is influenced by the culture of the organisation.

In Table 5.20, business size has a statistically significant direct positive relationship with "analysis of existing systems", recording a β value of .43, with a p value of 0.036. The prototype testing covers both software and hardware tests in order to detect bugs and system collisions. Technical staff are usually involved so as to support the testing and in order to resolve (debug) any technical problems detected in the test. The number of employees and technical expertise and resources will thus affect the success of the prototype testing phase of RFID implementation. This suggests that larger organisations are more likely to make a success of the prototype testing phase as they have superior resources than SMEs in terms of workforce and expertise.

In Table 5.21, BPR has a statistically significant direct positive relationship with “prototype testing”, recording a β value of .68, with a p value of 0.002. Protoype testing involves the adaptation of processes to ensure that the RFID system will deliver the expected performance results. BPR involves the redesigning of systems and processes and thus affects the recording and review of problems found during the pilot testing and thus has an effect on efforts to fine-tune the system and resolve the identified problems.

5.8.2.5 Implementation of RFID system

On the successful completion of prototype testing, the next phase is the implementation of the system in the actual business environment. Implementation involves the installation and commissioning of hardware and software systems, and change management, training and system deployment. All of the tasks in the implementation step are vital, as they will affect the success of the implementation. As seen in Table 5.19, strength of culture has a statistically significant direct positive relationship with “implementation”, recording a β value of .75, with a p value of 0.023. Many aspects of strength of culture including top management initiative, clear outlining of organisational goals and objectives, focus on organisational performance relative to competitors, and drive to introduce new technologies into business processes influences the success of system deployment, installation and commissioning of hardware and software systems, as well as developing the new procedures.

In Table 5.20, business size has a statistically significant direct positive relationship with “implementation of RFID system”, recording a β value of .67, with a p value of 0.035. The implementation of the RFID system requires software and hardware configuration and deployment. Additionally, users need to receive basic information about the system and training on technical operations of the system. Technical staff are involved in the configuration of hardware and software and their integration with existing business systems and processes. The number of employees and technical expertise and resources will thus affect the success of this phase of RFID implementation.

In Table 5.21, BPR has a statistically significant direct positive relationship with “implementation of RFID system”, recording a β value of .43, with a p value of 0.048. BPR involves the redesigning of systems and processes including centralization/decentralization of resources. Consequently, BPR specifically influences the configuration of software and integration of hardware systems into existing business processes, the use and positioning of centralized/dispersed resources, and the deployment of decision-support tools and strategies.

5.8.2.6 Continuous improvement

The last step for implementation is continuous improvement. Organisations continuously evaluate the system's performance and compare it with the pre-set objectives, enhance the system with emergent technologies, or else adapt it to match the changing needs of the market. This step includes the tasks of system monitoring and the collection of user feedback. As seen in Table 5.19, strength of culture has a statistically significant direct positive relationship with "prototype testing", recording a β value of .54, with a p value of 0.017. Organisations with top management initiative, drive to introduce new technologies, and focus on their performance relative to their competitors are likely to continuously improve their RFID system so as to adapt it to dynamic business environments, and make it more effective.

In Table 5.20, business size has a statistically significant direct positive relationship with "continuous improvement", recording a β value of .63, with a p value of 0.007. After system deployment, the performance of the RFID solution needs to be closely monitored - especially in the early stage of implementation - so that the project team can quickly respond to the problems encountered. Additionally, collection of feedback from users, and training them to use the new system are also essential aspects of continuous improvement. Therefore, the availability of funds to train users, availability of skilled workforce, IT/IS infrastructure, and range of products/services are likely going to influence the direction organisations take in order to continuously improve their existing RFID systems to match changing market needs.

After implementation, organisations often decide to adopt new technology to support or improve their existing RFID systems. In order to do this, the existing system has to be analysed and possibly redesigned. The provision for continuous improvement made when the system was initially designed will have an impact on organisational decision to adopt or integrate a new technology. In Table 5.21, BPR has a statistically significant direct positive relationship with "continuous improvement", recording a β value of .59, with a p value of 0.016. BPR involves the redesigning of systems and processes including centralization/decentralization of resources. Consequently, BPR influences the integration of hardware systems into existing business processes, the deployment of decision-support tools and strategies and other aspects of continuous improvement.

From the discussions in sections 5.8.2.1 to 5.8.2.6, the following decisions regarding hypotheses H10, H11 and H12 are shown in Table 5.22.

Table 5.22: Decisions for hypotheses on impact of strength of culture, size, and BPR on RFID implementation processes

Hypotheses	**Decision**
H10: A strong organisational culture has a significant positive influence on the implementation processes of RFID	Accept
H11: Organisational size has a significant positive influence on the implementation processes of RFID	Accept
H12: Business process re-engineering (BPR) has a significant positive influence on the implementation processes of RFID	Accept

5.9 Research question 4: Impact of strength of culture, size, BPR on benefits derived from RFID

This research question uses structural equation models (SEM) to establish the relationship between latent constructs of strength of culture, business size, and business process re-engineering and benefits derived from RFID implementation (financial measures, internal processes, customer measures, and learning and growth).

5.9.1 Model definition

5.9.1.1 Structural equation models (SEM)

Three structural equation models were developed for the three latent constructs (strength of culture, business size, and BPR) and the observed variable (RFID benefits). Model A investigated the impact of strength of culture on RFID benefits. Model B investigated the impact of business size on RFID benefits. Model C investigated the impact of BPR on RFID benefits. The notation for the three SEM models is shown below. X_i is the observed value of the independent variables for observation *i.*

$$Xi = \Lambda X \, \xi k + \vartheta\delta$$

where: ***Xi*** = a column vector of observed variables shown in Table 5.22*;*

ξk *= ksi,* a column vector of latent variables*;*

ΛX = lambda*, an* ***i X k*** matrix of coefficients defining the relations between the manifest ***(X)*** and latent ***(ξ)*** variables*;* ***ϑδ*** = theta-delta, an ***i X i*** variance/covariance matrix of relations among the residual terms of ***X***

The results of the structural equation models developed using the variables in Table 5.23 are presented in section 5.9.2.

Table 5.23: *Set of latent independent variables. x_i is the observed value of the independent variables for observation i.*

Variable	Model A - Strength of culture	Model B - Business size	Model C - BPR
X_1	Creating strong internal and external motivation for improvement	Number of trained/skilled employees	Adoption of flexible deployment architecture
X_2	Developing a clear RFID strategy	IT/IS infrastructure	Continuous review and improvement of procedures
X_3	Innovation	Annual turnover	Restructuring and streamlining activities including removal of non-value added tasks, controls and checks
X_4	Provision of training and support for employees	International reach	Integration and management of large amounts of data

X_5	Top management support and commitment from leadership	The number of office locations, warehouses, retail outlets, and service centres deploying RFID	Decentralization of resources and processes
X_6	Organisational knowledge accumulation	Range of products/services using RFID	Synchronization of business processes and IT resources

5.9.2 Results: Structural Equation Modelling (SEM)

In the structural equation model, strength of culture, business size, BPR, and RFID benefits were considered as latent constructs. The RFID benefits were categorized into four groups according to the Balanced Scorecard Approach of Kaplan and Norton (2004). The four categories are financial measures; internal processes; corporate/customer measures; and learning and growth. Financial measures include financially-related metrics such as sales increase, net profit, ROI, etc. Internal processes concern business process metrics that show how well an organisation is running. Corporate/customer measures concern customer focus and customer satisfaction. The learning and growth perspective includes employee training and corporate cultural attitudes related to both individual and corporate self-improvement.

Table 5.24, 5.25, and 5.26 show the results obtained from running the structural equation models (see figures 5.5, 5.6, and 5.7 in appendix C), including the β values, R^2, error variances, standard errors, and sig. values. Due to limited space, only β values between the latent constructs are reported on figures 5.5, 5.6, and 5.7. For all other β values, refer to tables 5.24, 5.25, and 5.26.

The “notes” section of in Table 5.24, 5.25, and 5.26 show the chi-square goodness of fit test for each model, along with its probability value. A non-significant p-value ($p > .05$) is indicative of good model fit. Further, corroborating evidence of the model fit is provided by the RMSEA fit statistic, and the NNFI.

Table 5.24: Impact of strength of culture on RFID benefits							
Independent variable		**Dependent variables**	**β**	**P-value**	**R^2**	**Error variance**	**S.E.**
Financial measures	←	Sales increase	0.67	0.018	0.48	.332	0.048
		Net profit	0.61	0.033	0.54	.320	0.032
		Return-on-investment	0.57	0.019	0.60	.248	0.040
		Market share gains	0.54	0.043	0.57	.394	0.027
		Cost reduction	0.62	0.020	0.69	.239	0.031
		Labour savings	0.67	0.035	0.65	.237	0.030
Internal processes	←	Risk minimization	0.45	0.041	0.53	.307	0.047
		Reduction of inventory	0.68	0.034	0.63	.237	0.035
		Improved product availability	0.59	0.028	0.46	.245	0.025
		Improved transaction accuracy	0.64	0.021	0.57	.345	0.063
		Improved visibility	0.80	0.018	0.70	.422	0.035
		Reduced out-of-stock items	0.65	0.027	0.67	.141	0.033
		Improved supply chain planning	0.49	0.033	0.56	.233	0.023
		Higher rate of complete orders	0.49	0.040	0.62	.327	0.056
		Improved data integrity	0.67	0.032	0.49	.253	0.023
		Electronic traceability	0.78	0.028	0.55	.453	0.032
		Improved sourcing of new products	0.54	0.043	0.45	.303	0.055
		Increase in transportation efficiency	0.69	0.023	0.56	.544	0.032
Corporate/Customer measures	←	Improved corporate social responsibility	0.54	0.033	0.54	.249	0.035
		Improved business sustainability	0.56	0.029	0.62	.550	0.045
		Environmental compliance	0.57	0.018	0.49	.263	0.038
		Improved organisational learning	0.64	0.043	0.60	.356	0.028
		Improved health and safety	0.59	0.027	0.45	.236	0.040
		Customer retention	0.73	0.027	0.61	.197	0.022
		Enhanced staff motivation	0.72	0.030	0.58	.203	0.043
Learning and growth	←	More accurate forecast of demand	0.64	0.015	0.59	.239	0.032
		Increase in organisational knowledge accumulation	0.58	0.041	0.43	.233	0.035
		Enhancement of employee satisfaction	0.60	0.037	0.51	.194	0.028
		Improvement in employees' RFID-related skills and proficiency	0.67	0.029	0.45	.234	0.021
Strength of culture	←	Creating strong internal and external motivation for improvement	0.77	0.018	0.51	.402	0.027
		Developing a clear RFID strategy	0.75	0.030	0.59	.01	0.036
		Innovation	0.66	0.017	0.65	.200	0.040
		Provision of training and support for employees	0.69	0.027	0.67	.417	0.058
		Top management support and commitment from leadership	0.72	0.019	0.58	.273	0.043
		Organisational knowledge accumulation	0.64	0.015	0.64	.324	0.032
	→	**Financial measures**	**0.63**	**0.019**	**0.59**	**N/A**	**0.045**
		Internal processes	**0.76**	**0.023**	**0.61**	**N/A**	**0.054**
		Corporate measures	**0.67**	**0.030**	**0.66**	**N/A**	**0.032**
		Learning and growth	**0.64**	**0.019**	**0.57**	**N/A**	**0.023**
Notes: χ^2 (97) = 281.032, p = 0.059; NNFI = .951; RMSEA = .055							

In Table 5.24, the RMSEA fit value obtained for our model was .055 and NNFI value of .951 was obtained. Both values denote good model fit. Also, the model accounts for a large proportion of the variance in the measured variables with the R^2 values ranging from .43 to .69

Table 5.25: Impact of business size on RFID benefits							
Independent variable		**Dependent variables**	**β**	**P-value**	**R^2**	**Error variance**	**S.E.**
Financial measures	←	Sales increase	0.60	0.018	0.51	.332	0.017
		Net profit	0.62	0.022	0.54	.421	0.036
		Return-on-investment	0.57	0.019	0.60	.302	0.052
		Market share gains	0.69	0.037	0.57	.423	0.056
		Cost reduction	0.62	0.035	0.53	.193	0.039
		Labour savings	0.66	0.043	0.59	.234	0.034
Internal processes	←	Risk minimization	0.50	0.011	0.54	.302	0.025
		Reduction of inventory	0.56	0.033	0.60	.234	0.038
		Improved product availability	0.60	0.028	0.60	.242	0.034
		Improved transaction accuracy	0.61	0.041	0.57	.153	0.045
		Improved visibility	0.55	0.032	0.49	.543	0.027
		Reduced out-of-stock items	0.61	0.023	0.53	.323	0.046
		Improved supply chain planning	0.60	0.019	0.55	.523	0.042
		Higher rate of complete orders	0.64	0.015	0.61	.407	0.050
		Improved data integrity	0.53	0.022	0.53	.213	0.037
		Electronic traceability	0.61	0.016	0.55	.219	0.029
		Improved sourcing of new products	0.59	0.020	0.59	.233	0.035
		Increase in transportation efficiency	0.58	0.023	0.61	.254	0.048
Corporate/Customer measures	←	Improved corporate social responsibility	0.53	0.018	0.55	.242	0.039
		Improved business sustainability	0.54	0.023	0.61	.235	0.043
		Environmental compliance	0.61	0.023	0.31	.648	0.031
		Improved organisational learning	0.60	0.034	0.49	.345	0.035
		Improved health and safety	0.53	0.050	0.54	.263	0.042
		Customer retention	0.56	0.023	0.60	.417	0.045
		Enhanced staff motivation	0.67	0.043	0.53	.233	0.036
Learning and growth	←	More accurate forecast of demand	0.57	0.025	0.43	.459	0.029
		Increase in organisational knowledge accumulation	0.64	0.011	0.45	.332	0.045
		Enhancement of employee satisfaction	0.62	0.043	0.32	.194	0.034
		Improvement in employees' RFID-related skills and proficiency					
Business size	←	Number of trained/skilled employees	0.59	0.028	0.45	.522	0.042
		IT/IS infrastructure	0.60	0.013	0.41	.201	0.053
		Annual turnover	0.60	0.014	0.50	.113	0.026
		International reach	0.72	0.023	0.60	.277	0.024
		The number of office locations, warehouses, retail outlets, and service centres deploying RFID	0.64	0.031	0.58	.293	0.053
		Range of products/services using RFID	0.59	0.042	0.60	.500	0.032
	→	**Financial measures**	**0.72**	**0.020**	**0.59**	**N/A**	**0.055**
		Internal processes	**0.65**	**0.026**	**0.61**	**N/A**	**0.068**
		Corporate measures	**0.71**	**0.031**	**0.46**	**N/A**	**0.039**
		Learning and growth	**0.61**	**0.023**	**0.57**	**N/A**	**0.072**
Notes: χ^2 (107) = 281.679, p = 0.069; NNFI = .980; RMSEA = .053							

In table 5.25, the RMSEA fit value obtained for our model was .053 and NNFI value of .980 was obtained. Both values denote good model fit. Also, the model accounts for a large proportion of the variance in the measured variables with the R^2 values ranging from .41 to .61.

Table 5.26: Impact of BPR on RFID benefits							
Independent variable		**Dependent variables**	**β**	**P-value**	**R^2**	**Error variance**	**S.E.**
Financial measures	←	Sales increase	0.60	0.026	0.54	.423	0.028
		Net profit	0.63	0.013	0.57	.352	0.032
		Return-on-investment	0.59	0.023	0.61	.256	0.030
		Market share gains	0.56	0.043	0.60	.394	0.057
		Cost reduction	0.70	0.029	0.61	.352	0.051
		Labour savings	0.64	0.015	0.62	.135	0.040
Internal processes	←	Risk minimization	0.57	0.021	0.57	.327	0.024
		Reduction of inventory	0.64	0.034	0.48	.147	0.053
		Improved product availability	0.56	0.018	0.46	.262	0.034
		Improved transaction accuracy	0.59	0.025	0.53	.264	0.045
		Improved visibility	0.75	0.034	0.67	.332	0.024
		Reduced out-of-stock items	0.60	0.039	0.63	.442	0.053
		Improved supply chain planning	0.55	0.036	0.56	.342	0.039
		Higher rate of complete orders	0.56	0.025	0.61	.137	0.035
		Improved data integrity	0.61	0.042	0.56	.453	0.049
		Electronic traceability	0.69	0.016	0.65	.245	0.033
		Improved sourcing of new products	0.58	0.032	0.54	.243	0.056
		Increase in transportation efficiency	0.62	0.027	0.56	.244	0.052
Corporate/Customer measures	←	Improved corporate social responsibility	0.50	0.043	0.66	.342	0.050
		Improved business sustainability	0.56	0.039	0.52	.254	0.035
		Environmental compliance	0.49	0.011	0.49	.263	0.053
		Improved organisational learning	0.60	0.035	0.60	.656	0.024
		Improved health and safety	0.59	0.024	0.55	.532	0.030
		Customer retention	0.67	0.043	0.59	.327	0.045
		Enhanced staff motivation	0.70	0.020	0.53	.453	0.032
Learning and growth	←	More accurate forecast of demand	0.59	0.050	0.58	.234	0.042
		Increase in organisational knowledge accumulation	0.60	0.042	0.67	.233	0.045
		Enhancement of employee satisfaction	0.61	0.033	0.43	.154	0.045
		Improvement in employees' RFID-related skills and proficiency	0.63	0.022	0.45	.234	0.045
BPR	←	Adoption of flexible deployment architecture	0.70	0.034	0.59	.412	0.029
		Continuous review and improvement of procedures	0.71	0.050	0.50	.421	0.031
		Restructuring and streamlining activities including removal of non-value added tasks, controls and checks	0.59	0.024	0.60	.256	0.044
		Integration and management of large amounts of data	0.66	0.023	0.62	.117	0.048
		Decentralization of resources and processes	0.70	0.043	0.65	.573	0.033
		Synchronization of business processes and IT resources	0.68	0.016	0.61	.364	0.032
	→	**Financial measures**	**0.61**	**0.042**	**0.53**	**N/A**	**0.052**
		Internal processes	**0.73**	**0.018**	**0.56**	**N/A**	**0.034**
		Corporate measures	**0.69**	**0.032**	**0.60**	**N/A**	**0.013**
		Learning and growth	**0.68**	**0.028**	**0.65**	**N/A**	**0.032**
Notes: χ^2 (94) = 275.001, p = 0.053; NNFI = .921; RMSEA = .050							

In table 5.26, the RMSEA fit value obtained for our model was .050 and NNFI value of .921 was obtained. Both values denote good model fit. Also, the model accounts for a large proportion of the variance in the measured variables with the R^2 values ranging from .43 to .67.

In figures 5.5, 5.6, and 5.7, the β values on the paths leading from any of the latent constructs (financial measures, internal processes, corporate measures, learning and growth, business size, strength of culture, BPR) to the measured variables signify the change in each measured variable per standard deviation change in the latent construct. In Figure 5.5 for example, a unit standard deviation change in “strength of culture” results in a .66 change in “innovation”. Similarly, in figure 5.6, a unit standard deviation change in “financial measures” results in a .62 change in “net profit”. However, the most noteworthy findings from the SEM models indicate that “strength of culture”, “business size” and “BPR” all have a statistically significant relationship with the different categories of RFID benefits. For instance, BPR has a significant direct positive relationship with “internal processes”, recording a standardized regression coefficient value of 0.73. This indicates that for a 1-unit standard deviation increase in BPR, internal processes increases by 0.73. Similarly, business size has a significant ($p < 0.05$) direct positive relationship with “financial measures”, recording β value of 0.72. This indicates that for a 1-unit standard deviation increase in business size, financial measures increases by 0.72.

5.9.3 Discussion: SEM

From the results of the structural equation models, the relationship of each factor of the independent variables (strength of culture, business size, BPR) with the dependent variable (RFID benefits) were determined. The relationships observed between organisational culture, size, and BRP (in figures 5.5, 5.6, and 5.7) with the four categories of RFID benefits were as follows:

5.9.3.1 Strength of culture

Strength of culture affects the extent to which innovative solutions are encouraged, supported and implemented. A culture supportive of innovation encourages innovative ways of representing problems and finding solutions, regards innovation as both desirable and normal, and favours innovators as models to be emulated (Lock and Kirkpatrick, 1995). In that regard, organisations and leaders try to create an institutional framework in which innovation will be accepted as fundamental cultural norms in the midst of technological and other changes. Thus, understanding culture is a vitally important for organisations aiming to maximize the benefits derivable from their technological innovations because it affects strategic expansion, efficiency, and learning at all levels of management.

Table 5.27 shows that strength of culture has a statistically significant relationship with all of the 4 categories of RFID benefits.

Table 5.27: *Hypotheses on impact of culture strength on RFID benefits*

Category	β value	p value	Hypothesis	Decision
Financial measures	0.63	0.019	H13: A strong organisational culture has a significant positive influence on the benefits derivable from RFID implementation	Accept
Internal processes	0.76	0.023		
Corporate measures	0.67	0.030		
Learning & growth	0.64	0.019		

5.9.3.2 Business size

The size of an organisation affects its financial resources and the availability of skilled workforce. Financial resources are important for successful IS investments, as the cost of integrating IS to achieve greater benefits can be substantial (Iacovou et al. 1995). In terms of RFID implementation, larger organisations which have adequate financial and technical resources are believed to be more capable of making a success of RFID implementations, and realizing the most benefits (Ngai et al., 2010).

Table 5.28 shows that business size has a statistically significant relationship with all of the 4 categories of RFID benefits.

Table 5.28: *Hypotheses on impact of organisational size on RFID benefits*

Category	β value	p value	Hypothesis	Decision
Financial measures	0.72	0.020	H14: Organisational size has a significant positive influence on the benefits derivable from RFID implementation	Accept
Internal processes	0.65	0.026		
Corporate measures	0.71	0.031		
Learning & growth	0.61	0.023		

The costs can include investment in hardware and software, ongoing support and maintenance, and modifications to current IT systems (O'Callaghan et al., 1992). In instances where RFID is part of an inter-organisational system (IOS) investment, the extent to which benefits are derived depend on the extent to which IOS is used to process data and link to trading partners; as this eventually leads to greater benefits (Williams et al., 1998). IOS implementation frequently involves a need to change and upgrade internal systems

(Saunders and Clark, 1992). Therefore, larger organisations which have highly integrated and digitized processes are better prepared to integrate their IOS systems and achieve greater benefits (Iacovou et al. 1995).

5.10.3.3 BPR

IT and IOS implementation frequently involves a need to change and upgrade internal systems (Saunders and Clark 1992). Thus, BPR is often required to adopt and integrate IT and IOS with existing internal applications, and establish links with trading partners (Premkumar and Ramamurthy 1995). Prior research shows that adequate IT infrastructure provides a platform that enables organisations to pursue important initiatives such as the electronic integration of supply chains and outsourcing to strategic partners (Bardhan et al. 2006a; Bardhan et al. 2006b; Zhu and Kraemer 2002). Consequently, in terms of RFID implementation, the compatibility of technology with internal IT systems leads to greater integration internally and with supply chain partners, and greater implementation success and benefits (Premkumar et al., 1994). Similarly, a strong IT platform is required to achieve greater benefits from RFID implementation. Organisations may need to upgrade existing applications and invest in new hardware and software, to aggregate and filter data generated by RFID, and to integrate this data with enterprise systems (Dutta et al., 2007).

Table 5.29 shows that business size has a statistically significant relationship with all of the 4 categories of RFID benefits.

Table 5.29: *Hypotheses on impact of BPR on RFID benefits*

Category	β value	p value	Hypothesis	Decision
Financial measures	0.72	0.020	H15: Business process re-engineering (BPR) has a significant positive influence on the benefits derivable from RFID implementation	Accept
Internal processes	0.65	0.026		
Corporate measures	0.71	0.031		
Learning & growth	0.61	0.023		

5.10 Question 5: Impact of RFID-related factors on benefits derived from RFID

This research question uses One-way ANOVA to investigate the impact of the following RFID–related factors on benefits derived from RFID implementation.

Independent variables: PULT, RFID implementation stage, and Organisational pedigree in RFID (each variable has 3 or more levels)

Dependent variables: RFID benefits

5.10.1 Results: One-Way ANOVA

As there is one independent variable (with three or more levels/groups) and one dependent continuous variable in this research question, one-way ANOVA is the most appropriate tool for analysing the differences between the groups and their associated procedures. It compares the variance between the different groups with the variability within each of the groups. An ***F ratio*** is calculated, which indicates the variance between the groups divided by the variance within the groups. Large ***F ratios*** indicate that there is more variability between the groups (caused by the independent variable) than there is within each group (referred to as error term). A statistically significant ***F test*** means that the null hypothesis should be rejected, which suggests that the groups' means are equal. Post-hoc tests are then conducted to find out which groups differ.

5.10.1.1 RFID implementation stage

The ANOVA test compares the variances between and within the three implementation stages. It indicates whether there is a significant difference among the mean scores on the dependent variable (benefits derived from RFID) for the three stages (pilot stage, partial implementation, full implementation). Table 5.30 in Appendix D gives information about each implementation stage, including the number in each group, the means, standard errors, and standard deviations. Table 5.31 in Appendix D indicates the statistical significance of the differences between each pair of stages.

For variables with a significant difference among the mean scores of the three implementation stages (significant p value), the results in Table 5.31 indicate exactly where the differences occur. In the column labelled ***Mean Difference***, the values with asterisks (*) indicate that there is a statistically significant difference between the three implementation stages being compared. The exact significance value is indicated in the column labelled ***Sig.***

As shown in Table 5.31, a one-way between groups analysis of variance was conducted to explore the impact of RFID implementation stage on benefits derived from RFID adoption. There are three stages of implementation considered – pilot stage, partial implementation stage, and full implementation stage. There was a statistically significant difference at the $p < .05$ level in mean scores of the following RFID benefits between at least two of the three stages of RFID implementation: *Sales increase F (2, 94) = 1.36, p = .048*; *Net profit F* (2, 94) = 14.74, p = .000; *Return-on-investment F* (2, 94) = 5.74, p = .004; *Cost reduction F* (2, 94) = 18.65, p = .000; *Labour savings F* (2, 94) = 3.21, p = .045; *Reduction of inventory F* (2, 94) = .285, p = .003; *Visibility F* (2, 94) = .751, p = .015; *Reduced-out-of-stock F* (2, 94) = .338, p = .038; *Supply chain planning F* (2, 94) = .274, p = .011; *Electronic traceability F* (2, 94) = .489, p = .039; *Organisational learning F* (2, 94) = 4.14, p = .019; *Demand forecast F* (2, 94) = 9.83, p = .000; *Organisation knowledge accumulation F* (2, 94) = .532, p = .017; *Employees' RFID-related skills and proficiency F* (2, 94) = .145, p = .024.

5.10.1.2 PULT

Table 5.32 gives information about each PULT group, including the means, standard errors, and standard deviations.

Table 5.33 shows the results of the analysis of variance between and within the four PULT groups. The statistical significance of the differences between each pair of groups is provided in Table 5.33, which gives the results of the post-hoc tests.

For variables with a significant p value, the post-hoc tests in Table 5.33 indicates exactly where the differences amongst the four PULT groups occur. In the column labelled ***Mean Difference***, the values with asterisks (*) indicate that there is a statistically significant difference between the four PULT groups being compared. The exact significance value is indicated in the column labelled ***Sig.***

A one-way between groups analysis of variance was conducted to explore the impact of Product Unit Level of Tagging (PULT) on benefits derived from RFID adoption. Four RFID tagging levels are considered – Pallet-level, Case-level, Container-level and Item-level. There was a statistically significant difference at the $p < .05$ level in mean scores of the following

RFID benefits between at least two of the four levels of tagging: *Net profit F (3, 93) = 9.300, p = .000*; *Cost reductions F* (3, 93) = 7.165, p = .000; *Labour savings F* (3, 93) = 1.742, p = .014; *Reduction of inventory F* (3, 93) = .938, p = .006; *Visibility F* (3, 93) = 1.644, p = .050; *Supply chain planning F* (3, 93) = .974, p = .009; *Data integrity F* (3, 93) = 5.156, p = .002; *Electronic traceability F* (3, 93) = 2.592, p = .037; *Transport efficiency F (3, 93) = 3.388, p = .021; Organisational learning F (3, 93) = 6.444, p = .001; Staff motivation F (3, 93) = 3.480, p = .019; Demand forecast F (3, 93) = 4.292, p = .007.*

5.10.1.3 Organisational pedigree in RFID

Table 5.34 gives information about the different levels of organisational pedigree in RFID, including the number in each group, the means, standard errors, and standard deviations.

Table 5.35 shows the results of the analysis of variance between and within the four levels of organisational pedigree in RFID. The table, which gives the results of the post-hoc tests, shows the statistical significance of the differences between each pair of levels of organisational pedigree in RFID.

A one-way between groups analysis of variance was conducted to explore the impact of organisational pedigree in RFID on benefits derived from RFID adoption. Four levels of organisational pedigree in RFID are considered – 'Fully conversant with aspects of RFID', 'Understand most of the concepts of RFID', 'Understand the principles of RFID', and 'Little knowledge of RFID principles but the system works'. There was a statistically significant difference at the *p < .05* level in mean scores of the following RFID benefits between atleast two of the four levels of organisational pedigree in RFID: *Cost reduction F (3, 159) = 8.407, p = .032*; *Labour savings F* (3, 159) = 4.536, p = .004; *Supply chain planning F* (3, 159) = 2.723, p = .046; *Business sustainability F* (3, 159) = 5.813, p = .001; *Organisational learning F* (3, 159) = 21.429, p = .000; *Staff motivation F* (3, 159) = 5.198, p = .002; *Organisational knowledge accumulation F* (3, 159) = 6.894, p = .000; *Employee satisfaction F* (3, 159) = 4.025, p = .009.

5.10.2 Discussion: One-way ANOVA

From the results of the structural equation models, the relationship of each factor of the independent variables (RFID implementation stage, PULT, organisational pedigree in RFID) with the dependent variable (RFID benefits) were determined. The relationships observed were as follows:

5.10.2.1 RFID implementation stage

Table 5.36 shows that RFID implementation stage has a statistically significant relationship with all of the 4 categories of RFID benefits. From the results of the one-way ANOVA, it can be seen that certain RFID benefits derived (across the four BSC categories investigated) are influenced by the stage of RFID implementation within the organisation.

Table 5.36: Hypotheses on the impact of RFID implementation stage on RFID benefits

Category	Hypothesis	Decision
Financial measures	H16: Higher implementation stage of an RFID system has a significant positive influence on the benefits derivable from RFID implementation	Accept
Internal processes		
Corporate measures		
Learning & growth		

The findings suggest that benefits accrue the most when RFID is fully implemented in the organisation, as opposed to partial or pilot implementation. This is likely because maximum synergy is achieved throughout the organisation. Also, benefits recorded when RFID is deployed as a pilot project outweigh benefits reaped when RFID is partially implemented. As Turban et al. (2002) reports, pilot projects within organisations are usually implemented within a limited boundary i.e. one department, location; while partial implementation usually takes place in phases, where the organisation gradually adopts the new technology in different phases, per module or sub-system. Due to the limited boundary of pilot projects, they are less sophisticated, experience less disruptions, and are often easier to manage. This explains why deploying RFID at the pilot stage reaps more benefits then when partially implemented within the organisation. Additionally, when RFID is partially implemented within the organisation, it is often alongside an already existing system, thereby making disruptions more likely.

5.10.2.2 PULT

Table 5.37 shows that PULT has a statistically significant relationship with all of the 4 categories of RFID benefits. From the results of the one-way ANOVA, it can be seen that certain RFID benefits derived (across the four BSC categories investigated) are influenced by the product unit level of tagging.

Table 5.37: Hypotheses on the impact of PULT on RFID benefits		
Category	**Hypothesis**	**Decision**
Financial measures Internal processes Corporate measures Learning & growth	H17: Lower Product Unit Level of Tagging (PULT) has a significant positive influence on the benefits derivable from RFID implementation	Accept

Generally speaking, it can be inferred from the results that the lower the tagging level, the greater the benefits derived. The findings show that implementing RFID at the item-level accrues the most benefits as compared to the case, pallet, or container levels. However, this largely depends on the industrial or business case application of the technology. In industries/applications like retail where numerous items need to be tracked, item-level tagging delivers more value than tagging cases, pallets or containers. This is because RFID offers an automated and fast way to count, track, and manage items, so the more items tagged, the more benefits accrued. However, in some industrial or business case applications, tracking multiple items is not necessary. For instance, in the automotive industry it will be more beneficial to tag parts bins rather than the parts themselves because the parts remain within the bins until the assembly/installation phase. In such cases, extra investment to tag individual parts might not yet greater benefits.

5.10.2.3 Organisational pedigree in RFID

Table 5.38 shows that PULT has a statistically significant relationship with all of the 4 categories of RFID benefits. From the results of the one-way ANOVA, it can be seen that certain RFID benefits derived (across the four BSC categories investigated) are influenced by the organisations internal capacity or knowledge of RFID.

Table 5.38: Hypotheses on the impact of organisational pedigree on RFID benefits		
Category	**Hypothesis**	**Decision**
Financial measures Internal processes Corporate measures Learning & growth	H18: An organisation's internal capacity/pedigree for implementing the technology has a significant positive influence on the benefits derivable from RFID	Accept

The findings suggest that the greater the organisation's pedigree/knowledge in RFID, the greater the benefits derived. Generally speaking, organisations with employees that are fully conversant in RFID derive more benefits from implementing the technology. This highlights the importance of training to RFID implementation success and benefits. Deploying an RFID system usually requires process change. Training users/employees and following up to ensure the new process is adhered to and that the technology is being used correctly and effectively is very important. However, it is not necessary for every individual within the organisation to become an RFID expert. Usually, there is a dedicated team that deploys and supports the system, handles training, attends to queries, manages upgrades and so on. This is usually adequate.

CHAPTER 6 – CASE STUDIES

6.1 Introduction

This chapter presents four case studies, all from organisations that have adopted RFID technology. The four organisations were chosen from the retail, manufacturing, healthcare, and logistics sectors, with the aim of giving a representative spread across a broad spectrum of industrial supply chains.

Case study is a common methodology adopted in operations management research, and is primarily used for theory building or as a follow-up technique for results validation. When used for theory building, it is adopted in the early phase of the research process, particularly in poorly studied fields, where prior studies are not available to guide subsequent studies. When case study is used as a follow up technique to validate results, it is essential that the context is properly defined, and that it is integrated into the overall research methodology. Rather than viewing and using methodologies as single entities that are mutually exclusive, researchers advocate that the synergy within different methodologies be exploited. This idea has been regarded as methodological fit or triangulation (Edmondson and McManus, 2007). Triangulation enables quantitative research like surveys and qualitative research like case studies to be seen as two ends of a continuum rather than as a mutually exclusive set of approaches. Accordingly, this research integrates both methodologies in order to utilise the strengths of each and to overcome their weaknesses; thus, improving the quality and validity of the findings.

Data collection methods in case study research include in-depth structured, semi-structured or unstructured interviews. In order to validate the results of the exploratory survey by questionnaire carried out in Chapter 5, studies of four cases were conducted, through a more detailed qualitative study of selected organisations.

6.2 Case study protocol

In this thesis, the case studies conducted provide the context regarding the findings that organisational and technological characteristics have an impact on the adoption, implementation, and benefits of RFID technology in organisations. All the organisations that took part in the case study were notified of the topic to be discussed well beforehand.

Additionally, they were informed that the method of data collection would be teleconference interviews and/or documentation review. In cases where interviews are conducted, the need for recording of the interviews for subsequent transcribing was also highlighted. A copy of the issues to be discussed, the estimated length of the interview, and the type of information to be solicited was communicated to the organisations prior to conducting the case studies. Finally, the responding organisations were assured of strict confidentiality adherence in relation to handling and reporting information obtained from them. Generally, suggestions on case study research best practices and guidelines from Yin (2003) were incorporated in the case study. The interview questions are shown in Appendix E.

6.2.1 Sample and organisation selection

The selection of a representative sample for case study research could be either based on random sampling techniques (Pagell, 2004) or based on purposeful or opportunistic samples (Voss and Frolich, 2002). In this research, respondents to the case study were solicited using the survey instrument (see Appendix A). Respondents were asked to indicate their interest in participating in a case study at the end of the questionnaire, by ticking a box for 'yes' or leaving it unticked for 'no'. Those respondents that ticked the box were informed of the issues to be covered in the case study. This was done by sending them a case study protocol (see appendix 3). Voss and Frolich (2002) recommend developing and sending (to respondents) a protocol at the start of a case study, detailing the research framework and the research questions. The case studies were set up across different business sectors.

6.2.2 Data Collection procedure and analysis in the case studies

Semi-structured interviews and documentation review were the two sources of information used in the case study. Interviews were conducted with top, middle, and lower management within the participating organisations. A cross section of supply chain managers, IT directors, operations managers, and technical specialists were interviewed, because they were in the best positions to provide the information solicited. Data collected was used to analyse the themes of the research case studies, and in validating the results obtained from the questionnaire survey in Chapter 5.

6.3 Business environment and the industrial context of the case studies

The four organisations used for the case study consist of one from the logistics industry, one from the retail industry, one from the manufacturing industry, and one from the healthcare industry.

6.3.1 UK Logistics Industry

The UK logistics industry employs around 2.2 million people in over 196,000 companies, and is worth £74.45billion (ONS, 2013). In 2014, the UK was ranked 4th in the World's top logistics performers. Freight logistics companies either manage their own distribution system or manage it on behalf of another as 'third-party logistics' (3PL) or 'hauliers'. Over 60% of UK freight is carried as 3PL.

The key to modern logistics management is the automatic identification of products, containers, vehicles and staff. In the transportation and logistics industry, the costs of inefficiencies caused by lack of visibility are considerable. RFID improves visibility across the supply chain by tackling shrinkage, inaccuracies and inefficient order fulfilment. RFID improves counting and tracking processes, shipping, receiving, and order accuracy; order processing; and reduces labour costs. Figure 6.1 shows some applications of RFID within the logistics industry.

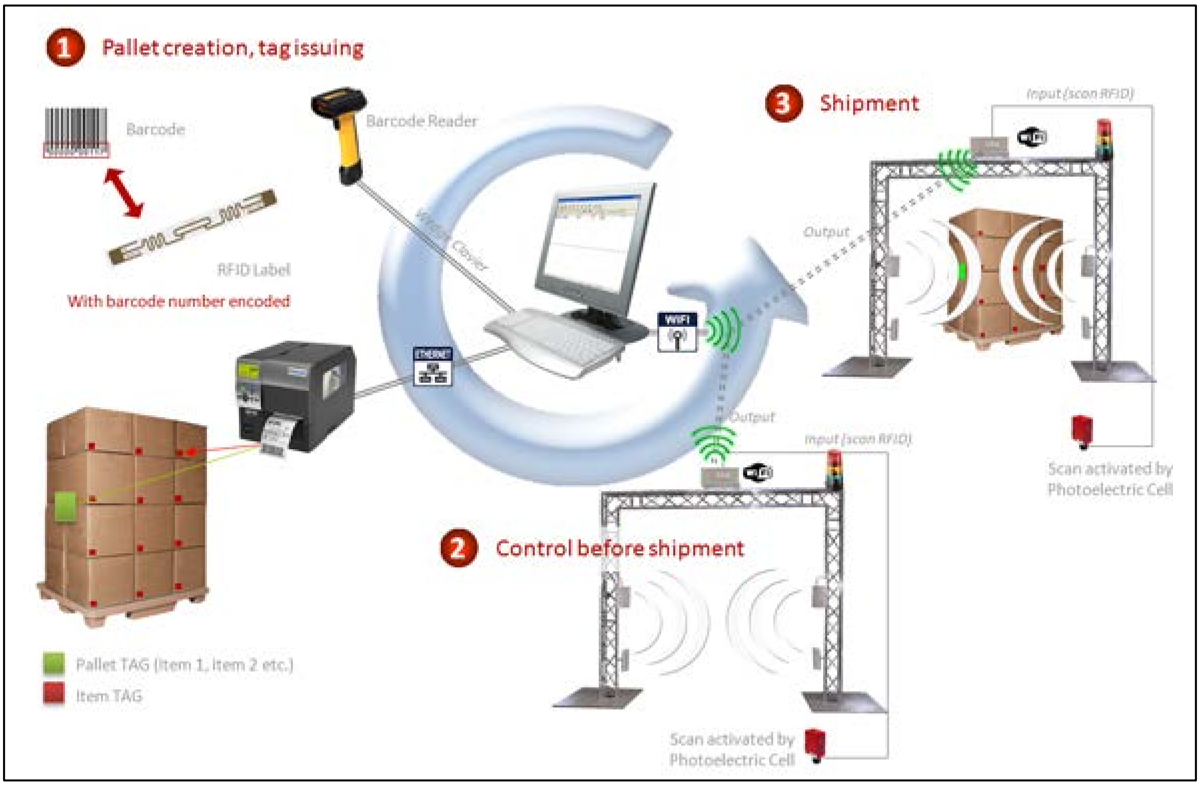


Figure 6.1. Some applications of RFID in the logistics industry (*Source: Stid.com*)

6.3.2 UK Retail Industry

The UK retail sector is a large and active industrial sector within the UK economy. It generates 5% of the Gross Domestic Product of the UK. In 2014, the total value of UK retail sales were £333 billion. In the retail sector, RFID has been considered an appropriate technology to alleviate the challenges of inventory management, supply and demand synchronization, and out-of-stocks. Although the adoption of RFID within this sector has been slow in the past decade, we are now seeing an ever increasing number of retailers and brands, in the UK and globally, adopting RFID for item-level tagging, providing the platform to generate multichannel growth, and offering consumers a seamless shopping experience (ONS, Eurostat, Retail Economics analysis). Figure 6.2 outlines some uses of RFID technology in simplifying retail processes.

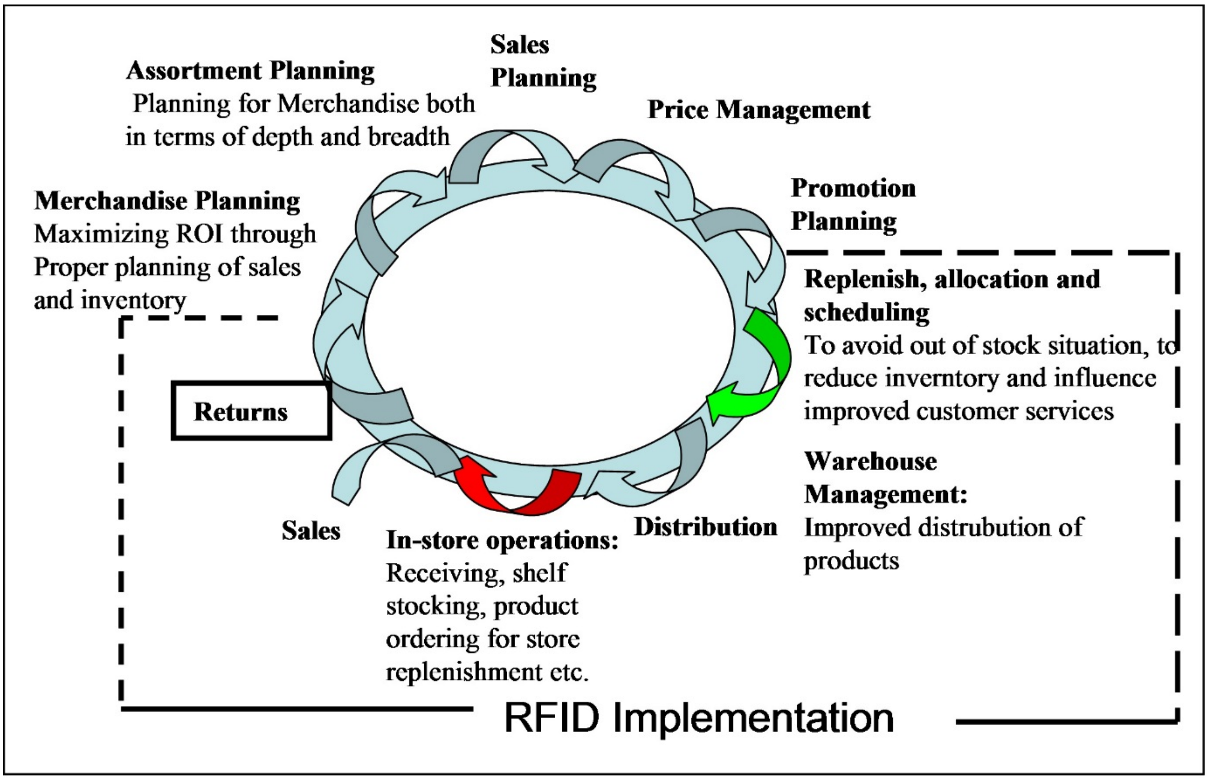


Figure 6.2. Uses of RFID technology in retailing processes (*Source: Stid.com*)

6.3.3 UK Manufacturing Industry

Manufacturing contributes 11% of UK Gross Value Added (GVA); 54% of UK exports; and directly employs 2.6 million people. Overall, the UK industrial sector has increased by 1.4% a year since 1948, according to the 2015 report from the Office for National Statistics (ONS, 2015).

In the manufacturing sector, RFID technology can provide high-quality, reliable product tracking and tracing across the supply chain; redefine production standards with improved execution, efficiency, and product quality; and automate processes to control and monitor operations and refine schedules, directly impacting their efficiency gains and improving production. Figure 6.3 outlines some the application areas (numbered 1-9) of RFID in manufacturing settings.

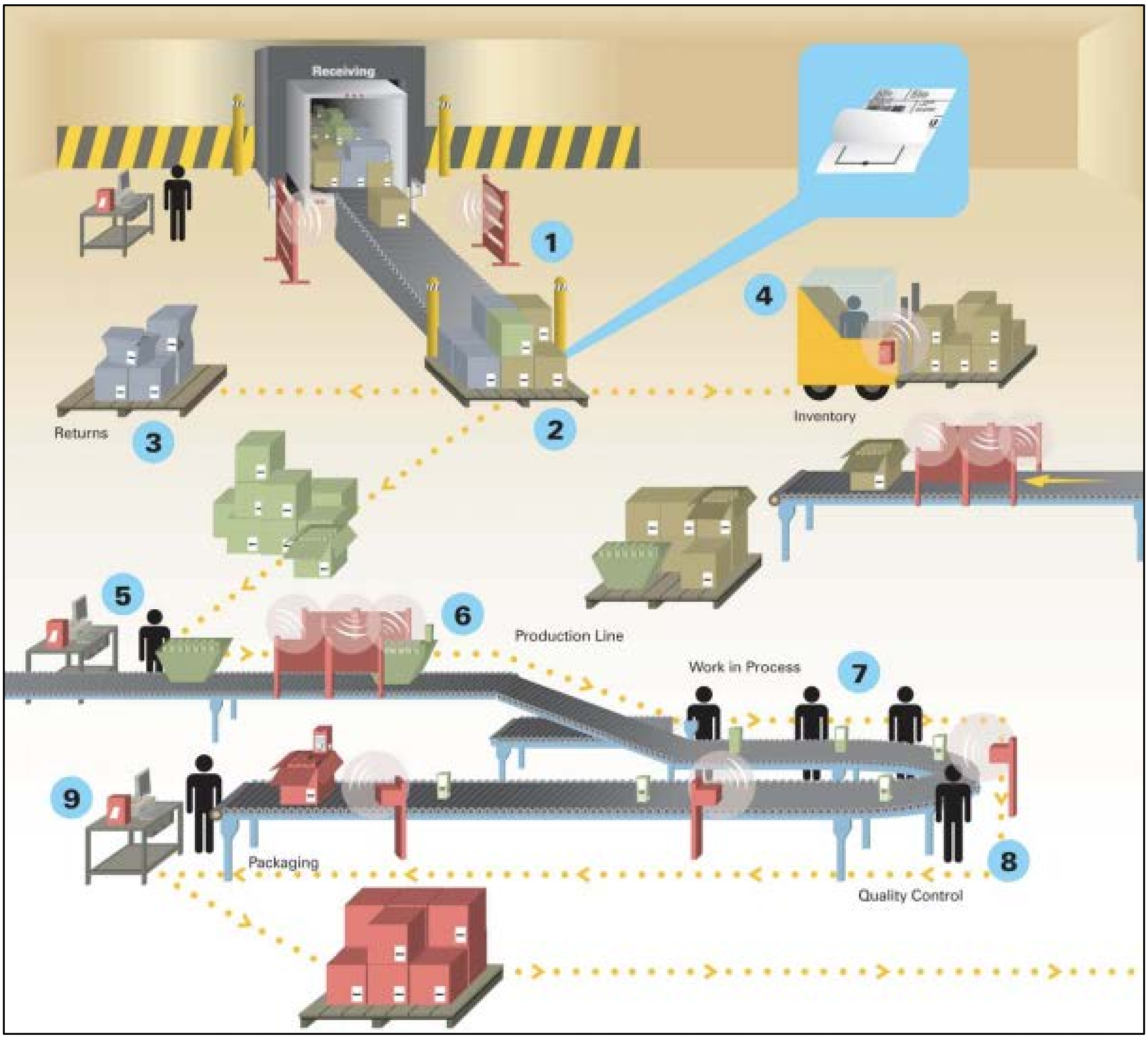


Figure 6.3. RFID application areas in manufacturing (*Source: Abr.com*)

6.3.4 UK Healthcare Industry

The UK Healthcare industry operates a decentralized system, with England, Northern Ireland, Scotland and Wales each having their own systems of publicly funded healthcare. Most healthcare in England is provided by the National Health Service (NHS), which is funded by the Department of Health (£110 billion in 2013-14).

In the healthcare sector, RFID has been used to reduce costs, improve operational efficiency, and ensure safety; enabling healthcare providers and administrators to make the most effective clinical and business decisions. A growing use of RFID in healthcare is for asset tracking (as shown in Figure in 6.4).

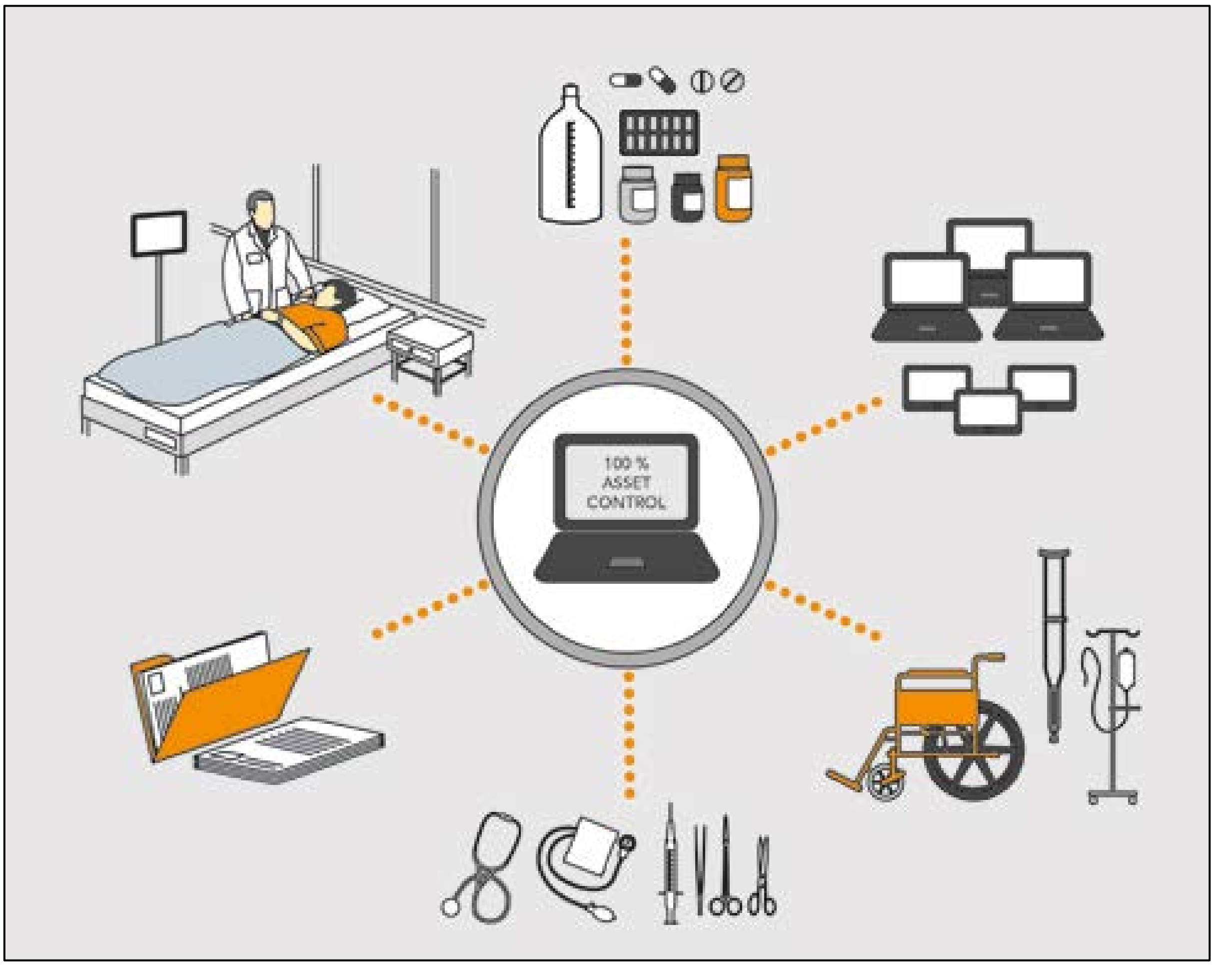


Figure 6.4. RFID application areas in healthcare (*Source: Flickr.com)*

6.4 Case studies

6.4.1 Case study organisation 1 (CSO-1)

6.4.1.1 Introduction

CSO-1 is a clothing and accessories manufacturer and retailer founded in 1963 and based in Arteixo, Galicia, Spain. It started life in a small workshop, making mostly women's and children clothing but today has over 6,900 stores worldwide. Through its history, the organisation has evolved to become the reputable business it is today, reaching many notable milestones along its journey. The organisation adopts a customer-oriented business model focussing on listening closely to its customers' fashion desires and appetites, and reacting quickly to the latest fashion trends.

"*CSO-1 is always striving to meet the needs of its customers at the same time as helping to inform their ideas, trends and tastes. The idea is to share responsible passion for fashion across a broad spectrum of people, cultures and ages*" – Press Dossier

CSO-1's customer focus underpins an organisational structure that encompasses all stages of the fashion value chain (design, manufacturing, distribution and sale in proprietary stores). Their customer oriented model is the driving force behind the integration of many sustainable and environmental policies used throughout the organisation's supply chain today.

"The organisation's goal is to offer products of the highest quality to all its customers while simultaneously striving to develop a sustainable business" – Press Dossier

CSO-1 has identified a set of stringent business principles. In consideration of the its goal of offering products of the highest quality to all its customers, a Code of Conduct and Responsible Practices framework was developed to stipulate the binding principles that apply in each and every area of the organisation's operations, both within the company and with its partners. Thus the organisation's processes are inspired by and stem from its Code of Conduct. With this as a basis, stringent product health and safety, labour, and environmental sustainability standards were enshrined by the Code of Conduct for Manufacturers and Suppliers. These form the foundations of the organisation's environmental and sustainable strategy, which comprise a key part of the group's effort to make products that will meet consumer expectations. This pledge means continuous open lines of communication with all of the organisation‘s stakeholders are necessary to provide access to sufficient, clear, comprehensive, and up to date information to enable stakeholders to evaluate the company's business practices. Figure 6.5 is an illustration of the operational business model of CSO-1.

The success stemming from adopting this strong customer orientation led to the launch of the first CSO-1 retail store in 1975, in the coastal town of A Coruña in the northwest of Spain. Today, CSO-1 has over 2,000 stores strategically located in leading cities across 88 countries. CSO-1's designers and customers are inextricably linked. Specialist teams receive constant feedback on the decisions its customers are making at every CSO-1 store. This feedback inspires CSO-1's creative team which is made up of over 200 professionals.

With its logistics headquarters in Spain, an RFID-enabled delivery system has been implemented to deliver new products to all of the CSO-1 stores twice weekly, in order to meet consumer demand. In addition, since 2008, RFID systems have been piloted and fully implemented in a number of CSO-1 UK warehouses and stores.

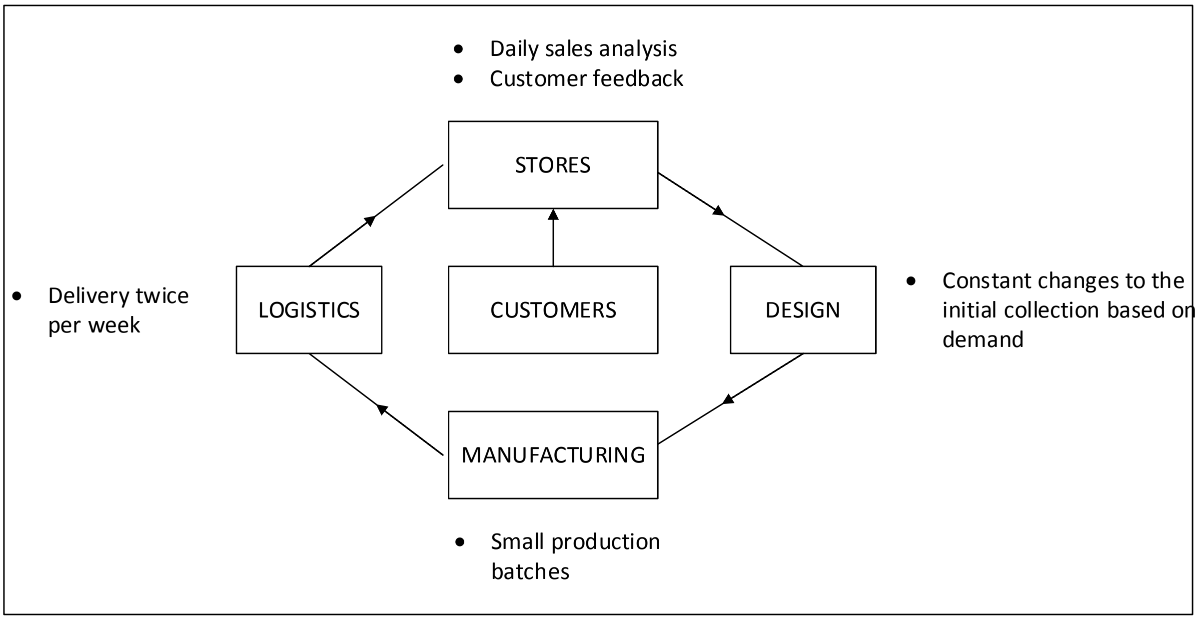


Figure 6.5: Business model of CSO-1

6.4.1.2 CSO-1 RFID System

CSO-1 began working on developing an RFID system in year 2007 and started implementing the technology in their CSO-1 retail division and distribution centers in 2012. Today, the system is being used in more than 800 CSO-1 stores in 22 countries, as well as in three CSO-1 distribution centres. The system includes RFID/acoustic magnetic tags, readers and tag detachers, mobile handheld readers that collect near-real-time data on inventory and application software and reporting that connect collected data with CSO-1's inventory system. The solution also includes RFID tag encoders in distribution centers (DCs).

CSO-1 is using Tyco Retail's new Sensormatic RFID/acoustic magnetic Dual Technology tags to deliver the security of an acoustic magnetic anti-theft solution together with the inventory visibility of an electronic product code-based RFID. The tags, empty of information save a unique serial number, are attached to products at the manufacturer's facilities. When those source-tagged products come into the DCs, they pass through the Checkpoint RFID encoding system, which includes hardware set up in a tunnel-like configuration. As packaged items pass through the tunnels, Checkpoint's encoding software assigns each garment a unique item number, coding the information CSO-1 wants tracked into the reusable and recyclable Tyco Dual Technology tags.

CSO-1 store associates can read those codes through any iOS device. When a tagged item is sold, the item information is read by Tyco's Smart Tag Detachers at the point of sale, giving CSO-1 real-time item data that makes quick replenishment possible. The detachers simultaneously deactivate the theft alarm stored on a chip inside the tag and delete the information embedded in the chip. If an item is not paid for and deactivated, it sounds an alert when someone tries to exit the store. To date, the tags are deployed on 90 percent of the items on display in CSO-1 stores. For fiscal year 2015, CSO-1 tagged around 500 million items. The tags enable individual identification of every garment; provide real-time knowledge of where every item's physical whereabouts throughout the entire distribution-to-sale process; and deliver precision, speed and enhanced in-store customer service (as shown in Figure 6.6).

At CSO-1's annual general meeting in July, CSO-1 Chairman and CEO (name withheld) described the simultaneous implementation and phased-in deployments of the RFID Inventory Intelligence and Loss Prevention solutions as "one of the most significant changes ever in how the organisation's stores operate. He said the organisation expects the system to be active in a total of 1,000 CSO-1 stores in 31 countries by the end of year 2015. He estimated the rollout to all CSO-1 stores will be complete by the end of 2016.

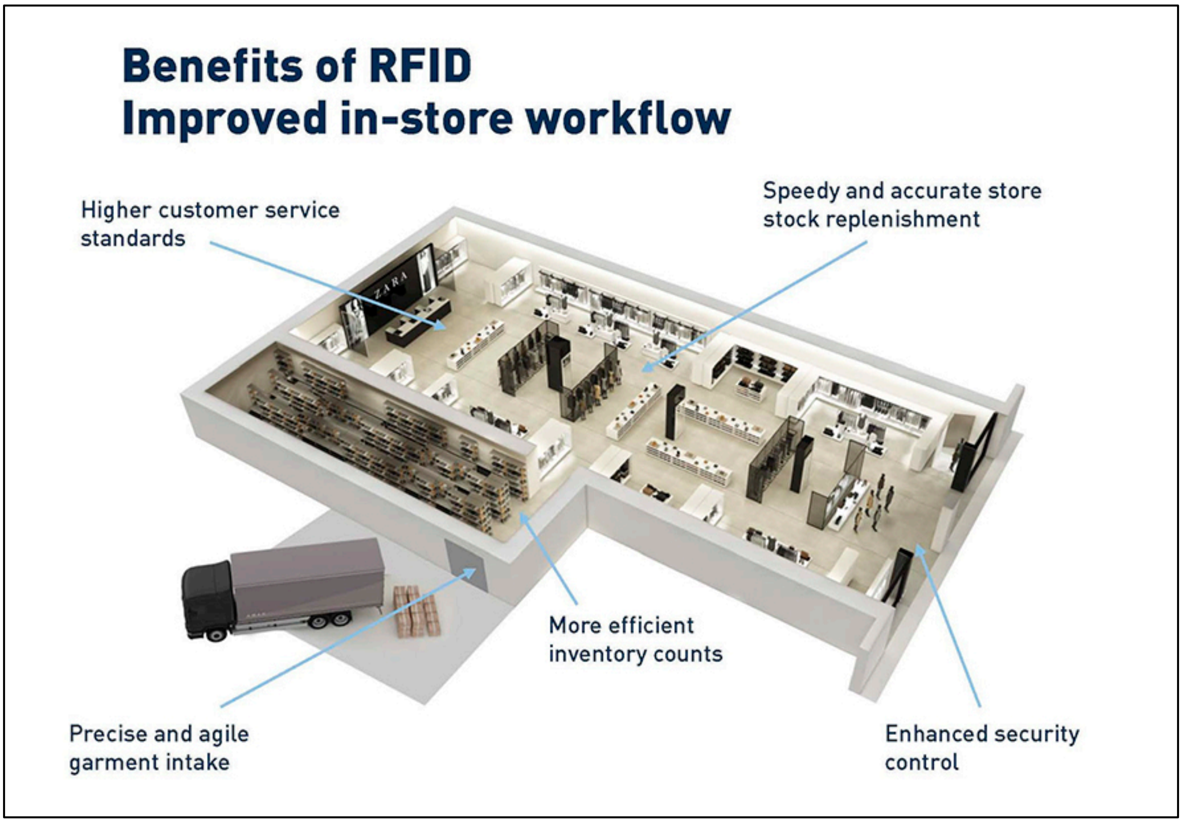


Figure 6.6: Improvements in CSO-1 store workflow attributable to RFID (*Source: CSO-1 RFID implementation report*)

6.4.2 Case study organisation 2 (CSO-2)

6.4.2.1 Introduction

Established in 1974, CSO-2 is a growing international freight forwarding, relocation and project logistics management company delivering cost-effective solutions throughout Europe, Asia, and the Middle East. The company develops comprehensive freight forwarding, project logistics and relocation service plans tailored to meet specific requirements of customers.

CSO-2's business model comprises learning customers' exact objectives with regards to their internal and external requirements, thus providing quality services more consistently than competing service providers in the market. Supported by numerous offices and associates worldwide, CSO-2 employs a team of professionals that efficiently monitor and manage every transaction handled by the company. With a service network across 65 countries, CSO-2 aims to be the most reliable logistics services company in the market with an inspired, people-driven and dedicated approach to serving customers.

"Our tried and proven multimodal transportation routes in Europe ensure international reach whatever your cargo and timeframe is. As the preferred supplier and the first point of contact for various companies aiming to increase supply chain efficiency, we are very proud of our reputation and always strive to maintain it." – CSO-2 Company Profile, 2015

Since establishment in 1974, CSO-2 has earned its mark as a reputable, reliable, and successful independent logistics services company in Europe, Asia and the Middle East. Successful freight forwarding, relocation and project logistics management services in challenging markets like the Middle East require expertise, inside knowledge, and reputation businesses can trust. This is why CSO-2 is the preferred choice of many Fortune 500 companies in the region.

"Our in-depth knowledge of Europe, Asia, and Middle East, coupled with our regional and international service network makes CSO-2 a leading service provider in the regions it covers. CSO-2 provides "one-stop-solution" to meet all of your logistics requirements. Whether you are looking to relocate household goods across the region or move an offshore drilling platform across the seas, CSO-2 has the level of service, expertise and experience to make it happen. You will get personalized service at every level with CSO-2 because we are truly

independent, make our own decisions and specialize in our market." - CSO-2 Company Profile, 2015

CSO-2's primary objectives are:

- To promote Total Quality Management and to maintain its success through steady investment in service expansions and innovations
- To promote health, safety and environmental safety throughout our organization
- To develop and maintain a first-class infrastructure to ensure employee satisfaction, which drives customer loyalty leading to sustained profit growth and creating improved company value
- To exceed the expectations of our customers through total quality management and providing cost effective and reliable solutions to help our customers to realize their goals

6.4.2.2 CSO-2 RFID system

In 2009, CSO-2 deployed an RFID system to help manage its growing cargo. The system was deployed to improve inventory and warehouse management and transportation processes such as shipping and receiving automation. The system operates passive UHF tags and different collections of active tags operating at a range of frequencies (from 270MHz to 2.0 GHz).

When cargo arrives at CSO-2's warehouse, the cases of individual items are tagged with the UHF passive transponders and the pallets of high value goods are tagged with active transponders. This enables the monitoring of the cargo within the warehouse. All transponders are encoded with a unique ID that is recognized and processed by the middleware system and stored in a database used by CSO-2 to maintain an inventory of the tagged items.

When cargo is to be transported, the pallets are loaded into the trucks. Readers installed on the warehouse entrance/exit read the active tags from the pallet. The middleware system is able to compare and match the appropriate outbound order and register the cargo as being in transit. For cargo that does not match the outbound order, an alarm sets off and a member of staff is notified. To track cargo in transit, CSO-2 installed mobile RFID readers inside trucking containers. The readers communicate with the active tags on the pallets of cargo and notify CSO-2 staff when a pallet is removed from the interrogation zone within the truck.

6.4.3 Case study organisation 3 (CSO-3)

6.4.3.1 Introduction

CSO-3 was founded in 1970. The company's core business is the manufacture of chemicals for water treatment, and the supply of commodity chemicals to the Steel manufacturing, Food and Paper making Industries. CSO-3 also operate purpose built grinding, milling, filtration, and spray drying plants, all of which are made available to customers seeking to process chemical materials on a short or long term basis.

CSO-3 has grown over the past 40 years from a company with just one vehicle to now operating six manufacturing sites in the UK and one in the USA; employing over 400 staff; and handling over a million tonnes of materials each year. CSO-3 delivers over 300,000 tonnes of products to customers in the detergent, paper, water treatment and chemical industries worldwide. Handling hazardous materials has meant that CSO-3 has needed to manage its operations in line with standards such as the UK's Pollution Prevention and Control Regulations and the Control of Major Accident Hazard Regulations.

CSO-3's West Thurrock site was one of the first to be granted a UK Pollution Prevention and Control permit. CSO-3 have traditionally supplied chemicals in bulk using the company's own fleet of tanker vehicles but have recently entered the packaged chemicals market delivering product in Intermediate Bulk Containers (IBCs), pump over pressure bins and other small containers. IBCs have a metal frame with a re-usable tank able to contain up to 1000 litres of product, CSO-3 has over 3000 IBCs representing an asset value over £400,000. IBCs are delivered to customer premises where the product will be consumed and then the IBC collected by the company for reuse.

CSO-3's business model is built on maximizing customer satisfaction through timely and quality products and services delivery. The company's definition of quality is products/services that are delivered when they're needed, in a safe and controlled manner, to specification, and at the right cost. CSO-3 operates a quality system that has been designed to meet the requirements of ISO 9001, and customer management systems. The company has maintained third certification for its quality management system since 1994. CSO-3's attention to product quality and high level of service has helped establish the company as a reliable and well-respected supplier. For example, CSO commands a high profile in the water utility Industry, as the one company in the UK with the ability to offer the greatest range of coagulants including both Aluminium and Iron Salts.

Shipping of hazardous chemicals has to be managed closely to ensure that both chemicals and their containers can be effectively tracked to minimize any loss of the assets and monitor all legal container compliance requirements. The IBCs and pump over pressure bins used by CSO-3 to deliver their products represent valuable assets which the company needs to monitor closely. Consequently, CSO-3 appreciated that electronic tagging of IBCs could provide them with the traceability they needed and could help to reduce the costs of lost and damaged IBCs. CSO-3 chose CoreRFID to work with them on the selection and supply of the correct RFID technology and develop a tailored, user friendly solution for their asset management needs.

6.4.3.2 CSO-3 RFID system

The primary purpose of CSO-3 developing a radio frequency identification solution was to track the location and condition of its reusable containers leaving its facilities or those returned by customers. The RFID system was developed with the objective of improving efficiency and ensuring that damaged or out-of-date IBCs are not used to ship chemicals.

The IBCs need to be tracked into and out of company premises and monitored to know where the assets are located at any time, how long the assets have been at customer premises, record any damage assets on return and monitor IBCs service status and service life. Manual tracking of IBCs, logging delivery points and checking stocks regularly, was not effective and was extremely time consuming. The packaged chemicals division is a fast growing area of the business and CSO-3 wanted to implement a tracking and monitoring solution that could grow with the development of the business and offer maximum control over these moving assets.

The RFID system used by CSO-3 to track their IBCs uses UHF RFID tags. The tags can be read from a distance of up to 3 metres. CoreRFID developed (and now host and operate) an application to track IBCs to the location where they were last checked and to control IBCs that can only be re-used a specified number of times.

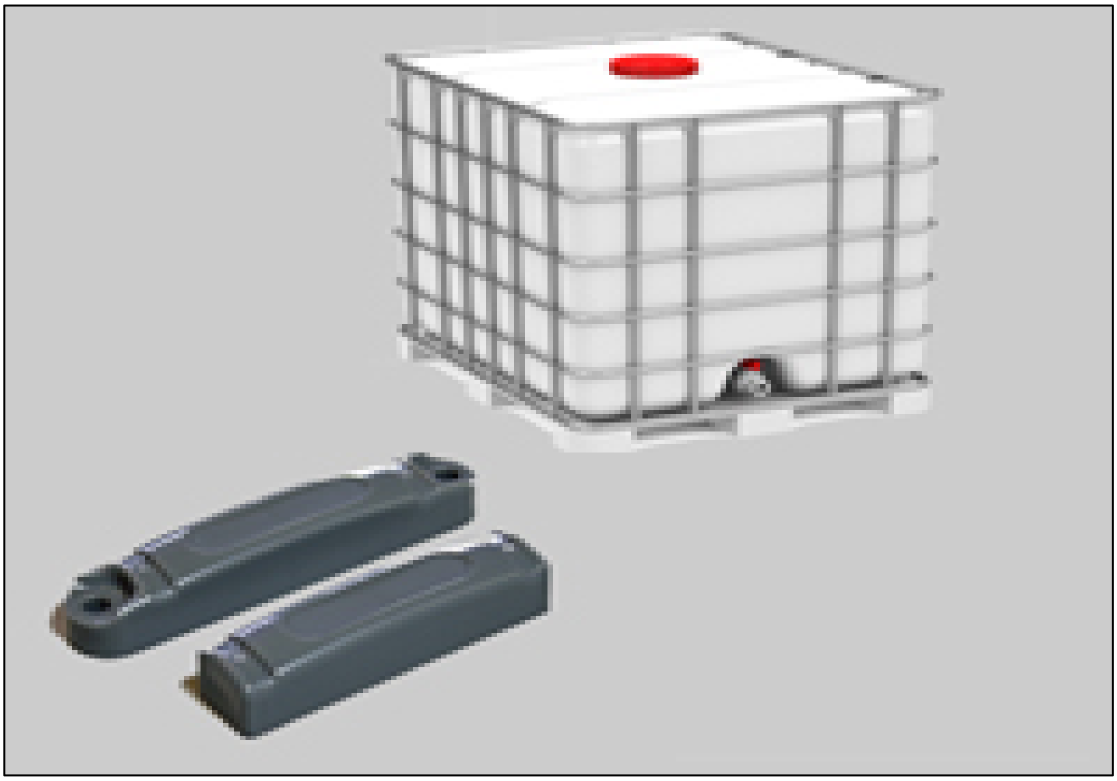


Figure 6.7: Intermediate Bulk Container and the RFID tags used to track it (*Source: CSO-2 RFID system report*)

The tags were selected for their ruggedness and suitability for use in an industrial logistics application as well as providing reading characteristics that allowed them to be easily detected and read. The selected tag was designed for use in a wide temperature range. It has a small footprint to allow it to be attached to the metal frame carriers of the IBCs. The device used to read tags is a compact, robust, handheld computer which is a Windows Mobile compatible computer that is able to read RFID tags and bar-code labels. The handheld has a camera and a wide range of communication options, CoreRFID has found it a flexible and reliable option in many logistics and asset related applications.

A software application running on an RFID reader is used to record in and out IBC movements from company premises and to carry out internal and external stock-takes. If an IBC is seen to be damaged on return, a photograph can be taken using the ATiD AB700's 3 mega-pixel camera and can be linked with the IBC check-in record. The application used is one of a number of similar Windows Mobile software solutions developed by CoreRFID. The application focus is on simplicity of operation with a minimum of data entry and menu choices needed to achieve the required result.

At the end of each day, or whenever needed, data can be uploaded to a database operated by CoreRFID on behalf of CSO-3. Access to this database provides CSO-3 with an easy way to determine the location of IBCs their usage history. They can also identify IBCs that are approaching the end of their operational life and data from the system can be easily downloaded for additional analysis.

6.4.4 Case study organisation 4 (CSO-4)

6.4.4.1 Introduction

CSO-4 is one of the largest Hospital Trusts in England. CSO-4 includes four major hospitals in the Midlands and also runs a number of smaller satellite units all around the UK, enabling people to be treated as close to home as possible.

CSO-4 originally developed from a fever hospital and sanatorium in Yardley, which opened in June 1895. After a number of successful mergers, the hospital developed into a Trust. Today, the Trust is a world leader in tackling MRSA and specialises in treating patients suffering from a wide range of illnesses including heart and kidney disease, cancer, HIV and AIDS, as well as respiratory conditions like Cystic Fibrosis. The Trust also has expertise in premature baby care, bone marrow transplants and thoracic surgery.

The Trust is one of top employers in the Midlands, with around 11,000 members of staff. The Trust treats over 1.2 million people each year, with about 25,000 people attending the hospitals’ emergency departments each year.

6.4.4.2 CSO-4 RFID system

CSO-4’s estates department (responsible for managing the trust's hospital buildings, infrastructure and equipment) developed an RFID pilot project at one of its hospitals to locate and manage beds, and to track and trace surgical equipment. In terms of bed tracking, the RFID system tracks both standard and specialized beds, as well as hoists used to lift patients onto and off of them. Once fully deployed in all the hospitals in the Trust, the solution is expected to track approximately 2,000 beds and hoists.

In 2013, the trust's clinical engineering department—which manages mobile medical devices, such as infusion pumps and monitors—deployed an active RFID system provided by Harland Simon. It has attached active 2.4 GHz tags, which use a proprietary air-interface protocol, to each of about 2,000 medical devices, and is currently tracking their locations and movements among different sites within the three hospitals that make up the trust.

The solution, known as RFID Discovery, consists of proprietary readers deployed throughout the hospitals, as well as software deployed on the departments' own servers. When applying a tag to a bed or hoist, hospital personnel first use a PDA with a built-in bar-code scanner to read a bar-coded serial number printed on a label attached to the bed or hoist itself, and then the bar-coded serial number on the front of the RFID tag, which is the same number as the one transmitted by the tag. The tag and bed (or hoist) ID numbers are thereby stored in the Discovery software and forwarded to the facilities-management system. Employees can input the maintenance date for a particular item so that users can be alerted in advance when that object is again due for maintenance or servicing.

Typically, readers capture a tag's ID at a distance up to 20 meters (65.6 feet). As the Discovery software receives data from the readers, it can approximate the location of that bed or hoist and then display that location on a dashboard that includes a map of the facility and an icon representing each tagged hoist or bed. In this way, the hospital staff can utilize the solution to identify where beds and hoists are located when engineers conduct inspections and any necessary maintenance. The software can also be used to determine when there are too many accumulating in one area, or not enough in another.

6.5 Interview Data Collection and Analysis

6.5.1 Introduction

As highlighted in section 6.2.2, semi-structured interviews were conducted with selected personnel, including managers, directors, and technical specialists with the view of assessing the impact of organisational factors on the decision to adopt RFID, RFID implementation processes, and benefits derived from RFID. Results from the case studies seek to validate empirical results obtained in the questionnaire survey in Chapter 5 by obtaining direct views and real-life experiences of RFID adopters. In gathering and analysing valid data from the interviews, this study followed a set of procedures (interview guide) before, during, and after the interviews. The protocol adopted was as follows:

Background
• Interviewer introduced himself, explained the aim of the interview, and briefed the interviewee of the purpose of the research.
Questioning
• Relevant interview questions were devised to help address the research objectives • A list of those questions or key points were outlined, with a plan to work through them methodically. The questions were grouped in themes that followed a logical sequence • Across the different organisations studied, similar questions were asked of the respondents. However, supplementary questions asked differed where appropriate. Supplementary questions were follow-up or probing in nature • Provision was made to easily move back and forth between questions or topic areas, as interviewees may naturally move on to another subject
Recording and Transcription
• The method of recording the responses was proposed. This was either by digital recording or note taking (with the informed consent of the interviewee). In either case the interview process was a flexible one, with the emphasis on the answers given by the interviewee. In cases where the interviewee agreed to be interviewed but decline to be recorded, the interview still went ahead, although the note taking then focused on writing down key points • Once interviews had been completed, transcription of notes/recordings followed

- The names of the participating organisations were withheld and coded as follows: CSO (case study organisation) and attached a number at the end to indicate the order of the case. e.g. CSO-1 means Case Study Organisation 1   - The identities/official positions of the respondents were coded in the following denominations: GM (General Manager), OM (Operations Manager), ITS (IT specialist or consultant), DR (Director), SCM (Supply Chain Manager), OE (Other Employee)
Post-interview reflection
Once the interviews were completed, the interviewer reflected on how it went and assessed whether there was anything that could have been done differently/better
Data analysis
- The researcher browsed through all transcripts, one by one and line by line, reading very carefully and making notes about any first impressions   - The researcher labelled or coded relevant words, sections, sentences, and phrases. Labels were about activities, actions, concepts, differences, processes, opinions or whatever the researcher thought was relevant for the study (this process is sometimes referred to as indexing or coding)   - The researcher subsequently decided which codes were important, to create categories by bringing several codes together, (for instance, words that were often repeated severally or identified as explicit by the interviewee(s); words that surprised the researcher; words that seemed to be relevant or important; words that the researcher has seen or read in a previous articles, reports or publications; words that reminded the researcher of a theory or a concept)   - The researcher decided if there was hierarchy among the categories i.e. whether one category was more important than the other   - The researcher finally writes up the result. The researcher draws diagrams or figures to summarize result

6.5.2 Reflective report on interview process

The four organisations studied provided valuable insights into the impact of organisational factors on RFID adoption decisions, RFID implementation processes, and RFID benefits. After the organisations had indicated their willingness to participate in a case study, the researcher explained to the interviewees his request to conduct an interview and to also secure a suitable date and time. An online link of informed consent forms was sent both before and on the day of the interview. In addition, some of the interviewees also requested for the interview schedule before an interview date could be agreed. Thus, prior to the interview date of each organisation, the researcher sent draft copies of the standardized interview questions to all of the respondents in the organisation. This was done to provide them with an overview of the type of questions they were to be asked.

In addition, all the participating organisations had already provided the researcher with a host of company profile documentation, RFID implementation reports, and other relevant material in advance of the official interview dates. On one occasion, the researcher was requested by the participating organisation to extract some information from the organisations' online resource portal. This was done in order to enable the researcher to ask questions in context of the organisation's operations, industry, and environment, focus on asking relevant questions and prevent duplication of information, and finally ensure that the interviews do not take longer than the indicated 20-25 minutes per interviewee.

The informed consent form was drafted to make sure potential participants were offered adequate information to allow them to decide whether or not they want to take part in the research study. While it was important to ensure that sufficient information was provided, the researcher also considered the need of using non-technical terms and the need to be easily understood by all respondents. The overall interview process was overseen by the researcher.

On the first day of interview, the researcher followed the interview guide by, first of all, introducing the research topic and research questions, and asked the participants if they would be willing to share their thoughts regarding their organisation's decision to adopt RFID, its subsequent implementation, and benefits derived. Even though, most of the participants granted an interview, majority of them insisted on remaining anonymous. In line with the consent forms distributed at the start off the interviews and the research privacy and confidentiality policies, the researcher concealed the identity of the respondents. Some of the respondents also requested that handwritten notes be taken rather than audio recordings. The researcher signified that transcribing by hand may make the interview process longer, to which the respondents offered no objections.

The interview process went on very smoothly and the participants were very free and friendly. They tendered information often beyond the content of the research question. They also responded willingly to follow-up questions, thereby enabling the researcher to collect in-depth and sufficient information on the research subject.

There were no major limitations to the interview process apart from two instances where the respondents were hesitant to provide certain information due to them feeling they are not in the best position to do so, and were cautious of providing potentially wrong or misleading information. In such instances, the respondents referred the researcher to the company reports or suggested contacting superior staff for further information. Overall, the researcher was happy with the quality and depth of case study data collected. All participating organisations and respondents were thanked for their role in the case study.

6.6 Interview Analysis

6.6.1 Research question 1: Drivers and constraints of RFID adoption

There are several significant drivers for industries and governmental institutions to develop and implement RFID solutions within their supply chains. This research had adopted factors from the Technology-Organisation-Environment (TOE) framework and the Diffusion of Innovation (DOI) model and assessed their influence on organisational decision to adopt RFID. The survey results in section 5.5.1 indicated that multiple factors (across all categories of the TOE framework) drive RFID adoption decisions. Perceived RFID benefits, convergence of various international standards and specifications, top management initiative, financial availability, competitive and dominant partner pressure were found to be significant drivers of RFID adoption.

6.6.1.1 Motives for adopting RFID

In the interviews conducted, the respondents were first of all asked of general motives and reasons behind their organisations to adopt RFID solutions. In that regard, OM-1, an Operations Manager in one of the responding organisations stated "*Although we knew RFID could have many applications in a wide range of settings for us, particularly within the supply chain, we however, adopted it for specialised applications. Applications where we were looking to have incremental performance and where a return-on-investment could be achieved ASAP*." Nevertheless, respondents from the other case study organisations highlighted that their adoption of RFID solutions were driven by the desire to either tackle a unique/particular set of challenges, cut costs or losses, or improve on some business processes. These were not necessarily considered to be specialised applications but rather general ones. Accordingly, OM-2 stated that "*Our adoption of RFID was problem-driven; we had clearly identified some pretty general issues within our operations that we needed resolved and had assessed a number of potential technological solutions. RFID presented us with the best outlook for the long term".* Similarly, OE-3 outlined that his organisation's decision to implement RFID solutions was based on perceived benefits of the technology. In his words, "*The top management had already agreed on finding ways to improve the efficiency of our warehouse operations. The choice of RFID was not particularly discussed in-house but was a decision made by top management in collaboration with consultants. An RFID-based inventory management system was put in place in order to keep record of inventory levels and reduce loss of items."*

When asked about what they specifically hoped to achieve by adopting the technology, each respondent gave a unique response. OE-3 stated that "*We adopted RFID to improve our inventory management. I can say that was our motivation. There was a whole lot being lost or misplaced so we needed to have a system that would help us track what's in stock, how much of it was used, how much needs to be replenished, etc*. *We also wanted to make product distribution more efficient*." OM-2 said "*We needed a user friendly tracking solution*. *Due to the sensitivity of our products, we needed to monitor their movements and be able to trace them on-site."* OE-4 stated *"As one of the largest hospital trusts in England, we have a vast amount of assets that need to be tracked and monitored efficiently. You are talking thousands of beds, hoists, medical devices such as pumps, monitors, and surgical equipment. We needed an efficient system to help us track and monitor available beds, allocate these medical devices, and so on. We also wanted to achieve maximum utilization of beds and equipment."* Lastly, OM-1 stated "*CSO-2 decided to add RFID-based systems to its operations so it could maintain an inventory on the cargo it stores and transports for its clients. At a glance, the system was developed for inventory and warehouse management, shipping and receiving automation. Additionally, the system was developed to provide a higher level of control and security for cargo*."

These responses allowed the researcher to establish the business context in which these organisations decided to adopt RFID solutions, thus, helping to ask appropriate follow up questions. The first trend discovered from the responses was that organisations adopt RFID for a variety of reasons.

6.6.1.2 Key drivers of RFID adoption

As indicated by the survey results and the literature review, the decision on RFID adoption is influenced by technological factors related to the development of the technology, costs and benefits of implementing the technology, organisational factors such as firm size, knowledge and readiness, and environmental factors related to external pressure and support. Accordingly, multiple drivers and constraints from the technology, organisation, and environment categories were discussed during the interviews.

Under the technology category, the main drivers discussed were "Availability of IT infrastructure", "Perceived RFID benefits", and "Perceived RFID standards convergence". Although the respondents generally agreed that all those factors played some role in their decision to adopt RFID, it became clear from the interview responses that "perceived RFID benefits" was the strongest driver of adoption. This is because all the respondents explained that the potential of deriving benefits from RFID led their organisations towards adopting the technology. This is consistent with our survey results, where "perceived RFID benefits" was also found to be the strongest driver of RFID adoption. From the interview responses, it was further observed that RFID adoption was either targeted at

(i) Solving pre-existing problems or challenges – For example, OE-3 stated "*We had already identified our problem area so our outlook was firmly fixed on tackling those challenges in managing our inventory management. So you can say that our eyes were fixed on the prize.*"

(ii) Providing a general solution/benefit – For example, SCM-2 stated that "*The potential benefit of getting a full asset management solution which would improve product accountability and overall management of our container fleet*." Similarly, OE-4 stated "*There is mounting pressure on our budgets and the desire for us to efficiently use available resources is high. Therefore, we considered RFID as an innovative way to improve our operational efficiency.*" Lastly, SCM-1 stated that "*The main driver was the desire to achieve greater operational efficiency and*

> *ensure that we have thorough visibility of the cargo we transport for our clients. We handle a vast amount of cargo types, going through different transportation methods. Therefore, knowing the location of inventory within the warehouse, within transport containers, at any one time is very important*."

Under the organisation category, the main drivers discussed were "Top management initiative", "Financial readiness/affordability", "Organisational technical capability", and "Global expansion". The respondents generally agreed to these factors playing a role in their adoption of RFID, but highlighted the key ones that played the strongest role. Accordingly, SCM-1 stated that "*Most of the factors you listed played some role. In particular, knowing that we have the capacity, financially and technically, to buy and run new IT systems and innovations helped us to make the decision to adopt RFID in the first place."* Similarly, OE-3, when asked about the key drivers of adoption, indicated that "Global expansion" and "Top management initiative" played key roles in his organisation's decision to adopt RFID. He stated that *"As we have multiple outlets around the world, such a decision (adopting RFID) is made solely by the CEO or other top execs of the company. Although, they do work and make decisions based on recommendations and reports from lower management, the decision of where to implement the technology is made based on where its required the most, size or location of outlets, and the projected impact it would have."*

Although these responses point in the direction that the decision to adopt RFID is often influenced by a combination of many factors, the strongest and most recurring drivers indicated were related to top management support or involvement, and financial and technical capacities of the organisations. Accordingly, OE-4 stated that *"The top management of the company were involved from the beginning to the end of the project and handled matters of finance, and put together a team of experts to work with the consultants. So yes, initiative from top management, availability of finance and technical capacity were key factors for us."*

Under the environment category, the main drivers discussed were "Competitive pressure", "Industry pressure", "Regulatory pressure", "Media pressure", "Dominant partner pressure" and "Government support". In general, the respondents agreed that external pressures played a role in their decision to adopt RFID. However, they did so in different capacities. For example, OM-2 identified "Regulatory pressure" as a key driver by saying *"We are required to* *comply with standards for handling hazardous materials such as the Control of Major Accident Hazard (COMAH) regulations and UK's Pollution Prevention and Control regulations. Therefore, regulatory pressure played a role our decision to go for the RFID solution."* However, OE-4 played down the role of some of the external factors by saying "*In terms of pressure from outside, I would say that the desire to be more competitive is always there but I do not think competitive pressure was a big enough factor in this adoption. It is more a matter of improving our own operations, reducing costs, and improving customer service and safety. So it's more of pressure coming from within the company than from outside".*

Another important factor that has been mentioned by respondents is the desire to have a good portfolio/scorecard with their major partners. For example, in a situation where a major (usually dominant) retailer demands its suppliers/vendors to use RFID, the dominant partner keeps scorecards of suppliers delivering products. This scorecard often includes product description, quantity, etc. When the products are delivered and an error or discrepancy is encountered, full inspection of the delivered cargo has to be conducted. For huge product quantities, this could mean spending a lot of time, money and effort on trying to rectify the error. The supplier is thus billed for the inspection costs. It is therefore in the best interest of suppliers to tag their products at the item-level or case-level in order to be able to pick out any errors right from their warehouses as opposed to after they've shipped out the products to the retailers. This would prevent the suppliers from incurring inspection costs and would secure a good reputation with their partners. In the specific context of the case organisations, they emphasized the importance of having seamless and efficient communications with their partners, one that is based on accurate information, in order to enable them make high-quality decisions. This is considered a major driver of RFID adoption.

6.6.1.3 Constraints of RFID adoption

Despite the potential of RFID to improve supply chain processes, several challenges remain, which hinder organisational decision to adopt RFID. The different constraints investigated were grouped under the technology, organisation, and environmental categories of the TOE framework. The survey results in section 5.5.2 and 5.5.3 reveal that high capital and recurrent costs, requirements for business process change, and security and compliance concerns are significant constraints of organisational decision to adopt RFID, amongst others.

Under the technology category, “capital and recurring costs”, “technical issues”, “security issues” and “compliance issues” were discussed. Under the organisation category, “manpower shortages” and “requirements for business process change required” were discussed. Lastly, under the environment category “lack of industry standards”, “unwillingness to use RFID”, and “privacy issues” were discussed. The interview responses indicated that several challenges (from across the 3 categories of the TOE framework) hindered organisational decisions to adopt RFID, albeit momentarily (as the organisations eventually decided to adopt the technology). In that regard, OE-3 remarked that *“Cost is always an issue when dealing with new technology. We adopted an improved barcode inventory system about 4 years ago and the cost implications were carefully assessed. RFID is considerably more expensive in comparison and therefore even more attention was paid to its cost implications. Since we eventually decided to go for an RFID solution, you can say that costs delayed rather than hindered our adoption of RFID.”* Similarly, SCM-1 stated that *“Initially, I couldn’t get my head round the issue of standards, thinking receiving cargo from different parts of the world was going to pose standardization issues. But as you’ve suggested now, that is no longer an issue these days as a lot of progress has been made in terms of standards convergence*. *Aside from that, cost was a determining factor too. Due to the scale of our application, the capital cost was very high when we looked getting RFID in 2006*. *However, six years later, the costs had come down considerably. What we struggled with was to actually find the right tag as there was a lot of variety out there with competitive pricing, better performance.*”

Therefore, it was observed that although high costs of RFID systems are still an issue, respondents were aware that as a result of technological gains made in the past decade, a greater variety of RFID components are available in the market, at cheaper rates and with better performance.

It was also observed that although most of the constraints were acknowledged to have played a role or to potentially play a role in hindering organisations to adopt RFID, organisations have good knowledge about them and so tend to thoroughly consider them before a decision is made whether or not to adopt RFID. In that regard, OM-2 remarked that “*As said earlier, we believe that we had the technical capacity to adopt RFID as a company, thereby potential shortage in skills was not considered as something that could happen quite frankly. We knew* *by putting the right team in place, any technical issues that may arise will be effectively managed. Actually, a lot of planning had gone into adopting RFID, so most of these factors were considered before the final decision was taken."*

Out of the constraints discussed, the key ones identified were "technical challenges" and "Requirements for business process change required" where SCM-2 stated that *"Prior to installing the new system, we had a manual tracking system that was very hectic and time consuming. We knew the new system would have to track and monitor, and offer control of moving assets. We expected that such a system would have to be tailored to our needs, therefore, the financial demands were carefully looked into. However, what concerned us the most was how we'd deal with technical challenges, and how we'd have to restructure some of our processes, train our employees, and so on. "* Similarly, it was observed that "Security issues" and "Privacy issues" were of particular concern to organisations planning on adopting RFID solutions. In that regard, OE-4 stated that "*Security and privacy issues were discussed even after we launched our RFID system. It goes to show you how important they are in society today. All the security or privacy issues discussed were momentarily considered before our decision to adopt the system and are still considered today in order not to make infringements".*

In addition to the constraints discussed in the survey section and those highlighted above, the respondents identified ROI uncertainties and poor tag reader rates as factors that discouraged their adoption of RFID solutions. SCM-1 stated "*Although projections on cost savings were made, the Return on Investment (ROI) was still unclear. This hindered talks for the new system for a while." Also, OE-4 stated that "Perhaps the biggest constraint was the technical inconsistencies. The Medical Engineering team reported imperfect read rates of some tags and interference from medical equipment as problems they faced with their RFID system*. *Therefore, for this bed tracking system, we needed to consider that."*

However, in terms of ROI, not all the respondents agreed that unclear ROI was a major concern. OE-3 stated that "*ROI is really up to those in finance to work it out, because it is dependent on so many other issues like compliance with partners. If you're not compliant with let's say your major supplier or retailer, you quickly realize that there are costs that go with every order you place, or every order you receive. In our case it was up to something like 50p per unit ordered. So when you order or receive thousands of units, you are talking big money.*

So what we decided to do was to make sure that we let the finance people deal with the ROI whilst we make sure we are compliant with our major partners".

6.6.1.4 Key findings and conclusions

As identified in Chapter 2, one of the most popular technology adoption research topics is the identification of factors that influence the adoption process, with the aim of facilitating or guiding the way to achieving best adoption procedures (Loraas and Wolfe, 2006). The survey findings from Chapter 5 indicate that technological, organisational and environmental factors influence RFID adoption decisions. Building on the survey results, the findings from the case studies offer more detailed insights into how those factors determine RFID adoption decisions. The following key findings were made:

1. Firstly, it was observed that a collection of several different factors determine an organisations decision to adopt RFID. These factors were found to transcend across the three contexts of the TOE framework investigated – technological, organisational, and environmental. No particular context was found to be the most important. This finding is expected as the effects of technological, organizational and environmental factors on RFID adoption vary from culture to culture and industry to industry. For example, all the case study organisations investigated had a clear idea of what RFID could potential offer them in terms of benefits through the feasibility studies they'd conducted. Therefore, motivated by the perceived benefits and some form of external pressure (competitive, industry, etc.), they'd decided to implement RFID and had identified a set of key performance indicators with which they'd assess the effect of the RFID system and how best to achieve a return on investment. This development was achieved with the necessary support, involvement, and cooperation of management and staff. So perceived benefits or relative advantage (belonging to the technological context of the TOE framework), top management initiative (belonging to the organisational context of the TOE framework) and external pressure (belonging to the environmental context of the TOE framework) have all played a significant role in influencing the decision to adopt RFID.

2. Secondly, it was observed that each organisation is driven or constrained by a variety of factors that directly or indirectly relate to its industrial context, modes of operation, vision, and culture. This is an important observation as it sheds light on the importance

of contextualizing the motives behind an organisation's adoption of RFID in order to fully identify and understand the factors that drive and constrain its adoption. For instance, CSO-3 was in the cargo/freight forwarding industry where competition is rife and had just expanded into a new market in Asia. Its decision to adopt RFID was majorly target-driven. In order to maintain high levels of customer satisfaction in the new market, it needed to ensure a tracking system was implemented to ensure visibility of goods in transit and at various points of the supply chain. Thus, in this particular context, CSO-3 adopted RFID in order to meet demands of the new market, which are inherently connected with the organisations vision and long term goals.

3. Thirdly, it was observed that RFID adoption was inherently targeted at two factors. These are (i) solving pre-existing problems or challenges or (ii) providing a general solution/benefit. The studied organisations either adopted RFID after identifying a number of challenges within their operations and/or processes that they needed to overcome or they adopted RFID in order to reap the benefits of an automated, accurate system. For example, CSO-3 adopted RFID because they'd identified the potential benefit of getting a full asset management solution towards improving product accountability and overall management of their container fleet. On the other hand, CSO-4 adopted RFID to mounting pressure on their budgets and their desire for to efficiently use available resources. Therefore, they considered RFID as an innovative way to improve our operational efficiency in light of shrinking budgetary allocations.

In summary, the case study findings are consistent with the survey results in Chapter 5. Technology factors were found to have a significantly positive influence on the organizational decision to adopt RFID. This finding is consistent with many prior studies on innovation and RFID adoption (Brown and Russell, 2007; Schmitt et al. 2007; Wamba et al. 2009; Leimeister et al. 2009). From the case studies, it was gathered that key attributes such as "perceived RFID benefits" and "perceived RFID standards convergence" were considered critical in making the decision to adopt RFID.

The case studies also indicated that organization factors had a significant positive effect on the RFID adoption. The finding is consistent with early studies on IT adoption (Rogers, 1995) 40] and current literature on RFID technology adoption (Wu et al. 2006; Ngai et al. 2008; Brown and Russell, 2007;Wamba et al. 2009). Organizational factors are critical in influencing an organisation's decision to adopt RFID because they concern the capability and readiness of the organisations (in terms of existing information infrastructures and IT skills and experiences) to adopt the technology. Key organisational factors found to play a significant role include “top management initiative” and “availability of IT/IS infrastructure”.

Environmental factors were also found to have a significantly positive effect on RFID adoption. This finding is consistent with the literature (Niederman, 2007; Brown and Russell, 2007; Wu et al. 2009). The case study results found that environment factors receive significant attention from the adopters of RFID. Key environmental factors found to have an effect on adoption include “competitive pressure” and “regulatory pressure”.

6.6.2 Research question 2: Impact of strength of culture, size, and BPR on decision to adopt RFID

Research on organisational attitude towards technological innovation has helped us to understand and explain technology adoption decisions, patterns, and diffusion. This research question explored how characteristics of organisations, namely, strength of culture, business size, and business process reengineering influence organisational decision to adopt RFID.

The survey results in section 5.6.2 indicated organisational culture, business size, and BPR all had a statistically significant relationship with decision to adopt RFID. Organisational culture factors such as "top management initiative", "effective decision making" and "drive to introduce new technology into business processes" were found to be key determinants of organisational decision to adopt RFID. Business size factors such as "annual turnover", "IT infrastructure" and BPR factors such as "synchronization of IT resources and business processes" were also found to be key determinants of organisational decision to adopt RFID.

6.6.2.1 Strength of culture

6.6.2.1.1 General overview of Strength of culture

The different factors of organisational culture and their impact on the decisions to adopt RFID were discussed during the interviews. The respondents were initially asked about their organisational cultures generally and in relation to technology adoption. SCM-3 stated "*I would say that our corporate culture is based on teamwork, open communication, and a high level of demand, and it offers employees and various other stakeholders a dynamic and international environment to work in. In terms of technological adoption, our corporate culture encourages innovation and offers an enabling environment in terms of pre-requisite technical infrastructure, support and training of employees, financial involvement, and manpower*".

DR-4 stated "Generally, the culture of the Trust is a good one. It is one where there is involvement of all stakeholders, and where all members of staff are well-regarded. I would say that the culture is one of a style of leadership which asserts the fundamental values and vision of the Trust, ensures that they are understood and embraced by all, that they are reflected in *all endeavours of both employees and the Trust, and that those who depart from them are swiftly brought back into line through the appropriate means".*

OM-2 stated that "Considering the history of our organisation and how much it's grown over just 40 years, I can attribute much of the success to our culture of hard work, dedication, and teamwork. We are always ready to add any technology to our operations as long as a clear ROI is worked out. This is a keen yet careful approach to improving our operational efficiency"

SCM-1 stated "CSO-2 operates a very open culture. While the structure is traditional, it is not strict. We operate a dynamic culture due to our involvement across many different sectors and countries. Overall, decentralised, flexible working practices are promoted throughout".

6.6.2.1.2 Impact of strength of culture on decision to adopt RFID

In the interviews conducted, the respondents were asked of the link between their organisations' culture and their decision to adopt RFID. The responses varied according to the use of RFID within the case study organisations. The main factors of organisational culture discussed were "organisational goals and objectives", "organisational focus on performance relative to competitors", "organisational focus on customer satisfaction", "effective decision making", "top management initiative", and "drive to introduce new technologies into business process". The respondents accepted those factors to be essential constituents of organisational culture and acknowledged their importance in achieving organisational synergy and ensuring the success of the technology implemented. In that regard SCM-2 stated that *"We were well aware that focusing only on the technology, without due attention to cultural aspects of the organisation, could lead to failed implementation; which we desperately wanted to avoid".*

Generally, it was observed that the implementation of RFID led to change within the organisations, particularly in terms of core working functions, related policies, administrative functions, and various other components of the organisation. Different factors of organisational culture play a role in different contexts/applications of RFID adoption. For example, when asked about the extent to which organisational culture affected their decision to adopt RFID. OE-3 stressed the importance of defining goals and objectives, where he stated that "*Due to the dynamic nature of our market, our business strategy involves adapting to changing market demands and being creative in creating constant variation, expanding on* *successful product items and continuing in-season development. This is drilled into every employee as it represents the values, goals, and objectives that the organisation stands for. Having clearly outlined objectives acts as a guideline towards achieving targets. Although top management has set us general targets, every store manager is responsible for a business unit and so has his own targets to meet. These goals and objectives thus guide any technological innovation requirements to be proposed to top management*".

Similarly, DR-4 explained the importance of top management support and involvement. He stated that *"Different types of technology are continuously being adopted in different departments of the Trust. Essentially, wherever the Trust identifies the need to improve quality and safety of patients' care through technological innovation, the top management are involved straightaway. Any requirements in terms of finance, training, structural changes and so on are evaluated and a decision is made".*

Other factors such as innovation and teamwork were highlighted to have played a role in the decision to adopt RFID. OE-2 stated *"As we are very action-oriented, adoption of technological innovation is often a necessity in order to get things done. Our culture supports innovation and encourages improved working conditions and results through teamwork."*

Summarily, it was observed from the interview responses that implementing RFID technology is perpetual and it affects functions and decision-making at multiple levels of the organisation. Notwithstanding, the culture and the type of leadership exercised had an impact on the organisations' decisions to adopt RFID, how they responded and changed, and how they developed their technology implementation strategies.

6.6.2.2 Business size

6.6.2.2.1 Impact of business size on decision to adopt RFID

The different factors of business size and their impact on the decisions to adopt RFID were discussed during the interviews. The main factors of business size discussed were "annual turnover", "number of employees", "IT infrastructure" and "Range of products/services". The respondents were initially asked about the size of their organisations and what effect that may have had on organisational decision to adopt RFID. Accordingly, DR-4 stated that *"Our size has definitely played a role in our adoption decision. For example, we knew we had to go for phased implementation of the new system. It didn't make economic sense for us to go for* *a complete roll-out at that moment. This was because we had quite a number of departments that would need to be linked up to use the new system."* Similarly, OE-1 added that *"Our highest number of employees are in the warehousing unit. Most times we hire part-time workers to help with inventory management and so on. With the automation of the inventory management system, we knew we couldn't train each and every one of them. So a number of dedicated permanent staff were trained to use the new system and other staff were redeployed elsewhere. So yes, we had to consider the number of employees we had before making a decision to adopt RFID".*

The interview responses generally indicated that availability of funds, IT infrastructure, and number of employees were the key attributes of business size that play a role in organisational decision to adopt. In that regard, OM-2 noted that "*Without investing sufficient financial resources, you stand the risk of not making the most out of the RFID system. So although we are not the biggest company around, I would imagine that we dedicated sufficient financial and technical resources to the project, and that's why it's worked*." OE-4 also stated that *"The technical demands for implementing our type of RFID system are quite high actually. Before the adoption, the consultants conducted an in-house assessment of our infrastructure and capabilities. I was part of the technical team that was assessed. We had a good IT infrastructure in place, and we had a good technical and data mining team. These helped top management in deciding to go for the RFID system".*

The range of products and services that will be using RFID also influence the decision to adopt RFID. This became apparent when OE-3 stated that *"Yes, we considered our product range before making a decision on whether to go for the technology or not. As we have a wide range of clothing in the shop we needed to decide what to tag. At the moment, we tag mainly high value goods".*

6.6.2.3 Business process Reengineering (BPR)

6.6.2.3.1 Impact of BPR on decision to adopt RFID

The BPR factors investigated were "data standardization and integration", "restructuring and streamlining of business processes", "Decentralization of consolidated resources and processes", "provision of decision support tools", and "synchronization of IT and business processes". Responses from the interview indicate that organisations acknowledge the importance of strategically aligning business processes and IT in order to efficiently use IT assets to assist business management and practices. In that regard, SCM-1 stated that "*When the RFID system was proposed, decisions were taken to decentralize certain resources including decision making. This is largely because we wanted to start RFID as a pilot project in the warehouse, and we believed the operations manager should have greater control of the system without the need to be subject to hierarchical or bureaucratic interference*. *So before our adoption of the system, top management had to evaluate the management structure and reposition some key processes. For example, warehouse and transportation operations were initially under the same department. Since the planned introduction of RFID for inventory management, the warehousing operations have been given greater autonomy."*

The respondents also indicated that their organisations were generally aware of BPR requirements that accompany the adoption of RFID, but that were mostly concerned about indirect effects of BPR, particularly workforce changes. OE-2 stated that "*Top management had to deliberate about automating some business processes and practices. On the one hand, they'd reduce costs, on the other, they'd reduce manpower required. This would mean that staff would have to be reassigned elsewhere or allocated roles appropriate for their expertise. At the end of the day, we all had to put our thinking hats on and design the best implementation strategy. This included, as you mentioned earlier, removal of some tasks and processes*".

In general, the responses indicated that organisations are very much aware of BPR requirements as a result of project scoping and assessment carried out either in-house or by RFID vendors or consultants. Decentralization of consolidated resources is observed to be a common process in BPR before RFID is adopted. This is usually because a pilot or phased implementation of the system is launched. The decision to go for full implementation/roll-out is usually made after assessing benefits derived from the pilot projects. Similarly, the ways and techniques to achieve synchronization of existing IT resources with the new system and the restructuring of business processes were found to be considered before RFID adoption decisions are made.

6.6.2.4 Key findings and conclusions

Impact of strength of culture on decision to adopt RFID

The survey findings from Chapter 5 indicate that a strong culture has a positive significant relationship with organisational decision to adopt RFID. Building on that, the case study results underline the key dimensions of strong culture that influence RFID adoption decisions. In addition, the case study results highlight the fashion in which these dimensions operate in either driving or constraining the adoption of RFID. The following key findings have been made:

1. The dominant dimensions of a strong organisational culture such as management involvement and cooperation, clear definition of goals and objectives, and innovation have a significant impact on the generation of new and innovative ideas and practices that lead to the adoption of RFID.
2. Strong culture is found to be critical in enabling organisations to develop the capacity to absorb RFID into the organisational operations and management processes.
3. Strong culture influences the extent to which RFID solutions are encouraged, supported, and implemented by empowering management to innovate ways of representing problems and finding solutions. This has been the case in at least two of the case study organisations investigated where the implementation of RFID was largely problem-driven. The culture in those organisations empowered and supported the different processes of RFID systems development from conducting initial feasibility studies to the eventual deployment of the system.
4. Strong culture attributes such as effective decision making, flexibility, and teamwork promoted the adoption of RFID by enabling employees to bond, coordinate, and cooperate in effectively contributing towards innovation.
5. Finally, strong cultures that ensure the provision of support mechanisms have a positive influence on the decision to adopt RFID. The provision of decision support tools and training – an attribute of strong cultures- promotes the adoption of RFID by creating an enabling atmosphere and environment for such technological innovation.

The implications of the findings of points 1 to 5 are that the results capture the dynamic linkages between strength of culture and RFID adoption, including patterns across different organisations and industrial contexts. Summarily, the case study results reveal that organisations that adopt RFID have imparted innovation into their aims, objectives, and vision.

They have also prescribed a set of strategic goals and objectives that reflect the priorities and values of the organisation thus promoting the adoption of RFID and general organisational innovation.

Impact of business size on decision to adopt RFID

Business size has long been considered a critical determinant of organisational decision to adopt technological innovation. The survey findings from Chapter 5 indicate that business size has a positive significant relationship with organisational decision to adopt RFID. Building on that, findings from the case studies provide valuable insights into the impact of organisations' resources; workforce size and availability; and IT/IS infrastructure on RFID adoption. Key findings from the case studies are:

1. Business size is considered a key determinant of RFID adoption in terms of its structure and processes. It was observed that decentralization of managerial decision-making authority, the availability of financial and technical resources, complex and diverse facilities, provision of decision support tools, and the availability of skilled workforce profoundly influence the processes in which organisations adopt RFID.
2. RFID adoption was prevalent in organisations of different sizes. The characteristics of different organisational sizes play a role in the adoption of RFID. Larger organisations are driven towards adopted by primarily by superior financial and technical resources and adequate IT/IS infrastructure. However, smaller organisations also adopt RFID and are primarily driven by their greater flexibility/adaptability i.e. the less complex nature (in terms of management structure, hierarchy and processes) of smaller organisations means it becomes easier to coordinate and collaborate when developing RFID systems.
3. The availability of funds, IT infrastructure, and number of employees were the key attributes of organisational size that were found to play a role in the decision to adopt. These were found to be determinants that influence how deeply committed organisations are towards strategic planning of the RFID projects, developing pilots, and the eventual RFID project implementation.

In summary, business size has been shown to be a determinant of RFID adoption decisions. These findings validate the survey findings in chapter 5 by explicitly stating how individual attributes or organisational size influence the adoption of RFID. For example, the case studies reveal that greater financial resources of larger organisations do not only help them in overcoming high capital and recurrent costs of RFID systems but also enable them to take greater risks associated with RFID adoption. This view is supported by findings of Thong (1999); Kuan and Chau (2001); Zhu et al., (2003); and Gibbs and Kraemer (2005). However, in comparison, smaller organisations also benefit from attributes such as flexibility and adaptability, which drive them towards the decision to adopt RFID.

Impact of Business Process Reengineering (BPR) on decision to adopt RFID

Implementing RFID often necessitates business process change. The survey findings from Chapter 5 indicate that BPR has a positive significant relationship with organisational decision to adopt RFID. Building on that, the findings from the case studies provide clearer insights into the interaction of BPR attributes with the decision to adopt RFID. In that regard, the following key findings were made.

1. Organisations' strategic alignment of business processes and IT resources is paramount in order to efficiently deploy and use RFID systems.
2. Organisations may not necessarily have to change their management structure but may have to change some processes in order to functionally integrate incoming RFID systems with already existing systems.
3. As found in the survey results in chapter 5, the case studies confirm that BPR attributes such as "data standardization and integration", "restructuring and streamlining of business processes", "decentralization of consolidated resources and processes", "provision of decision support tools", and "synchronization of IT and business processes" are critical determinants of the decision to adopt RFID. They give the implementation team and/or management a clearer picture of how proposed RFID systems will integrate with existing processes to create new ones and how those processes will be managed effectively. It also gives management an idea of the technical and manpower resources and support tools required to implement the proposed RFID system, thus enabling top management to make informed decisions about the adoption.

In summary, the responses from the case studies indicated that organisations are very much aware of BPR requirements as a result of project scoping and assessment carried out either in-house or by RFID vendors or consultants. Decentralization of consolidated resources is observed to be a common process in BPR before RFID is adopted. This is usually because a pilot or phased implementation of the system is launched. The decision to go for full implementation/roll-out is usually made after assessing benefits derived from the pilot projects. Similarly, the ways and techniques to achieve synchronization of existing IT resources with the new system and the restructuring of business processes were found to be considered before RFID adoption decisions are made.

6.6.3 Research question 3: Impact of strength of culture, size, and BPR on RFID implementation processes

This research question investigates the impact of strength of culture, business size, and BPR on RFID implementation processes with the eventual aim of providing guidelines for practitioners for the implementation of RFID projects. The question investigates how strong culture factors such as goals and objectives, top management initiative; business size factors such as number of employees, annual turnover, IT/IS infrastructure; and BPR factors such as decentralization of consolidated resources, provision of decision-support tools influence the adoption of RFID. The RFID implementation processes investigated were “project scoping”, “analysis of existing systems”, “design of RFID system”, “prototype testing”, “implementation of RFID system” and “continuous improvement”.

6.6.3.1 Impact of strength of culture on RFID implementation processes

The survey results from section 5.7.2 indicated that strong culture has a statistically significant relationship with RFID implementation processes. Scoping of RFID projects involves defining the objectives of the proposed system and understanding its potential benefits and limitations. When asked how organisational culture impacted the scoping of RFID projects, the respondents generally indicated that a culture with good organisation and clearly defined goals and objectives gives a clear direction as to where the proposed system is going, how it is expected to be beneficial, how the deployment will occur, and what level of participation is required from employees. In that regard, ITS-1 stated *“Getting the implementation strategies right is very important. For example, we knew the best way to achieve the most benefits was to divide the project into different phases and to continuously improve the system based on the benefits achieves. Therefore, I would say our culture of teamwork and effective decision-making helped develop well-defined boundaries for the implementation of the scoping and eventual implementation of the RFID project.”*

Often RFID projects come in to supplement or overhaul already existing systems. This calls for the analysis of the existing system and often includes collecting data about the strengths and limitations of the existing system. Respondents indicated that, where existing systems were in place, data about them is usually documented in company reports either annually or monthly. SCM-3 highlighted that process mapping of their existing team was carried out in phases before their implementation of RFID. In his words, "*We had a barcode system in place that we wanted to continue running alongside the RFID system. Top management had taken the decision that the RFID solution would be implemented in phases, thereby the existing barcode system process and information flows were mapped to help prioritize what stage of the process to start implementing RFID in*". The respondents also highlighted teamwork, effective-decision making and support from top management to be key corporate culture attributes that impact the analysis of existing systems. OE-4 stated "*That decision (analysis of existing systems) was taken by top management, and it was done by the same IT consulting firm offering us the RFID solution. This was done so as to be able to tailor to our specific demands about the proposed system. I believe it was a vital step to ensure that the system meets expectations.*" Similarly, OE-3 remarked that "*It involved a lot of data collection as our existing system was quite vast. Employees were split into groups and were assigned objectives. A lot of teamwork and effort was put into that process. I remember being part of the interviewing team and we had to work overtime for some days*."

The next phase of RFID implementation discussed was the design of the RFID system. This stage involves very vital processes such as requirement analysis, software and hardware selection, and development of new processes. From the interview responses, it became clear that this stage was mainly handled by consultants rather than in-house. The respondents could not specifically pinpoint how their culture may have influenced the design of the RFID system. OE-2 remarked that "*The consultants had that job to do. Quite frankly we had no idea what they were doing. We were involved in the requirement analysis phase, where we reviewed potential business process that needed to be modified. Otherwise, the consultants dealt with everything else really."* Nevertheless, OE-1 added that "*After the software and hardware were selected, they were tested to understand the characteristic of each element. A number of our employees were brought in to decide which options were more suited for our current environment."* In general, it was observed that top management initiative and involvement is very vital at this stage of RFID implementation. The respondents indicated that decisions had to be taken by top management to approve the design of the integrated RFID system and its associated item functions. At this phase of RFID implementation, the participation of top management and effective-decision making appear to be the key cultural attributes that give a clear picture of the operations and reliability of the proposed RFID system.

The next phase of RFID implementation is the prototype testing phase. It involves testing the designed RFID system to assess its fit for purpose and readiness for deployment. With regards to this phase, OE-3 stated that *“Essentially all the technical staff of the organisation were rallied for this phase. They were involved in supporting the testing and in debugging. Operations staff were also involved to assess the flexibility and capability of the system. There were orders from top management to make sure all concerns or comments are reported accordingly.”* Generally, respondents agreed that this phase required and involved a lot of top management initiative, teamwork, and effective decision-making.

After successful prototype testing, the integrated RFID system is implemented. This stage involves the installation of all software and hardware packages and the commission of the system. It also involves a lot of capacity development, change management, and training. When asked how organisational culture affects this stage of the RFID implementation process, OM-3 stated “*As we decided to run the RFID system alongside our existing barcode system, employees needed training on how to run the two systems concurrently and how to phase out of the old system when/if the performance of the new system is assured.”* It was indicative from the responses that cultures that encourage capacity development/employee empowerment make the most success of this stage. “*Rather than allowing employees to learn on the job, the consultants were retained for a couple of weeks after implementation, where they conducted training programmes for all employees*” remarked OE-4. The tasks in this phase affect the success of the overall RFID system and hence the eventual benefits derived thereof.

The final phase of the RFID implementation process is continuous improvement. This phase involves monitoring the system to identify limitations and areas requiring improvement. The respondents identified organisational focus on competitors and on customer satisfaction to be key attributes of culture that influence the desire for continuous improvement. OM-3 stated “*Competitive pressure played its role in getting us to adopt RFID. Therefore we always keep an eye on our competition and look for ways to improve our system to help us cut costs, increase efficiency and so on“.* In addition, top management involvement is necessary to ensure feedback is collected from the different stakeholders of the RFID system in order to analyze and spot potential problems and issues in the newly deployed system. Accordingly, OE-2 "*We are encouraged to continue to independently evaluate the performance of the system including individual processes. Any issues or concerns were reported to the supervisor or manager in charge of operations".*

6.6.3.2 Business size

6.6.3.2.1 Impact of business size on RFID implementation processes

The survey results from section 5.7.3 indicated that business size has a statistically significant relationship with RFID implementation processes. Scoping of RFID projects involves defining the objectives of the proposed system and understanding its potential benefits and limitations. When asked how business size impacted the scoping of RFID projects, SCM-3 stated *"When you begin to consider implementing any new technology, you must have in mind the scale to which you picture it working. Is it just in a department? Is it throughout the organisation? Is it a pilot project or a full roll out? Those are issues you'd be deliberating. Most, if not all of these issues are determined by the size of the organisation. For us, we were thinking of implementing the system in one shop, but we needed it to integrate with our international delivery system, which is based in Spain. Therefore, defining the scope of the project considered our size, our resources, and our expectations. For example, if we were a bigger outlet, we'd certainly have had different objectives in terms of what the inventory system would entail".* This indicates that the project scoping phase of RFID implementation is influenced by the range of products and/or the number of offices, retail outlets, warehouses etc. that are looking to be RFID-enabled.

With regards to the other phases of RFID implementation. The responses indicated that availability of resources and skilled manpower is very critical to implementation success. Availability of financial resources was particularly highlighted. OE-2 noted that *"Yes I believe having the necessary financial resources is key. Money is required at multiple stages, from the analysis of the existing system to testing the RFID system. In our case all financial obligations were met to ensure the success of the project. I wouldn't be able to say whether that is directly attributed to our annual turnover or not. Nevertheless, I believe top management budgeted quite generously for the RFID project".* He also stressed the importance of having skilled manpower that possess the necessary technical skills to be at the helm of the implementation process. He remarked that "*The consultants solicited the participation and expertise of our in-house IT team and worked with them throughout the process of implementing the new system. So having the skilled manpower available helped in business process mapping, scoping of the project, prototype testing, and eventual installation".*

6.6.3.3 BPR

6.6.3.3.1 Impact of BPR on RFID implementation processes

In the survey results in section 5.7.3, BPR had a statistically significant relationship with RFID implementation processes. From the interviews conducted, responses indicated that BPR mainly influences RFID system design, RFID implementation, and continuous improvement. With regards to analysing existing systems, BPR is observed to set the stage and give a clear outline of existing business processes including mapping out disconnects, non-value added processes, and areas requiring improvement. In that regard, DR-4 stated that "*When the RFID solution was proposed, we saw it as an enabler for the organisation to improve processes, cut costs, and so on. But due to the technical requirements of developing such a system, some process structures had to change. We had to upgrade our IT infrastructure to support the proposed system including the establishment of a databank, which is now essentially a storage database of generated RFID data. The IT infrastructure and BPR are interdependent in the sense that deciding the information requirements for the new business processes determines the IT infrastructure to be used for the RFID system*".

The responses indicated that effective overall system architecture, flexible IT infrastructure and proper installation of IT components all contribute to building an effective IT infrastructure for business processes. In addition, recognition of IT capabilities provides alternatives for BPR. Building a responsive IT infrastructure is highly dependent on an appropriate determination of business process information needs. This, in turn, is determined by the types of activities within a business process, and the sequencing and reliance on other on other organisational processes.

Some respondents also highlighted that business process mapping that occurred during BPR helped to give the project decision-makers a clearer picture of the IT infrastructure required to support the RFID system, and how software and hardware items function in an integrated system. In that regard, SM-3 remarked that "*We had to look at the processes to design the* *best way in which the readers will be connected to the network and the software architecture, including the RFID middleware and the application software*. *This provided data for measuring the reliability of the proposed system*".

6.6.3.4 Key findings and conclusions

Impact of strength of culture on RFID implementation processes

Building on the survey results from chapter 5, the findings from the case studies provide insights into how the different processes of RFID implementation interact with strong culture attributes. The key findings made in that regard are listed as follows.

1. Project scoping – An organisation with a strong culture ensures that its aims, objectives, and vision are clearly defined, stated, and communicated to all concerned stakeholders. This is paramount in ensuring the success of RFID implementation processes at project scoping stage. Clearly defined goals and objectives give the implementation team a clear direction as to where the proposed system is going, how it is expected to be beneficial, how the deployment will occur, and what level of participation is required from concerned stakeholders.
2. Analysis of existing systems – It was found that teamwork, effective-decision making, and support from top management to be key attributes of a strong culture that impact the analysis of existing systems. This was particular in cases where RFID projects come in to supplement or overhaul already existing systems. Also, strong culture was found to have an influence on processes such as collecting and documenting data about the strengths and limitations of the existing system.
3. Design of RFID system – In general, it was observed that top management initiative and involvement is very vital at this stage of RFID implementation. The respondents indicated that decisions had to be taken by top management to approve the design of the integrated RFID system and its associated item functions. At this phase of RFID implementation, the participation of top management and effective-decision making appear to be the key attributes that give a clear picture of the operations and reliability of the proposed RFID system.
4. Prototype testing – It was found that key attributes of strong culture such as effective decision-making and top management initiative influence this stage of RFID

implementation by enabling the efficient testing of the designed RFID system in order to assess its fit for purpose and readiness for deployment.

5. Implementation – It was indicative from the case studies that strong cultures encourage organisations to focus on capacity development/employee empowerment thereby enabling the efficient installation of appropriate software and hardware packages and the commissioning of the system. It also means that change management and training associated with the installation of the new RFID system is accorded priority.
6. Continuous improvement – The case study responses identified organisational focus on competitors and on customer satisfaction to be key attributes of strong culture that influence the desire for continuous improvement. Strong culture supports the monitoring of the system to identify limitations and areas requiring improvement. In addition, top management involvement was found to be necessary in ensuring feedback is collected from the different stakeholders of the RFID system in order to analyze and spot potential problems and issues in the newly deployed system.

In summary, strong culture provides a clear direction and visibility of the various RFID implementation processes thereby enabling the project implementation team to design the system to meet the demands of the organisation, integrate and supplement existing systems, and to understand the functionality of the system.

Impact of business size on RFID implementation processes

Findings from the survey results in chapter 5 indicate that business size has a positive significant relationship with RFID implementation processes. Building on that, responses from the case studies provide insights into the interaction of specific business size attributes with the different processes of RFID implementation. The key findings made in that regard are listed as follows.

1. The availability of financial and technical resources is very critical to implementation success. Availability of financial and technical resources was particularly highlighted to have an effect across the various phases of RFID systems deployment from the analysis of the existing system through to the testing the RFID system, and the eventual installation. It determines the scope of the RFID project, the selection of hardware and software, and the execution of key processes such as prototype testing.

2. It is critical to have skilled manpower with the necessary technical skills to be at the helm of the implementation process. In the case of 3 of the studied organisations, the participation and expertise of both in-house IT teams and external consultants were solicited throughout the process of implementing the new systems. This was done in order to ensure that key processes such as business process mapping, scoping of the project, prototype testing, and eventual installation of the system were conducted in a hitch-free manner.
3. RFID implementation processes like the project scoping, system design, prototype testing, implementation, and continuous improvement are influenced by the range of products and/or the number of offices, retail outlets, warehouses etc. that are going to be RFID-enabled. For instance, the scoping of RFID projects involves defining the objectives of the proposed system and understanding its potential benefits and limitations. This indicates that the extent to which RFID is developed will thus be determined by the range of products and/or the number of offices, retail outlets, warehouses, etc. looking to be RFID-enabled.

In summary, different attributes of business size were found to impact different processes of RFID implementation. Larger organisations benefit from having greater financial and technical resources and are likely to have greater influence in determining the scope of the RFID project, have access to a greater selection of hardware and software, and strongly influence the execution of key processes such as prototype testing and continuous improvement. Nevertheless, smaller organisations also benefit from attributes such as flexibility and adaptability, which enable easier integration of the RFID system.

Impact of BPR on RFID implementation processes

Building on the survey results from chapter 5, responses from the case studies provide detailed insights into the interaction of BPR attributes with the different processes of RFID implementation. The key findings made in that regard are listed as follows.

1. BPR mainly influences RFID system design, RFID implementation, and continuous improvement. BPR is observed to set the stage and give a clear outline of existing business processes including mapping out disconnects, non-value added processes, and areas requiring improvement. In that regard, BPR is perceived as an enabler for the organisation to improve processes, cut costs, and so on.

2. BPR attributes such as effective overall system architecture, flexible IT infrastructure and proper installation of IT components all contribute to building an effective IT infrastructure for business processes which leverage the RFID systems.
3. Through business process mapping, BPR gives the project decision-makers a clearer picture of the IT infrastructure required to support the RFID system, and how software and hardware items function in an integrated system. For instance, in CSO-2, the implementation team were able to have an idea on how readers will be connected to the network and the software architecture, including the RFID middleware and the application software. This provided them with data for measuring the reliability of the proposed system.

In summary, the success of RFID implementation processes is highly dependent on an appropriate determination of business process information needs. BPR enables organisations to determine the types of activities within a business process, and the sequencing and reliance on other on other organisational processes. This helps in structuring how the RFID system hardware and software function as part of an integrated system.

6.6.4 Research question 4: Impact of strength of culture, business size, and BPR on benefits derived from RFID

This research question investigates the impact of strong culture, size, and BPR on benefits derived from RFID implementation. The question investigates how strong culture factors such as team orientation and capability development, top management commitment and support; business size factors such as number of skilled employees, annual turnover, IT/IS infrastructure; and BPR factors such as decentralization of consolidated resources, provision of decision-support tools influence the derivable benefits of RFID. The RFID benefits investigated were categorized according to the Balanced Scorecard (BSC) approach, into (i) financial, (ii) internal processes, (iii) corporate, and (iv) learning and growth.

6.6.4.1 Impact of strength of culture on RFID benefits

The survey results from section 5.8.2 indicated that organisational culture influences benefits derived from RFID across the four categories of the BSC. In the interviews conducted, respondents were asked of the influence of their culture on benefits derived. SCM-1 stated that "*It took us a while to realize and sustain benefits from the new system. This was because we needed to acclimatize and get proper hands-on experience with the system. It took some employees a while to wrap their heads round it but they all did so eventually. There was a lot of training and support available to ensure employees were guided."* Similarly, OE-3 stressed the importance of training and capacity development and the provision of decision support tools as key culture attributes that help realize and sustain benefits derived from the RFID system. He noted that *"Training was really important for us. Top management was very particular also, about providing all necessary IT support tools for employees. This way, the efficiency and learning increased over time, and so did the benefits. For example, we learnt that placing tags on or close to metals led to poor read rates for some warehouse inventory. This enabled us to move the tagging to pallets rather than items. This provided us with much better visibility and accountability for inventory".*

In general, it was observed that developing a clear RFID strategy, creating a strong internal and external motivation for improvement, organisational knowledge accumulation, and provision of training and decision support tools were the key attributes of organisational culture that influence benefits derived from RFID implementation. DR-4 indicated that *"The* *strategy we developed from the beginning helped us to manage our expectations and to plan how best to operate the new system. We also documented our experiences while using the system. Benefits, shortfalls, all the lot. We now have a comprehensive database that we've accumulated over the past 4 years that we access regularly for continuous improvement".* Similarly, OE-2 stated that "*We always want to improve. We realized many benefits in terms of cost savings, better visibility, reduction in inventory, better staff motivation and much more but we still want to improve. This is the culture in this organisation really. No sleep, no slumber. If we feel can improve, we will try our best to do so".*

In general, the respondents indicated that benefits from across the four categories of the BSC were influenced by organisational culture.

6.6.4.2 Impact of business size on RFID benefits

From the survey results in section 5.8.3, there was a significant relationship between business size and benefits derived. The size of a business affects the availability of financial and technical resources and of skilled workforce. From the interview responses, it was observed that for RFID benefits to be realized and sustained, continuous support for users of the RFID system, regular maintenance of the RFID system, and system improvement procedures need to be provided. Therefore, top management involvement in ensuring that sufficient financial and technical resources are available for training and support, for system upgrades, maintenance, and data processing is key realizing and sustaining benefits. In that regard, OM-4 noted that "*The Trust employs around 11,000 people, with thousands working in a range of departments and playing a variety of roles. Aside from the four main hospitals in Birmingham, Solihull, and Sutton, we also run smaller satellite units. Although still part of the Trust, the smaller units do not have the technical capacity, nor the space really, to host RFID hardware and middleware systems. So even within the same organisation, you can see that size can be a factor in how smoothly you run the system, and hence how much benefits accrue."*

Some respondents also indicated that their organisations' IT infrastructure provided a platform for better integration internally and with supply chains. This allows for the implementation of data mining techniques. In that regard, SCM-1 stated "*With the amount of cargo coming in, a lot of data is generated and the important bits need to be sieved out and* *used to continuously improve our processes. We have a great IT team that works on that and the necessary infrastructure in place to support data processing*".

6.6.4.3 Impact of BPR on RFID benefits

Accordingly, it was observed from the responses that the continuous review of processes and procedures, provision of decision support tools, synchronization of IT resources and business, and data integration and management were key BPR attributes that influence RFID benefits. In that regard, DR-4 noted *"After the process mapping, we had to move things around, redesign some business processes, and decentralize some resources and so on. However, the key to us achieving and sustaining benefits is by granting greater employee control and involvement. Decision-making was decentralized allowing division leaders/managers to take full charge of the systems. This meant that those that come in contact with the system or supervise its usage, get to make decisions"*.

The respondents generally indicated that BPR processes enabled their organisations to structurally and dynamically align their business processes with their IT resources. This enabled them to derive benefits by removing non-value added tasks, therefore making processes leaner. With specific regards to which benefits were influenced, OE-3 stated that "*We made savings by preventing inventory loss and misplacement, increase in transportation efficiency and so on. This was made possible by making sure our business processes were in tune with our IT resources".*

6.6.4.4 Key findings and conclusions

Impact of strength of culture on RFID benefits

The survey results in Chapter 5 indicate that strong culture positively impacts benefits derivable from RFID deployment. Building on that, responses from the case studies provide insights into how the attributes of strong culture interact with RFID benefits. The key findings made in that regard are listed as follows.

1. It was observed that developing a clear RFID strategy, creating a strong internal and external motivation for improvement, organisational knowledge accumulation, and provision of training and decision support tools were the key attributes of organisational culture that influence benefits derived from RFID implementation. They were found to help the organisation manage expectations and to plan how best to

operate the new system. This has knock-on effects on the success of the implemented system and thus influences the benefits derivable.

2. Training and capacity development and the provision of decision support tools were also found to assist organisations in realizing and sustaining benefits derived from the RFID system. Training is critical in ensuring that the system is operated as required and that key issues such as interference and operability are fully understood by staff operating the system or handling equipment such as readers. This has an effect on the performance of the system and hence the benefits derivable.
3. Provision of necessary IT support tools for employees. Respondents indicated that this ensured that employee efficiency and learning increased over time. For example, CSO-3 learnt that placing tags on or close to metals led to poor read rates for some warehouse inventory. This enabled them to move the tagging to pallets rather than items, consequently achieving better visibility and accountability for inventory.

In summary, strong cultures provide a direction for the implementation of RFID systems in terms of encouraging capacity development and the provision of tools to support employees in operating the new RFID system.

<u>Impact of business size on RFID benefits</u>

The survey results in Chapter 5 indicate that business size positively impacts benefits derivable from RFID deployment. Building on that, responses from the case studies provide insights into the interaction of business size attributes with RFID benefits. The key findings made in that regard are listed as follows.

1. The size of a business affects the availability of financial and technical resources and of skilled workforce. From the interview responses, it was observed that for RFID benefits to be realized and sustained, continuous support for users of the RFID system, regular maintenance of the RFID system, and system improvement procedures need to be provided. Therefore, top management involvement in ensuring that sufficient financial and technical resources are available for training and support, for system upgrades, maintenance, and data processing is key realizing and sustaining benefits. For example, CSO-4, a Hospital Trust, employs around 11,000 people, with thousands working in a range of departments and playing a variety of roles. Aside from the four main hospitals in Birmingham, Solihull, and Sutton, they also run smaller satellite

units. Although still part of the Trust, the smaller units do not have the technical capacity, nor the space really, to host RFID hardware and middleware systems. So even within the same organisation, size can be a factor in how smoothly the RFID system is run, and hence how much benefits accrue.

2. Some respondents also indicated that their organisations' IT infrastructure provided a platform for better integration internally and with supply chains. This allows for the implementation of data mining techniques. For instance, in CSO-1, a lot of data is generated from the RFID system and thus the most important details need to be sieved out and used to continuously improve the system processes. Thus, the organisation equipped its IT team with the necessary infrastructure in place to support data processing.

In summary, business size plays a role in determining both financial and technical resources that are dedicated to an RFID project. This affects the daily operational activities of the system, the tools provided for supporting employees, and the benefits derivable.

BPR impact on RFID benefits

The survey results in Chapter 5 indicate that BPR positively impacts benefits derivable from RFID deployment. Building on that, responses from the case studies provide insights into the interaction of the attributes of BPR with RFID benefits. The key findings made in that regard are listed as follows.

1. BPR processes enabled their organisations to structurally and dynamically align their business processes with their IT resources. This enabled them to derive benefits by removing non-value added tasks, therefore making processes leaner. For instance, OE-3 stated that "We made savings by preventing inventory loss and misplacement, increase in transportation efficiency and so on. This was made possible by making sure our business processes were in tune with our IT resources".
2. The key to achieving and sustaining benefits is by granting greater employee control and involvement. In organisations where decision-making was decentralized, it allowed division leaders/managers to take full charge of the systems. This meant that those that come in contact with the system or supervise its usage get to make decisions.

3. The continuous review of processes and procedures, provision of decision support tools, synchronization of IT resources and business, and data integration and management were key BPR attributes that influence RFID benefits. For instance, after the process mapping, CSO-4 redesigned some of its business processes and decentralized some resources in order to maximize benefits.

In summary, BPR is necessitated by RFID systems implementation. BPR enables synchronization of business processes and the RFID systems functional units, ensuring that the system operations are aligned with the strategic decision-making of the organisation. This helps support decision-making capabilities such as resource decentralization, and data management and integration. Through these processes, the level of benefits derivable from RFID systems can be determined.

6.6.5 Research question 5: Impact of RFID-related factors on benefits derived from RFID

This research question investigated the impact of RFID–related factors on benefits derived from RFID implementation. The RFID-related factors investigated were PULT, RFID implementation stage, and organisational pedigree in RFID. The RFID benefits investigated were categorized according to the Balanced Scorecard (BSC) approach, into (i) financial, (ii) internal processes, (iii) corporate, and (iv) learning and growth.

6.6.5.1 Key findings and conclusions

RFID implementation stage

The three stages of RFID implementation investigated were Full implementation, Partial Implementation, and Pilot implementation. The survey results obtained in Chapter 5 indicate that RFID implementation stage has an impact on benefits derived from RFID. Building on that, the case studies reveal the following key findings:

1. Benefits accrue the most when RFID is fully implemented, as opposed to pilot or partial implementation. This is because full implementation enables the different departments within an organisation and/or partners along the supply chain to have access to RFID-enabled data capture and sharing and benefit from any process optimization.
2. Full implementation provides greater synergy and integration between business processes in the organisation. For instance, DR-4 stated "*I cannot tell with our system at the moment as we are still in the pilot phase. But if anything, we can be able to judge from the RFID Discovery system implemented in the Medical Engineering department. They initially started with a small section of the department and later decided to go for full implementation because they wanted to achieve greater synergy and integration between all the processes in the department. For example, it was the electronics and mechanical section of the department that implemented the pilot. Although they were getting benefits, what they came to realize was that they needed to maintain timely and effective communication with the renal support unit and the intensive care unit. However, it was just the electronics and mechanical unit that had access to accurate data and could locate resources so quickly. So within that unit, they*

made asset tracking quicker and more effective but this wasn't transcending to the other units, when it did, it caused delays and confusion".

3. Full implementation provides greater insights from the data generated. For instance, OM-3 indicated that "*You obviously get far more benefits from the technology when it is fully deployed than when it is partially deployed. Moreover, you are likely to gain additional, unexpected benefits as you use the fully deployed system. That's because you will discover insights from the data that you did not expect. You might also be able to tag a few more things and get benefits you originally did not plan on. For example, we tagged most of our products in order to improve inventory management. But then we were also benefitting from better product availability on the shop floor, we had an idea of what we had in store and helped us calculate how soon we can get it out and ready for customers. This ofcourse means we can plan better. So we have better operational efficiency. So that's how it goes. It's a bit like a chain. Knock-on effects from this to that".*

However, some of the respondents also indicated that full implementation poses a challenge and requires not only expertise but also dedication to keep it profitable. In that regard, SCM-2 stated "*Pilots and partial are good. They allow you to do things at your own pace. You can view and assess the performance of the system in different phases, at different points, or per module, and so on. But as you point out, you also only see the benefits in that light, in that context. For example, if deployed in just one phase in one department, you will have a general idea or to imagine or project what full implementation will be like but you may not necessarily be able to see and accurately assess the full benefits on the whole organisation. That's because full implementation presents its own challenges. Greater data generation so better filtering required, more integration and training of staff is required, likely to have more disruptions, and so on. All these are issues that need to be taken into account. But having said that, if you get those right, then you also gain a lot more benefits*".

Lastly, from the survey results in section 5.9.2, it was observed that when RFID is deployed as a pilot project, the benefits reaped outweigh benefits derived when RFID is implemented partially. When asked about this, the respondents indicated that there were not many differences in benefits between pilot and partial deployments of RFID. This was mainly due to the fact that both systems usually work alongside already existing ones and are executed within limited boundaries. SCM-1 stated "*We are still running a pilot project so I wouldn't be able to compare it with the others. But as it is, we are achieving our objectives of asset tracking and I'm sure we will further expand when the need arises. One of the main reasons for going for a pilot project is that it is less costly and less sophisticated. This allows us, as beginners, to learn the system and easily manage it. I don't believe it will be much different with a partial implementation. I imagine it will have the same effects. With a full rollout however, the ball game changes. Everything is on a bigger scale. There will be a lot more benefits but a lot of sophistication as well*".

Product Unit Level of Tagging (PULT)

The four levels of PULT investigated were item-level, case-level, pallet-level, and container-level. The survey results in Chapter 5 indicate that PULT has a statistically significant relationship with benefits derived from RFID. Building on that, the case study results indicate that the lower the tagging level, the greater the benefits derived. The key findings are as follows:

1. The lower the tagging level, the greater the benefits. The reason tagging individual items delivers more value than cases, pallets or containers is that RFID is an automated and fast way to count and track things. The more things you count, track and manage, the more benefits you receive. But in some cases, tracking items is not necessary. For example, CSO-2 deals with cargo, and so it is more beneficial for them to track pallets or even containers because the cargo remains in the pallet or container before it's shipped or even when it's shipped. This concept can be observed even across other industries. For instance, a car manufacturer might consider it more beneficial to track parts bins than the actual parts because the parts remain within the bins until they are put in a car. The extra money tracking the individual part might not yield much of a benefit. On the other hand, a store where individual items are handled constantly, knowing exact location of a shirt in the store is more important than knowing where the box the shirt came in is.
2. The industrial and business context determines which PULT is the most effective in deriving maximum benefits. In industries like retail where numerous items are tagged and traced, the benefits of item-level tagging are emphasized. OE-3 buttressed this point by stating that "*Certainly item-level is what works the best for us. Most of the goods in our store are tagged to allow us to see where they are at any given time.*

Either in the warehouse or on the shop floor, we know how many shoes, watches, bags are available. As we get our orders delivered every 2 weeks, this is invaluable to us. It automatically feeds the system on what products need to be replenished. I agues it's possible to also do that with cases but mainly in instances where you sell in bulk. We do not do that here so I'm not in a position to speak about it". Similarly, DR-4 emphasis the benefits of item-level tagging "We need to track individual beds, hoists, and other equipment. Item-level is good in showing us where they are at any one time. At the moment, we have not deployed RFID beyond the item-level".

However, it was also observed that in instances where respondents tag at various levels, the benefits derived are not necessarily dependent on the level of tagging but on how the system is being operated. This means that strategies and business procedures affect benefits derived regardless of the PULT. SCM-1 stated that "*I cannot say categorically the impact of tagging levels on benefits. I mean we tag at item-level, pallet-level and container-level here and we derive benefits accordingly. Each level of tagging has its own role to play. For instance, we tag at individual levels when bringing cargo into the warehouse. This enables us to monitor individual items in the warehouse. We then tag at pallet levels when transporting the cargo between warehouses or to the dock or shipping yard. This allows us to monitor cargo in transit and so on. We also tag the containers to know the trucks conveying the cargo and for shipping monitoring. So each application has its benefits".*

Organisational pedigree in RFID

The four levels of organisational pedigree investigated were "fully conversant with aspects of RFID", "understand most of the concepts of RFID", "understand the principles of RFID", and "little knowledge of RFID but operate a working system". The survey results in Chapter 5 indicate that the greater knowledge in RFID, the greater the benefits derived. Building on that, the following key findings were derived from the case studies:

1. Training and capacity development towards ensuring the success of RFID systems was highlighted to be particularly important in determining the benefits derivable from RFID implementation. It was observed that deploying an RFID system usually requires process change. Training people and following up to ensure the new process is followed and RFID is being used correctly is therefore critical. However, it is not necessary for everyone in the company to become an RFID expert. Usually there is a

team that deploys and supports the systems, handles training, answers questions, manages upgrades and so on. This is usually adequate.

2. Some respondents emphasized the importance of knowledge on running an RFID system. Knowledge accumulation and training was found to inform operations from which benefits are subsequently derived. These include processes such as the automatic scanning or tracing of products, data mining, etc. However, some respondents played down the impact of knowledge on benefits derived. They highlighted that only knowledge on the basic principles of RFID operation is required to reap benefits. This was particularly prevalent in organisations that use consultants to handle all complex aspects of the RFID system. In such a case, employees do not need to have complex knowledge on RFID and most learnt by demonstration.

In summary, respondents agree that knowledge in RFID systems and training is important in operating RFID systems and deriving benefits. However, they indicate that expertise is not necessarily required because (i) interfaces are friendly enough to enable employees with light to medium level training to use the system, and (ii) dedicated teams are in place to tackle any complex issues that may arise.

CHAPTER 7 – SUMMARY AND IMPLICATIONS

7.1 Introduction

This thesis investigated three phases of RFID systems deployment. In the pre-adoption phase, it investigated the role of technological, organisational and environmental factors on driving and constraining RFID adoption decisions, and on how those factors are moderated by the strength of an organisational culture, business process re-engineering and business size. Secondly, the study identified the key processes in RFID systems implementation and investigated their interaction with the strength of culture, business process re-engineering, and business size. Six key processes were investigated; project scoping, analysis of existing systems, system design, prototype testing, implementation, and continuous improvement. Lastly, the study investigated how benefits are derived from RFID implementation and how they are moderated by the strength of an organisational culture, business process re-engineering and business size, and by RFID-related factors (RFID implementation stage, organisational pedigree in RFID, and product unit level of tagging).

In doing so, this thesis provides detailed empirical accounts on the influence of different determinants on RFID adoption decisions and the processes involved in RFID systems deployment. The thesis also provides insights on how underlying organisational and technological factors such as culture strength, size, BPR affect RFID adoption decisions, implementation processes, and benefits derived from RFID deployment. It is expected that organisations seeking to adopt RFID, organisations that have already adopted RFID, and practitioners and academics can derive valuable insights from this study that will further stimulate RFID adoption and research.

The succeeding sections present the summary of the findings, the original contribution made by this study, the limitations of this study, and recommendations for further research.

7.2 Summary of findings

The findings are discussed according to the three phases of RFID system deployment i.e pre-adoption phase, implementation phase, and post-implementation phase.

7.2.1 Pre-adoption phase of RFID system deployment

In the pre-adoption phase, the study found that the decision to adopt RFID was influenced by technological, organisational and environmental factors. It was observed that these factors were significant in either driving or constraining organisations towards adoption of RFID. The key findings made are as follows:

1. Overall, technological, organisational and environmental factors were found to have significant relationships in either driving or constraining the adoption of RFID. In terms of drivers, technological factors like "perceived RFID benefits" and "availability of IT/IS infrastructure" were found to play the strongest role in driving organisations towards RFID adoption. This is reflective of the current state of RFID research where multiple studies and business cases have identified applications and benefits of RFID implementation in the supply chain, thus driving organisations towards adoption. The availability of IT infrastructure enables the integration of RFID components with existing legacy systems and provides the platform for organisations to satisfy business and management needs, and enable process changes. As RFID technology adoption requires a huge effort in terms of standardization, convergence of interface protocols, data structures, etc. drive organisations towards adoption.

   Within the organisational context, "top management initiative" was found to play the strongest role in driving organisations towards RFID adoption. Due to the high costs of RFID systems, having adequate financial and technical resources encourages adoption. However, it's the support and encouragement of top management that is key, particularly because the resources and decision-making required for the adoption of new technologies are often the responsibility of top management. Therefore, if the management responsible for these resources support the plans, the likelihood of organisations adopting RFID increases.

   It was found that environmental factors have a direct positive relationship with decision to adopt RFID. In order to keep up with their competitors, follow industry trends, or meet demands and mandates of business partners, organisations are driven towards adopting RFID. Their effort is often propelled by government support in terms of finance and favourable policy formulation.

2. In terms of constraints, in the technological context, “high capital and recurring costs”, “technical issues”, “security issues”, “compliance issues” were found to have a negative direct relationship with “decision to adopt RFID”. “Capital and recurring costs” were found to play the strongest role in constraining organisational decision to adopt RFID. Although, the cost of RFID projects largely depends on the sophistication of the RFID system; the product unit level of tagging i.e. whether RFID tagging occurs at item-level, case-level, pallet-level or container level; and scope of the project/deployment, it has been observed however, that RFID solutions have built a reputation of being grossly expensive, with the prices of tags, readers and middleware cited as constraints of adopting the technology. This is still a popular opinion despite the fact that today, less expensive, more portable and modular RFID components have been designed. For example, technology has been developed to detect tags in motion and those stationary, longer read ranges have emerged, and ability to read tags on metals and in liquids.

   In the organisational context, “manpower shortages” and “degree of process change required” were found to have the strongest negative direct relationship with “decision to adopt RFID”. Despite the fact that software systems related to RFID are becoming more turnkey, making the integration into existing legacy systems and the management of data generated from reading RFID tags easier, the requirements for business process change in order to integrate RFID with an organisation’s existing processes remains the top organisational hindrance factor of RFID adoption. This view is still held likely due to low awareness of the progress made in terms of RFID middleware integration and standardization.

   In the environmental context, “Lack of industry standards” and “privacy issues” were found to have a negative direct relationship with “decision to adopt RFID” and to be the most pertinent constraints of organisational adoption of RFID. Although a lot of progress has been made in terms of standardization in frequency bands between countries, a lot remains to be done in terms of hardware and software standardization. The RFID market is congested, with a massive amount of diverse players such as chip makers, transponder manufacturers, system integrators or consultancies, all of whom offer different, and generally proprietary, products and services. Available systems consist of different frequency ranges, transfer modes, etc.

For a potential adopter, it is difficult to acknowledge the distinct benefits and disadvantages of these different RFID solutions.

In addition to the technological, organisational, and environmental factors discussed in the paragraphs above, the study also investigated the impact of the strength of organisational culture, business size and BPR had significant influence on decisions to adopt RFID. In that regard, the key findings are as follows:

- Firstly, it was observed that strong cultures supportive of innovation have a greater likelihood of adopting RFID. Specifically, it was found that the goals and objectives of an organisation play a crucial role in shaping employees' collective and individual understanding of the targets and visions of the organisation – enabling employees to set personal goals and define agendas. This study has found that organisations with clearly outlined goals and objectives and those keen to stick to or enforce them, albeit in a flexible yet steadfast approach, set the precedent for the development of innovative ideas and innovative technologies. As adopting RFID is largely dependent on shared vision and mission, regarding its implementation as a crucial means towards achieving organisational targets helps drive organisations towards adopting the technology.

  Other key dimensions of strong organisational culture that drive RFID adoption is the support and encouragement from top management and effective decision making. Top management support affects organisations' decision-making strategies and financial resource allocations.
- Secondly, the thesis findings indicate that business size has a significant direct positive relationship with organisational decision to adopt RFID. Overall, the results indicate that the superior resources (financial and non-financial) of larger organisations makes them more likely to adopt RFID than SMEs. Larger organisations have more financial resources to not only face the burden of high capital costs of RFID systems but to also hire specialized/skilled workforce. In addition, larger organisations tend to have more capable and sophisticated IT infrastructure in place, thereby providing the necessary technical platform for RFID systems integration.

  Larger organisations also have a greater international reach, with their partners and supply chains likely to span across countries. This means that coordination of processes between all stakeholders becomes even more important, leading to their adoption of RFID. However, overall, restricted resources of SMEs is regarded as the major differentiator between RFID adoption in SMEs and large organisations.

- Thirdly, the thesis findings indicate that there is a significant direct positive correlation between BPR and RFID adoption. It was found that synchronization of business processes and IT resources, and the streamlining of business processes play a crucial role in the decision to adopt RFID. They offer organisations the opportunity to remove any non-value added activities from their processes and to enable greater integration and synergy between existing legacy systems and incoming RFID systems. In cases where resources and processes are consolidated, it was found that decentralizing business processes such as decision-making encourages the adoption of RFID.

7.2.2 Implementation phase of RFID system deployment

In the implementation phase, the thesis examined the impact of the strength of organisational culture, business size, and BPR on the implementation processes of RFID. Six RFID implementation processes were investigated. These are “project scoping”, “analysis of existing systems”, “design of RFID system”, “prototype testing of RFID system”, “implementation of RFID system”, and “continuous improvement”. The key findings are as follows:

1. Firstly, the findings indicate that strong culture has a significant direct positive relationship with RFID implementation processes. The results indicate that the strength of culture is important for organisations because it affects strategic expansion, efficiency, and learning at all levels of management. The first phase of RFID implementation is project scoping. Project scoping of RFID systems typically involves defining the objectives and understanding the potential benefits and limitations of the proposed system. Strong culture with clearly outlined goals and objectives will help give a clear direction to the RFID implementation team, in terms of developing strategies for deployment. This is important because it prevents organisations from creating unrealistic expectations of the proposed system.

   The second phase of RFID implementation is the analysis of existing systems, in which data collection is a critical component. The strength of culture affects the techniques, strategies, and efficiency of data collection. The details of the processes of an existing system are often collected by various methods, such as conducting interviews with the key individuals and front-line staff who use the present system, collecting comments from stakeholders, and eliciting experts' opinions. In strong cultures, support from top management is readily available to support processes including collecting data to identify the limitations of existing systems. Thus, organisations with a strong culture support effective data collection and analyses, through the support of top management and adequate allocation of financial and technical resources, are more likely to implement RFID, and make a success of it.

The third phase of RFID implementation is the "design of RFID system". The system design stage includes requirement analysis, hardware and software selection, and the development of the new process. In strong cultures, support from top management and clear outlining of organisational goals and objectives assist the implementation team in performing requirement analysis. This is done so as to thoroughly understand the ways in which RFID technology can address the problems identified in the existing systems, identify and select the appropriate software and hardware for the proposed system, and map out and develop new business processes.

Before the actual implementation of the RFID system, it is very important to conduct a pilot test, so as to understand the system and establish its readiness for deployment. Prototype testing is the fourth phase of RFID implementation. It may be conducted in the laboratory or in the actual business environment. The key stages of prototype testing include debugging and system adaptation. Organisations with strong culture attributes such as top management initiative and effective decision making are more likely to make a success of the prototype testing phase of RFID implementation. This is because, apart from debugging the technical system and eliminating the mistakes in the analyses, prototype testing also includes collecting feedback from users after the pilot testing. This is designed as such in order to elicit comments on the various user interfaces and in order to fine tune their design. Thus, this feedback collection process is influenced by the culture strength of the organisation.

On the successful completion of prototype testing, the next phase is the implementation of the system in the actual business environment. Implementation involves the installation and commissioning of hardware and software systems, and change management, training and system deployment. All of the tasks in the implementation step are vital, as they will affect the success of the implementation. Many aspects of strong organisational culture including top management initiative, clear outlining of organisational goals and objectives, focus on organisational performance relative to competitors, and drive to introduce new technologies into business processes influence the success of system deployment, installation and commissioning of hardware and software systems, as well as developing the new procedures.

The last step for RFID implementation is continuous improvement. Organisations continuously evaluate the system's performance and compare it with the pre-set objectives, enhance the system with emergent technologies, or else adapt it to match the changing needs of the market. This step includes the tasks of system monitoring and the collection of user feedback. Organisations strong culture attributes such as top management initiative, drive to introduce new technologies, and focus on their performance relative to their competitors are likely to continuously improve their RFID system so as to adapt it to dynamic business environments, and make it more effective.

2. Secondly, the results indicate that business size has a significant direct positive relationship with RFID implementation processes. The annual turnover, number of employees, IT/IS infrastructure were found to be particularly pertinent in influencing the different processes of RFID implementation. The size of an organisation affects its financial resources and the availability of skilled workforce. The implementation of IS systems like RFID and its components requires long term investment and technical expertise, therefore larger organisations which have adequate financial and technical resources are more capable of making a success of RFID implementations, and developing a clear scope and objectives in implementing the system.

   Specifically, the impact of the size of an organisation comes into effect in RFID implementation processes like the analysis of existing systems. Analyzing existing systems involves collecting information about the operation processes, and the analysis and evaluation of the current processes. This is usually performed by using the diagramming techniques and tools that have been agreed upon by the key individuals who are currently using the system. By examining the current process with the aid of workflow diagrams, areas for improvement can be identified. Larger organisations have (i) greater number of employees and so could appoint the right candidates to study the existing system; (ii) greater annual turnover, so could allocate more resources to the tasks; and (iii) have better IT/IS infrastructure so have access to diagramming techniques and tools used for analysing existing systems.

In designing the RFID system, the selection of appropriate hardware and software is an essential process. This is to understand the characteristics of each element of hardware and software and to decide which option is more suitable for the current environment. Accordingly, the financial resources and IT/IS infrastructure of organisations influences the selection and testing of hardware and software in the design of a proposed system. The financial resources and IT/IS infrastructure of organisations also influence the development of new processes (based upon the knowledge of the current processes). Similarly, business size impacts the prototype testing phase of RFID implementation. Prototype testing covers both software and hardware tests in order to detect bugs and system collisions. Technical staff are usually involved so as to support the testing and in order to resolve (debug) any technical problems detected in the test. The number of employees and technical expertise and resources will thus affect the success of the prototype testing phase of RFID implementation. This suggests that larger organisations are more likely to make a success of the prototype testing phase as they have superior resources than SMEs in terms of workforce and expertise.

Lastly, business size impacts continuous improvement phase of RFID implementation. After system deployment, the performance of the RFID solution needs to be closely monitored - especially in the early stage of implementation - so that the project team can quickly respond to the problems encountered. Additionally, collection of feedback from users, and training them to use the new system are also essential aspects of continuous improvement. Therefore, the availability of funds to train users, availability of skilled workforce, IT/IS infrastructure, and range of products/services are likely going to influence the direction organisations take in order to continuously improve their existing RFID systems to match changing market needs.

3. Thirdly, the results indicate that there is a significant direct positive correlation between BPR and RFID implementation processes. The redesign of business processes and systems, and the synchronization of business processes and IT resources are seen

to play a crucial role in the determining the success of RFID implementation processes. BPR also influences key aspects of the RFID implementation process such as “continuous improvement” especially when organisations come to align their dynamic capabilities with the environment and optimize their business processes.

In designing an RFID system, the organisation design the way in which the readers are connected to the network and the software architecture, including the RFID middleware and the application level software. The BPR of business processes involves the restructuring and streamlining of business processes and activities. Accordingly, BPR influences the design of RFID systems as it would give decision-makers a clearer picture of how the hardware and software items function in an integrated system, as well as providing data for measuring the reliability of the proposed system.

Protoype testing of RFID systems involves the adaptation of processes to ensure that the RFID system will deliver the expected performance results. BPR involves the redesigning of systems and processes and thus affects the recording and review of problems found during the pilot testing and thus has an effect on efforts to fine-tune the system and resolve the identified problems. Additionally, BPR involves the redesigning of systems and processes including centralization/decentralization of resources. Consequently, BPR influences the integration of hardware systems into existing business processes, the deployment of decision-support tools and strategies and other aspects of continuous improvement.

7.2.3 Post-implementation phase of RFID system deployment

The post-implementation phase examined the impact of the strength of organisational culture, business size, and BPR on the benefits derived from RFID implementation. It also examined the impact of RFID-related factors on benefits derived from RFID implementation. The RFID related factors investigated are Product Unit Level of Tagging (PULT), organisational pedigree in RFID, and RFID implementation stage. The benefits derived from RFID were divided into four categories proposed by Kaplan and Norton (2004), namely, financial measures; internal processes; corporate measures; and learning and growth. The key findings in that regard are as follows:

1. Firstly, the findings indicate that strong organisational culture has a significant direct positive relationship with all four categories of RFID benefits. The results indicate that

strong organisational culture where support from top management is readily available, goals and objectives are pre-set and carefully outlined, and where training and support is available for employees are essential in making a success of RFID implementation, and deriving benefits from the implementation.

2. Secondly, the results indicate that business size has a significant direct positive relationship with all four categories of RFID benefits. Annual turnover and IT/IS infrastructure in particular, were found to be particularly pertinent in influencing the benefits derived from RFID implementation. Larger organisations tend to have more financial and technological resources to hire specialized/skilled workforce, extensively train users of RFID systems to become conversant with operating the system, and integrate necessary hardware or software required to have seamless synchronization of RFID system with existing IS systems. These are critical steps in making the most of RFID solutions.
3. Thirdly, the results indicate that there is a significant direct positive correlation between BPR and all four categories of RFID benefits. The redesign of business processes and systems, and the synchronization of business processes and IT resources are seen to play a crucial role in the determining the success of RFID implementation processes, and benefits derived thereof. BPR also influences key aspects of the RFID implementation process such as "continuous improvement" especially when organisations come to align their dynamic capabilities with the environment and optimize their business processes. These in turn, allows the RFID system to be improved to realize more benefits, overtime.

In terms of the impact of RFID-related factors on RFID benefits, the following key findings were made:

- Firstly, the findings from this study indicate that RFID implementation stage has a significant direct positive relationship with all four categories of RFID benefits. This is important because despite RFID's potential to improve supply chain processes and offer significant business advantage, there have been more pilots and trials than full-scale implementations. However, our results indicate that a full roll-out of RFID implementation offers significantly greater benefits than when partially implemented or trialled as a pilot project. This is because fully implementing RFID allows for insights to be gained from the RFID data generated, which often leads to additional unexpected benefits.

- Secondly, the findings indicate that product unit level of tagging (PULT) has a significant direct positive relationship with all four categories of RFID benefits, and that the lower the tagging level, the greater the benefits derived. However, this depends on the industrial application of RFID. For example, item-level tagging accrues more benefits than case, pallet, or container level tagging in industries dealing with high value products, multiple handled products, or sensitive products including retail, pharmaceutics, and logistics industries. In logistics industries, pallet-level or container-level tagging may offer the most benefits.
- Lastly, the findings indicate that organisational pedigree in RFID has a significant direct positive relationship with all four categories of RFID benefits. Generally, the greater the knowledge on RFID, the more benefits derived. This could be due to the fact that specialized/skilled workforce is required to deploy and operate the system, to extensively train users of the system to become conversant with operating the system, and to integrate necessary hardware or software required to have seamless synchronization of RFID system with existing IS systems. However, in instances where RFID integrators or consultants are used, employee knowledge on RFID is not as important.

7.3 Implications and original contribution from this study

The development of this study was motivated by the lack of (i) practical advisory framework which considers quantifiable firm characteristics and the costs and benefits of implementing RFID, in yielding advice to guide decisions on RFID adoption, and (ii) a framework that covers the complete processes of RFID project deployment (from adoption decision to benefits derived) in yielding advice to guide decisions on RFID adoption. This thesis set out to close that gap and hence makes the following contributions.

1. The first contribution of this thesis is that it provides detailed empirical accounts of the different determinants of RFID adoption across a variety of contexts. Although numerous studies (Alqahtani and Wamba, 2012; Schmitt and Michahelles, 2009; Huber et al., 2007; Eckfeldt, 2005; Swanton, 2005; Asif and Mandviwalla, 2005; Walker, 2004) provide evidence that a variety of factors influence whether

organisations will adopt RFID systems, many of the studies simply focus on the technology itself, often disregarding broader societal, organisational, cultural, and environmental factors that often determine how a new technology is adopted. Thus, those studies have fallen short of drawing important conclusions that can be applied in practice. This study fills that gap by adding new perspectives to the study of determinants of RFID adoption by investigating drivers and barriers of RFID adoption across technological, organisational and environmental contexts; including investigating privacy, security, regulatory, and cultural aspects of RFID adoption.

In doing so, the thesis provides new insights on factors that drive and constrain RFID adoption based not only on theoretical technological adoption models but also on social and industrial processes by which diffusion of innovation/technology occurs.

The implication is that the findings will help organisations that have adopted RFID and those seeking to adopt RFID to understand the concepts of RFID adoption and identify and analyse factors that drive and constrain RFID adoption decisions. This will support them in weighing the perceived benefits and balancing them against the costs, before making optimal decisions to adopt RFID or not.

2. The second contribution of the thesis is that it provides insights into the impact of the strength of organisational culture on RFID decision, implementation processes, and benefits derived. Although numerous studies have investigated the role of organisational culture in activating or inhibiting technological innovation, this thesis builds on those studies and adds value by highlighting the significance of organisational culture strength in providing a platform in which RFID will be accepted and implemented to achieve maximum derivable benefits. In doing so, this thesis investigates the dimensions of strength of culture that are not just based on typical ideal organisations or the importance of leadership in creating ideal organisations but also on organisational (structural, managerial, and social) subsystems and the external environment.

   The implication is that the findings offer practitioners practical insights or guidelines towards understanding and pinpointing which aspects of their corporate culture affect their adoption, implementation, and benefits of RFID. This will enable that have adopted RFID or those seeking to adopt RFID in aligning their internal characteristics and capabilities with RFID implementation requirements and procedures.

3. The third contribution of this thesis is that it provides empirical accounts of the impact of business size on RFID adoption decision, implementation processes, and benefits. Previous studies on the impact of business size on RFID adoption considered business size as a single dimensional construct. For instance, many studies investigated impact of number of employees on IT adoption. This thesis adds value by investigating business size as a multidimensional latent variable, with dimensions from managerial, structural, environmental and organisational contexts. The implication of this is that factors that are known to be significant in determining the adoption of RFID solutions, for example, number of skilled workforce, management structure, international reach, IT infrastructure, and number of offices, warehouses and service centres are investigated. The implication is that the findings can be applied more widely and be used to draw conclusions that can be applied in practice.

   It is expected that the findings will offer practitioners a more realistic approach towards understanding how the size of their organisation or how size-related organisational changes impact RFID adoption decisions, subsequent implementation processes, and benefits derived.

4. The fourth unique contribution of this thesis is that it provides empirical insights into the impact of BPR on RFID adoption decisions, implementation processes, and benefits. To the best of our knowledge, studies on the impact of BPR, specifically on RFID technology, are lacking. Previous studies either focus on theoretical discussion of successful factors of business process reengineering (BPR) or employ a case study approach that offers insights for IT implementation strategies based on a specific firm's experience (Pan and Jang, 2008; Shin, 2006). Thus, this study addresses that gap by providing insights on the impact of BPR on the decision to adopt RFID, RFID implementation processes and benefits and considering inter-relationships between the decision to adopt RFID, RFID-enabled BPR, and related performance outcomes and benefits. As organisations are constantly evolving within a dynamic environment of increasing complexity, it is valuable to assess these interrelationships.

   Findings in this study provide insights into how organisations can design a framework through which they can achieve aligning their dynamic capabilities with the environment and optimizing business processes. Also, it would enable organisations to bring forward policies and frameworks that encourage and guide BPR for RFID implementation.

Overall, this thesis provides insights and acts as a useful reference to help managers to understand how RFID should be implemented along with the activities and issues that need to be considered in implementing RFID systems. Managers find it difficult to make decisions on the implementation of RFID systems due to a lack of knowledge about RFID technology. Unfamiliarity with the system leads to creating unrealistic expectations and erroneous perceptions about the benefits that an RFID system can deliver. With contributions from this study, organisations would be able to assess the factors that drive them towards adoption and weight them against perceived costs. Organisations will also have a better understanding on how their internal characteristics (organisational culture strength, size, and BPR) influence the deployment of RFID and benefits derived thereof. This will help them to understand how to make a success of each phase of RFID implementation and to be able to realistically manage their expectations.

7.4 Recommendations for practitioners and researchers

Findings obtained from this study provide insights on strategies for promoting and accelerating the adoption of RFID by organisations, the deployment processes of RFID and their interactions with organisational characteristics, and the factors that determine the extent to which benefits are derived from RFID deployments. This will enable practitioners to make informed decisions of RFID adoption and optimize their processes to derive the most benefits from RFID solutions. Based on the findings, the following recommendations could be considered in order to stimulate interest of organisations to adopt RFID.

1. Government policies and financial assistance are needed to stimulate interest of potential adopters, particularly SMEs, which are often deterred by the financial burden of RFID systems, despite having strong needs for the technology.
2. Success stories of RFID implementations, along with guidelines for such implementations should be shared amongst industry corporate executives in order to promote successful business cases and stimulate interest of other potential adopters. Industry participation and collaboration through shared learning and experience from pilots is a significant driver of RFID adoption. However, collaboration does not exist in

numerous industries at the moment. Therefore, the RFID industry needs to address this.

3. Training programmes and technical consulting should be made more accessible so as to assist organisations in understanding the RFID systems and determining whether RFID is compatible with their existing systems and processes. These programmes could be provided by independent media/technology companies such as RFID Journal, NGOs, or through government policies.
4. Organisational culture, size, and BPR are significant determinants of RFID adoption and should be studied in greater detail by future researchers. Future researchers should conduct multi-industry comparative studies to consider the role of industry-related parameters on the decision to adopt RFID.
5. As discussed in the literature review chapter of this thesis, numerous studies highlight the contribution of RFID in supporting supply chain processes such as enabling more responsive and efficient logistics activities, improving product quality, customer satisfaction, and hence overall supply chain efficiency (Mehrjerdi, 2013; Zelbst et al. 2012; Wang et al. 2011; Brusey and McFarlane, 2009). However, realizing these benefits is dependent on the nature, efficiency and effectiveness of intra- and inter-organisational culture, processes and information systems. Therefore, further research is needed, on the one hand, to explore the impact of RFID on legacy information systems and intra- and inter-organisational setups and processes, and, on the other hand, to identify and understand how these processes can be optimized by RFID.
6. There is equally a need to concretely characterize what “benefits” imply. For example, in the case of business benefits, it is necessary to map the dimensions and sub-dimensions that may be used to define business benefits. Future researchers could build on this study to investigate how the benefits of RFID are likely to be moderated by factors such as business/industrial sector of the firm, product line, business structure, existing information technologies and systems, the external environment, etc. The external environment is determined by elements such as the available basic infrastructure, present communication systems, economic conditions, regulatory policies, taxation, culture, skills market, manpower costs, and climate. The extents to

which these factors influence the benefits derivable from RFID investments have not been well studied in the extant literature.

7. IoT is a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols. RFID is considered to be one of the sensory organs of the IoT. The integrity of the data collected by RFID systems and appropriate curbs on the technology's wireless power are essential. However, the communications bandwidth between RFID tags and readers needs to be improved. Further research is required in designing a system that can boost data rate and could be used to transmit images and possibly video if enough energy could be harvested.

8. Although this study offers insights into the impact of BPR on RFID implementation, there are areas requiring further research. For example, in a survey of RFID user community, Musa et al. (2014) found that users prefer open and interoperable systems to proprietary systems (tags, readers, middleware, and data exchange infrastructure and formats between RFID and legacy backend ERP systems). However, the development of compatible RFID platforms and systems seems is still far behind expectation. Full compatibility between RFID systems, and between RFID and other sensor types and communication protocols, is needed if RFID is to play the roles that have been projected for it in the era of Internet of Things (IoT). Fortunately, industry and government directives are gradually leading to common standards across industries and technologies, permitting future interoperability across devices (Wu et al., 2013; Farris et al., 2013; Xu and Chen, 2013; Gao et al., 2012).

7.5 Limitations of this study

There are a number of limitations to the study. Firstly, the study surveyed organisations from multiple countries in the questionnaire but could only gain access to case study organisations within the UK. Although, the case study organisations were across different industrial sectors, the opportunity to assess differences (if any) in responses that could be attributed to foreign cultures was lost. Secondly, data collected on the aspects of RFID implementation was primarily from managers (rather than through direct observation). This presents the possibility of bias in responses. However, the potential biases cannot be verified without direct observation of the phenomenon (Woodside and Wilson, 2003). In similar regard, RFID systems these days are mostly deployed by integrators or consultants, who are more knowledgeable in the processes involved and can give first-hand accounts of their experiences. However, getting hold of consultants to give information on projects they executed years ago is a difficult task. So, this study was limited in gaining first-hand accounts on some of the processes investigated.

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APPENDICES

Appendix A – Questionnaire (Survey instrument)

Questionnaire on RFID adoption decision, implementation, and benefits

Dear Sir/Madam,

Re: Research questionnaire on RFID adoption in UK companies

I am a PhD student at the University of Central Lancashire, Preston, UK. I am undertaking a research project to establish the relationship between the adoption of Radio Frequency Identification (RFID) technology and business performance.

The project investigates the links between organisational characteristics and RFID adoption, implementation process, and benefits. I would very much appreciate your contribution to this important research by completing this questionnaire. It will take only a short time (approx. 20 minutes) to complete this questionnaire, as most of the questions require only a tick. It will be most helpful if you could be as accurate as possible and return your responses within a week.

All information obtained in this study will be used for academic purposes only; your identity and that of your company will be kept strictly confidential.

If you are interested, a summary of the findings of the research will be made available to you. A check box is provided at the end of the questionnaire to this effect.

If you have any questions please contact me on phone +447760983842 or by email at aadabo@uclan.ac.uk.

Thank you for your time and support.

Sincerely,

Al-Amin Abba Dabo

PART I – COMPANY DETAILS

1. Respondent's organization/company

2. Respondent's name (if the respondent is willing to provide it)

3. Respondent's post or position in the organization

4. Contact telephone number (if the respondent is willing to provide it)

5. Respondent's or company's email address

6. In which year was your company established?

7. How many people work in your organization?

   1-10 ☐ 11-50 ☐ 51-250 ☐ 251-500 ☐ 501 and above ☐

8. What is your company's annual turnover?

   <£2m ☐ £2m-10m ☐ £11m-£50m ☐ £51m-100m ☐ >£100m ☐

9. How would you describe your business in terms of its nature? Please tick as many as applicable.

Manufacturing – Industrial ☐	Retail: Specialty merchandising ☐
Manufacturing – Consumer ☐	Logistics & physical distribution ☐
Mining (including oil and gas) ☐	Defense and security ☐
Retail: General merchandising ☐	Transport (including aviation) ☐
Other (please specify) ………………………………………………………………… ☐	

10. How would you describe your business in terms of its sector? Please choose one.

Healthcare ☐	Asset and facilities ☐	Military and/or military aviation ☐
Automotive ☐	Finance and banking ☐	Education/publishing ☐
Civilian aviation ☐	Consumer goods ☐	Professional services ☐
Agriculture ☐	Other(s) (please specify) ………Aerospace ☐	

11. What legal form of company is your organization?

Sole proprietorship ☐	Public Limited Company (Plc) ☐	Private Limited Company (Ltd) ☐
Partnership ☐	Private Unlimited Company ☐	Other (specify) .... ☐

PART II – RFID TECHNOLOGY

12. **Has your company adopted RFID technology?** Yes ☐ No ☐

If yes, please answer ONLY questions 13 to 25. If no, please go to question 26 and complete to the end of the survey.

13. Which of the following best describes your state of RFID technology adoption?

Currently in pilot stage on RFID adoption	☐
Currently in partial RFID implementation stage	☐
Currently in full RFID implementation stage	☐

14. How long has your company been using RFID technology for?

<1 year ☐ 1-5 years ☐ 6-10 years ☐ 11-15 years ☐ >15years ☐

15. Which of the following situations best describes your company's knowledge of RFID (please choose one)?

Fully conversant with all aspects of RFID	☐
Understand most of the concepts of RFID	☐
Understand the principles of RFID	☐
Little knowledge of RFID principles but the system works for us	☐

16. Which of the following is the single MOST compelling reason to adopt RFID?

Lack of product visibility ☐	Return processing costs ☐	Stock-outs ☐
High inventory costs ☐	Replenishment cost ☐	Industry mandates ☐
Missed fulfillment commitments ☐	Lack of demand visibility ☐	Inventory shrinkage ☐
Pressure from partner company ☐	Low inventory turns ☐	Other (please specify) ………………………………. ☐

17. At what product level is your company implementing RFID? Tick as many as applicable.

Item level ☐ Case level ☐ Pallet level ☐ Container level ☐ Other ……………. ☐

18. **To what extent has RFID technology been adopted across your company?**

10-20% ☐ 21-40% ☐ 41-60% ☐ 61-80% ☐ 81-100% ☐

19. **In which of the following areas do you see the most use of RFID in your industry?**

Business-to-business logistics	☐
Internal operations	☐
Business-to-customer marketing and logistics	☐
Business-to-customer after-sales service	☐

20. **Who is the key champion or has the greatest responsibility in your company for RFID adoption? Please choose one.**

Chairman	☐	Supply chain manager/director	☐
CEO/MD	☐	Technical specialist	☐
Executive Director	☐	Sponsorship from business partner	☐

21. **To what extents have the following factors influenced your company's decision to adopt RFID?**

	None	Low	Moderate	High	Very high
Drivers of adoption					
Top management support	☐	☐	☐	☐	☐
Availability of IS/IT infrastructure	☐	☐	☐	☐	☐
Financial readiness/affordability	☐	☐	☐	☐	☐
Perceived RFID benefits	☐	☐	☐	☐	☐
Organisational technical capability	☐	☐	☐	☐	☐
Desire to achieve lean processes	☐	☐	☐	☐	☐
Effective data sharing with supply chain partners	☐	☐	☐	☐	☐
Perceived RFID standards convergence	☐	☐	☐	☐	☐
Competitive pressure	☐	☐	☐	☐	☐
Industry pressure	☐	☐	☐	☐	☐
Professional & trade association pressure	☐	☐	☐	☐	☐
Favourable transactional climate	☐	☐	☐	☐	☐
Regulatory pressure	☐	☐	☐	☐	☐
Dominant partner pressure	☐	☐	☐	☐	☐
Government support	☐	☐	☐	☐	☐
Media pressure	☐	☐	☐	☐	☐
Global expansion	☐	☐	☐	☐	☐

22. **To what extent have the following measures of business performance been impacted by your organisation's adoption of RFID?**

	None	Low	Moderate	High	Very high
Financial measures					
Sales increase attributable to RFID	☐	☐	☐	☐	☐
Net profit attributable to RFID	☐	☐	☐	☐	☐
Return-on-investment attributable to RFID	☐	☐	☐	☐	☐
Market share gains attributable to RFID	☐	☐	☐	☐	☐
Cost reduction attributable to RFID	☐	☐	☐	☐	☐
Labour savings attributable to RFID	☐	☐	☐	☐	☐
Internal processes					
Risk minimization attributable to RFID	☐	☐	☐	☐	☐
Reduction of inventory attributable to RFID	☐	☐	☐	☐	☐
Improved product availability attributable to RFID	☐	☐	☐	☐	☐
Improved transaction accuracy attributable to RFID	☐	☐	☐	☐	☐
Improved visibility attributable to RFID	☐	☐	☐	☐	☐
Reduced out-of-stock items attributable to RFID	☐	☐	☐	☐	☐
Improved supply chain planning attributable to RFID	☐	☐	☐	☐	☐
Higher rate of complete orders attributable to RFID	☐	☐	☐	☐	☐
Improved data integrity attributable to RFID	☐	☐	☐	☐	☐
Electronic traceability attributable to RFID	☐	☐	☐	☐	☐
Improved sourcing of new products attributable to RFID	☐	☐	☐	☐	☐
Increase in transportation efficiency attributable to RFID	☐	☐	☐	☐	☐
Corporate/Customer measures					
Improved corporate social responsibility attributable to RFID	☐	☐	☐	☐	☐
Improved business sustainability attributable to RFID	☐	☐	☐	☐	☐
Environmental compliance attributable to RFID	☐	☐	☐	☐	☐
Improved organizational learning attributable to RFID	☐	☐	☐	☐	☐
Improved health and safety attributable to RFID	☐	☐	☐	☐	☐
Customer retention attributable to RFID	☐	☐	☐	☐	☐
Enhanced staff motivation attributable to RFID	☐	☐	☐	☐	☐
Learning and growth					
More accurate forecast of demand attributable to RFID	☐	☐	☐	☐	☐
Increase in organisational knowledge accumulation attributable to RFID	☐	☐	☐	☐	☐
Enhancement of employee satisfaction attributable to RFID	☐	☐	☐	☐	☐
Improvement in employees' RFID-related skills and proficiency	☐	☐	☐	☐	☐

23. Before your organisation's adoption of RFID, to what extents have the following factors hindered its decision to adopt it?

	None	Low	Moderate	High	Very high
Cost issues	☐	☐	☐	☐	☐
Manpower (skills) issues	☐	☐	☐	☐	☐
Compliance issues	☐	☐	☐	☐	☐
Privacy issues	☐	☐	☐	☐	☐
Security issues (e.g., identity theft)	☐	☐	☐	☐	☐
Technical issues	☐	☐	☐	☐	☐
Lack of industry standards	☐	☐	☐	☐	☐
A Requirements for business process change required	☐	☐	☐	☐	☐
The unwillingness of the customer and supplier to use it	☐	☐	☐	☐	☐

24. **Rate the extent to which the following factors affected your organisation's adoption of RFID.**

Note: *By business process re-engineering, we are referring to the redesign and/or streamlining of work process in order to achieve significant levels of improvement in quality, time management, and cost.*

	None	Low	Moderate	High	Very high
Organisational culture measures					
Company goals and objectives	☐	☐	☐	☐	☐
Company focus on its performance relative to its competitors	☐	☐	☐	☐	☐
Company focus on customer satisfaction	☐	☐	☐	☐	☐
Top Management initiative	☐	☐	☐	☐	☐
Effective decision making	☐	☐	☐	☐	☐
Drive to implement new technologies into business processes	☐	☐	☐	☐	☐
Business size measures					
Number of employees	☐	☐	☐	☐	☐
Annual turnover	☐	☐	☐	☐	☐
International reach	☐	☐	☐	☐	☐
IT/IS infrastructure	☐	☐	☐	☐	☐
The number of office locations, retail outlets, service centres, etc.	☐	☐	☐	☐	☐
Product/service range	☐	☐	☐	☐	☐
Business process re-engineering (BPR) measures					
Data standardization and integration	☐	☐	☐	☐	☐
Restructuring and streamlining of business processes and activities including removal of non-value added tasks, controls and checks	☐	☐	☐	☐	☐
Decentralization of consolidated resources and processes	☐	☐	☐	☐	☐
Provision of decision-support tools	☐	☐	☐	☐	☐
Synchronization of IT resources and business processes	☐	☐	☐	☐	☐

25. **Rate the extent to which the following factors affect the benefits your organisation derives from RFID.**

	None	Low	Moderate	High	Very high
Organisational culture measures					
Creating strong internal and external motivation for improvement	☐	☐	☐	☐	☐
Developing a clear RFID strategy	☐	☐	☐	☐	☐
Innovation	☐	☐	☐	☐	☐
Provision of training and support for employees	☐	☐	☐	☐	☐
Top management support and commitment from leadership	☐	☐	☐	☐	☐
Organisational knowledge accumulation	☐	☐	☐	☐	☐
Business size measures					
Number of trained/skilled employees	☐	☐	☐	☐	☐
IT/IS infrastructure	☐	☐	☐	☐	☐
Annual turnover	☐	☐	☐	☐	☐
International reach	☐	☐	☐	☐	☐
The number of office locations, warehouses, retail outlets, and service centers deploying RFID	☐	☐	☐	☐	☐
Range of products/services using RFID	☐	☐	☐	☐	☐
Business process re-engineering (BPR) measures					
Adoption of flexible deployment architecture	☐	☐	☐	☐	☐
Continuous review and improvement of procedures	☐	☐	☐	☐	☐
Restructuring and streamlining activities including removal of non-value added tasks, controls and checks	☐	☐	☐	☐	☐
Integration and management of large amounts of data	☐	☐	☐	☐	☐
Centralization of dispersed resources and processes	☐	☐	☐	☐	☐
Synchronization of business processes and IT resources	☐	☐	☐	☐	☐

NOTE: ***Answer Q26 to Q29 only if you have answered "No" to Q12***

26. **Although your company hasn't yet adopted RFID, to what extents will the following factors influence its decision to adopt it?**

	None	Low	Moderate	High	Very high
Drivers of adoption					
Top management support	☐	☐	☐	☐	☐
Availability of IS/IT infrastructure	☐	☐	☐	☐	☐
Financial readiness/affordability	☐	☐	☐	☐	☐
Perceived RFID benefits	☐	☐	☐	☐	☐
Organisational technical capability	☐	☐	☐	☐	☐
Perceived RFID standards convergence	☐	☐	☐	☐	☐
Competitive pressure	☐	☐	☐	☐	☐
Industry pressure	☐	☐	☐	☐	☐
Professional & trade association pressure	☐	☐	☐	☐	☐
Favourable transactional climate	☐	☐	☐	☐	☐
Regulatory pressure	☐	☐	☐	☐	☐
Dominant partner pressure	☐	☐	☐	☐	☐

Government support	☐	☐	☐	☐	☐
Media pressure	☐	☐	☐	☐	☐
Global expansion	☐	☐	☐	☐	☐

27. Although your company hasn't yet adopted RFID, to what extents will the following factors hinder its decision to adopt it?

	None	Low	Moderate	High	Very high
Cost issues	☐	☐	☐	☐	☐
Manpower (skills) issues	☐	☐	☐	☐	☐
Compliance issues	☐	☐	☐	☐	☐
Privacy issues	☐	☐	☐	☐	☐
Security issues (e.g., identity theft)	☐	☐	☐	☐	☐
Technical issues	☐	☐	☐	☐	☐
Lack of industry standards	☐	☐	☐	☐	☐
A Requirements for business process change required	☐	☐	☐	☐	☐
The unwillingness of the customer and supplier to use it	☐	☐	☐	☐	☐

28. Rate the extents to which the following factors will affect your organisation's adoption of RFID

Note: *By business process re-engineering, we are referring to the redesign and/or streamlining of work process in order to achieve significant levels of improvement in quality, time management, and cost.*

	None	Low	Moderate	High	Very high
Organisational culture measures					
Company goals and objectives	☐	☐	☐	☐	☐
Company focus on its performance relative to its competitors	☐	☐	☐	☐	☐
Company focus on customer satisfaction	☐	☐	☐	☐	☐
Top Management initiative	☐	☐	☐	☐	☐
Effective decision making	☐	☐	☐	☐	☐
Drive to implement new technologies into business processes	☐	☐	☐	☐	☐
Business size measures					
Number of employees	☐	☐	☐	☐	☐
Annual turnover	☐	☐	☐	☐	☐
International reach	☐	☐	☐	☐	☐
IS/IT infrastructure	☐	☐	☐	☐	☐
The number of office locations, retail outlets, service centers, etc.	☐	☐	☐	☐	☐
Product/service range	☐	☐	☐	☐	☐
Business process re-engineering (BPR) measures					
Data standardization and integration	☐	☐	☐	☐	☐
Restructuring and streamlining of business processed and activities including removal of non-value added tasks, controls and checks	☐	☐	☐	☐	☐
Decentralization of resources and processes	☐	☐	☐	☐	☐
Provision of decision-support tools	☐	☐	☐	☐	☐
Synchronization of IT resources and business processes	☐	☐	☐	☐	☐

29. **Rate the extent to which the following factors will affect the benefits derived from RFID**

	None	Low	Moderate	High	Very high
Organisational culture measures					
Creating strong internal and external motivation for improvement	☐	☐	☐	☐	☐
Developing a clear RFID strategy	☐	☐	☐	☐	☐
Innovation	☐	☐	☐	☐	☐
Provision of training and support for employees	☐	☐	☐	☐	☐
Top management support and commitment from leadership	☐	☐	☐	☐	☐
Organisational knowledge accumulation	☐	☐	☐	☐	☐
Business size measures					
Number of trained/skilled employees	☐	☐	☐	☐	☐
IT/IS infrastructure	☐	☐	☐	☐	☐
Annual turnover	☐	☐	☐	☐	☐
International reach	☐	☐	☐	☐	☐
The number of office locations, warehouses, retail outlets, and service centers deploying RFID	☐	☐	☐	☐	☐
Range of products/services using RFID	☐	☐	☐	☐	☐
Business process re-engineering (BPR) measures					
Adoption of flexible deployment architecture	☐	☐	☐	☐	☐
Continuous review and improvement of procedures	☐	☐	☐	☐	☐
Restructuring and streamlining activities including removal of non-value added tasks, controls and checks	☐	☐	☐	☐	☐
Integration and management of large amounts of data	☐	☐	☐	☐	☐
Centralization of dispersed resources and processes	☐	☐	☐	☐	☐
Synchronization of business processes and IT resources	☐	☐	☐	☐	☐

30. **Please provide below any additional information about your company that you believe is not covered by any of the above and may be useful to this survey.**

……
……
……
……

Please tick (✓) here if you will like to participate in company-based case study that will be conducted as part of this research. Such a case study will be brief and will not in any way interrupt the normal flow of activities in your organization. I desperately need to conduct company-based observations and interviews as part of this research. Thank you for volunteering. ☐

If you are interested in receiving a summary of the findings of the research, please tick this box ☐

**** **END** ****

Thanking you so much for your time and support.

Appendix B – Descriptive and distribution statistics of the research variables

Table 5.3: Descriptive and distribution statistics of the research variables

		RESEARCH VARIABLES	Min	Max	Mean	Std dev.
RFID technology		Number of people working in responding organisation	3	5	3.82	.761
		Organisation's annual turnover	1	5	2.69	1.107
		Has company adopted RFID?	0	1	.60	.492
		Time period organisation has adopted RFID for	1	3	2.05	.627
		Area of most use of RFID within the responding organisation's industry	1	4	1.85	.524
RFID Characteristics (RC)		State of RFID adoption	0	3	.91	.888
		Company's pedigree in RFID	1	4	1.96	.841
		Product Unit Level of Tagging (PULT)	1	4	2.18	1.054
		Extent of RFID implementation across the company	1	4	1.56	.802
Organisational characteristics (adoption)	Business Process Re-engineering (BPR)	Data standardization and integration	1	5	4.16	-1.575
		Restructuring and streamlining activities, including the removal of non-value-adding tasks, controls and checks	3	5	4.61	-1.485
		Decentralization of consolidated resources and processes, including decision-making	2	4	2.69	-.256
		Provision of decision-support tools	1	3	2.25	-.358
		Synchronization of IT resources and business processes	2	5	3.55	.264
	Business size	Number of employees	2	5	3.45	.680
		Annual turnover	3	5	4.65	-1.223
		International reach	1	5	3.71	-1.364
		IS/IT infrastructure	2	5	3.48	-.646
		The number of office locations, retail outlets, service centres, etc.	1	5	3.34	-.257
		Range of products/services	1	5	3.74	-.276
	Strength of culture	Organisational goals and objectives	2	5	3.93	.271
		Focus on performance relative to competitors	2	5	3.67	.243
		Focus on customer satisfaction	1	5	3.90	-.809
		Top management involvement	3	5	4.55	-1.153
		Effective decision-making	2	5	3.06	.723
		Drive to implement new technologies into business processes	1	5	4.13	-1.179
Organisational characteristics (implementation)	Business Process Re-engineering (BPR)	Data standardization and integration	1	5	3.71	-.445
		Restructuring and streamlining activities, including the removal of non-value-adding tasks, controls and checks	1	5	4.04	-.874
		Decentralization of consolidated resources and processes, including decision-making	1	5	3.29	-.347
		Provision of decision-support tools	1	5	3.96	-1.050
		Synchronization of IT resources and business processes	3	5	4.21	-1.513
	Business size	Number of employees	1	5	3.20	-1.041
		Annual turnover	1	5	3.48	-.759
		International reach	1	5	3.71	-.445
		IS/IT infrastructure	1	5	3.66	-.708
		The number of office locations, retail outlets, service centres, etc.	1	5	4.21	-1.513
		Range of products/services	1	5	3.20	-1.041
	Strength of culture	Organisational goals and objectives	1	5	3.40	-.333
		Focus on performance relative to competitors	2	5	3.54	-.812
		Focus on customer satisfaction	1	5	3.71	-.445
		Top management initiative	1	5	3.64	-.432
		Effective decision-making	3	5	4.04	-.874
		Drive to implement new technologies into business processes	2	5	4.21	-1.513
Or ga nis	Or ga nis	Creating strong internal and external motivation for improvement	2	5	3.96	-.277
		Developing a clear RFID strategy	3	5	4.64	-1.500

		Innovation	2	5	3.94	-.324
		Provision of training and support for employees	3	5	4.80	-2.331
		Top management support and commitment				
		Organisational knowledge accumulation	2	5	3.71	-.158
	Business size	Number of trained/skilled employees	2	5	3.71	-.158
		IT/IS infrastructure	2	5	2.77	.645
		Annual turnover	2	5	3.84	-.459
		International reach	2	5	3.77	-.646
		The number of office locations, warehouses, retail outlets, and service centers deploying RFID	1	5	3.07	.415
		Range of products/services using RFID				
	Business Process Re-engineering (BPR)	Adoption of flexible deployment architecture	2	5	3.88	-.325
		Continuous review and improvement of procedures	1	5	4.18	-1.107
		Restructuring and streamlining activities including removal of non-value added tasks, controls and checks	3	5	4.64	-1.262
		Integration and management of large amounts of data	1	5	3.20	-.006
		Centralization of dispersed resources and processes	2	5	4.00	-.249
		Synchronization of business processes and IT resources	2	5	3.72	.001
Business performance (BSC approach)	Financial measures	Sales increase attributable to RFID	2	5	2.90	1.054
		Net profit attributable to RFID	1	3	2.15	-.223
		Return-on-investment attributable to RFID	1	4	2.67	-.473
		Market share gains attributable to RFID	1	3	1.75	.185
		Cost reduction attributable to RFID	2	5	4.11	-.757
		Labour savings attributable to RFID	3	5	4.18	-.165
	Internal processes	Risk minimization attributable to RFID	1	5	2.87	-.004
		Reduction of inventory attributable to RFID	3	5	4.66	-1.108
		Improved product availability attributable to RFID	3	5	3.66	.672
		Improved transaction accuracy attributable to RFID	3	5	4.67	-1.436
		Improved visibility attributable to RFID	3	5	4.75	-2.252
		Reduced out-of-stock items attributable to RFID	3	5	4.28	.492
		Improved supply chain planning attributable to RFID	1	5	2.79	-.149
		Rate of complete orders attributable to RFID	2	5	3.34	.364
		Improved data integrity attributable to RFID	2	4	3.15	-.031
		Electronic traceability attributable to RFID	4	5	4.85	-2.010
		Improved sourcing of new products attributable to RFID	2	5	4.01	-.351
		Increase in transportation efficiency attributable to RFID	2	5	3.11	.599
	Corporate/Customer measures	Improved corporate social responsibility attributable to RFID	1	3	2.34	-.649
		Improved business sustainability attributable to RFID	1	3	1.82	.203
		Environmental compliance attributable to RFID	1	3	2.33	-.500
		Improved organisational learning attributable to RFID	2	5	3.36	-.083
		Improved health and safety attributable to RFID	1	3	1.65	.477
		Customer retention attributable to RFID	1	5	3.09	.356
		Enhanced staff motivation attributable to RFID	3	5	3.90	.182
	Learning and growth	More accurate forecast of demand attributable to RFID	3	5	3.77	.422
		Increase in organisational knowledge accumulation attributable to RFID	2	5	3.88	-.508
		Enhancement of employee satisfaction attributable to RFID	2	5	3.27	.760
		Improvement in employees' RFID-related skills and proficiency	3	5	4.07	.065
Drivers of RFID adoption	Top management support		3	5	4.77	.462
	Availability of IS/IT infrastructure		3	5	4.15	.750
	Financial readiness/affordability		4	5	4.85	.355
	Perceived RFID benefits		4	5	4.65	.372
	Organisational technical capability		3	5	4.06	.585
	Perceived RFID standards convergence		1	5	3.53	.964
	Competitive pressure		2	5	4.09	.715
	Industry pressure		1	5	3.13	.946
	Professional & trade association pressure		1	3	2.63	.694
	Favourable transactional climate		3	5	3.57	.770
	Regulatory pressure		1	3	1.75	.610
	Dominant partner pressure		2	5	3.41	.768

	Government support	1	4	2.72	.788
	Media pressure	1	3	1.79	.623
	Global expansion	2	5	3.52	.912
Constraints of RFID adoption	Cost issues	2	5	4.44	.620
	Manpower (skills) issues	1	4	2.27	.685
	Compliance issues	1	5	2.00	.809
	Privacy issues	1	3	1.80	.675
	Security issues (e.g., identity theft)	1	3	1.74	.644
	Technical issues	1	5	3.33	.728
	Lack of industry standards	1	5	3.48	.898
	A Requirements for business process change required	1	5	3.62	.983
	The unwillingness of the customer and supplier to use it	1	4	2.01	.662

Appendix C – Path diagrams of SEM

Figure 5.1: Impact of strength of culture, size, BPR on decision to adopt RFID (research question 2)

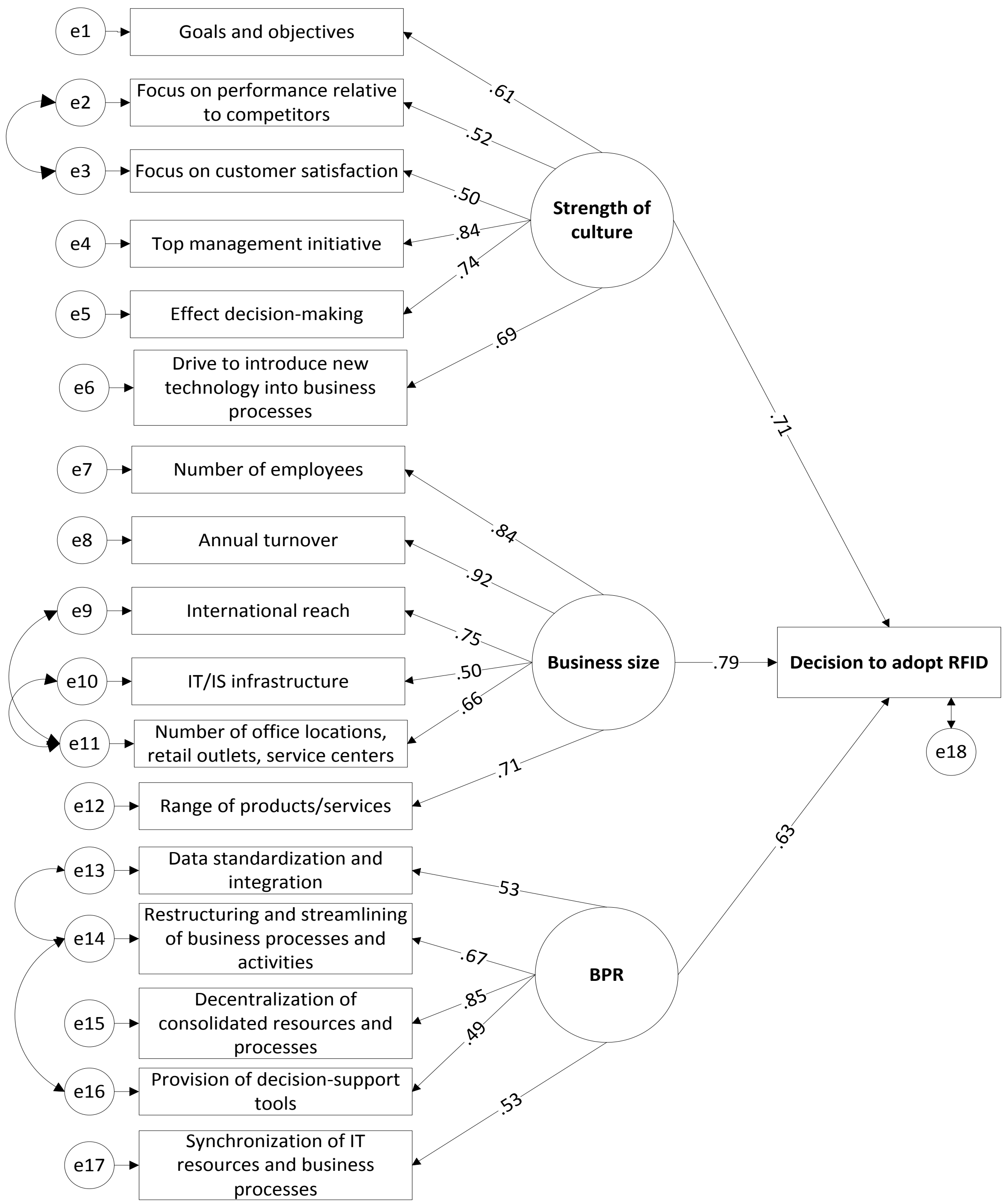


Figure 5.2: Impact of strength of culture on RFID implementation processes

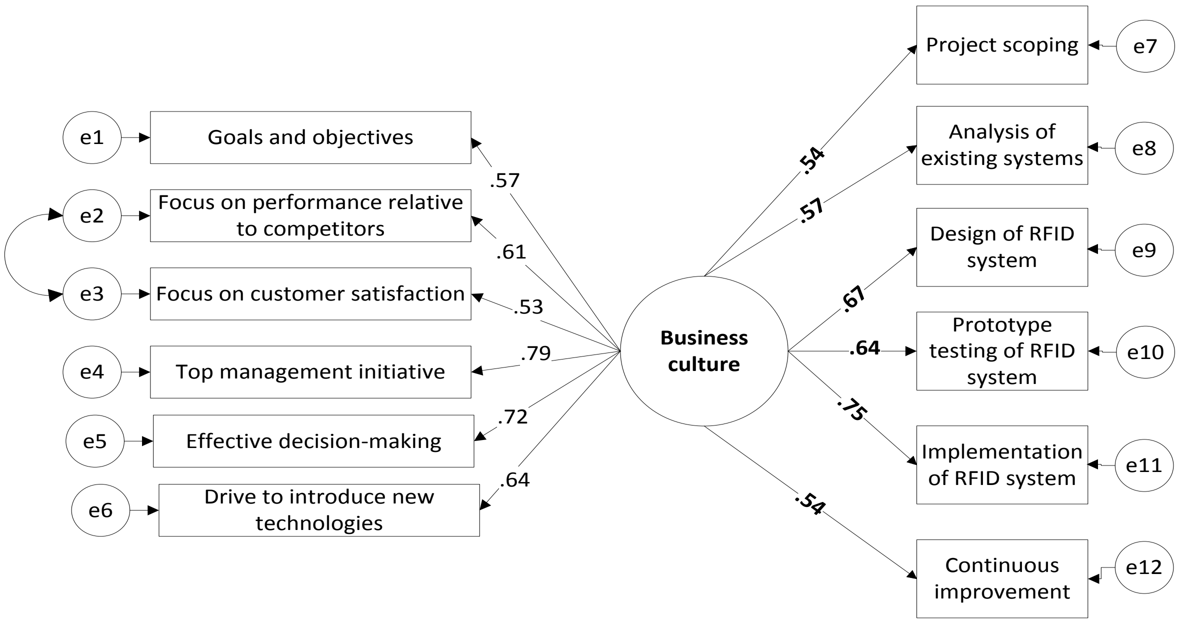


Figure 5.3: Impact of business size on RFID implementation processes

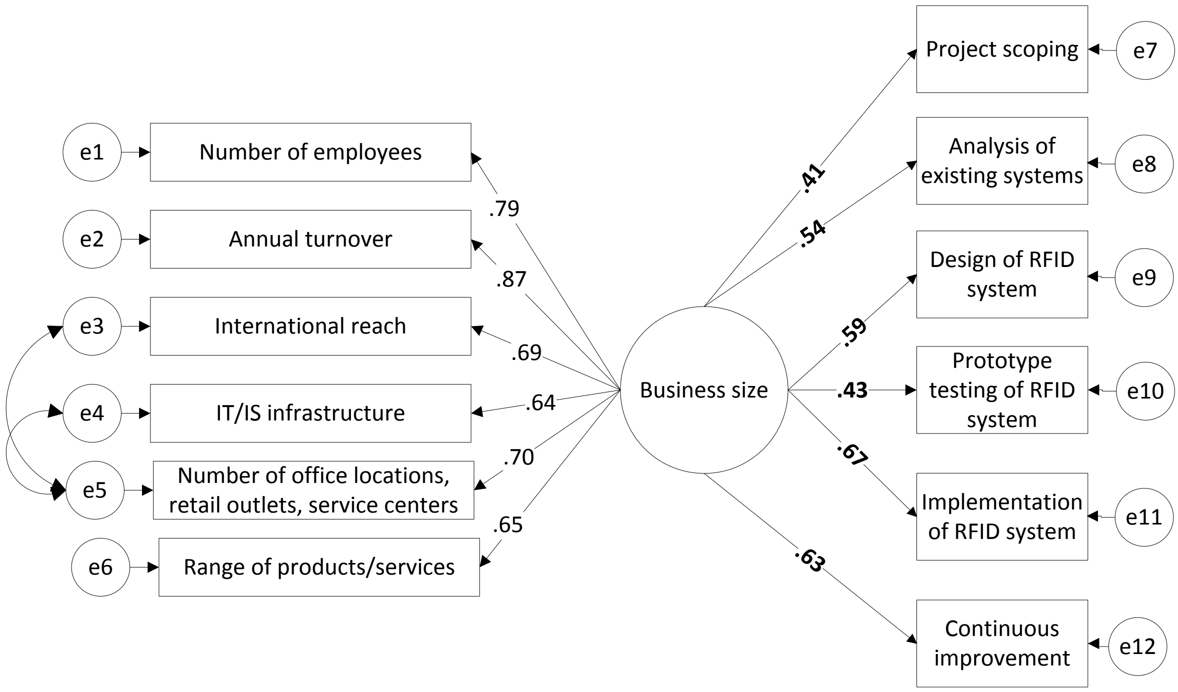


Figure 5.4: Impact of BPR on RFID implementation processes

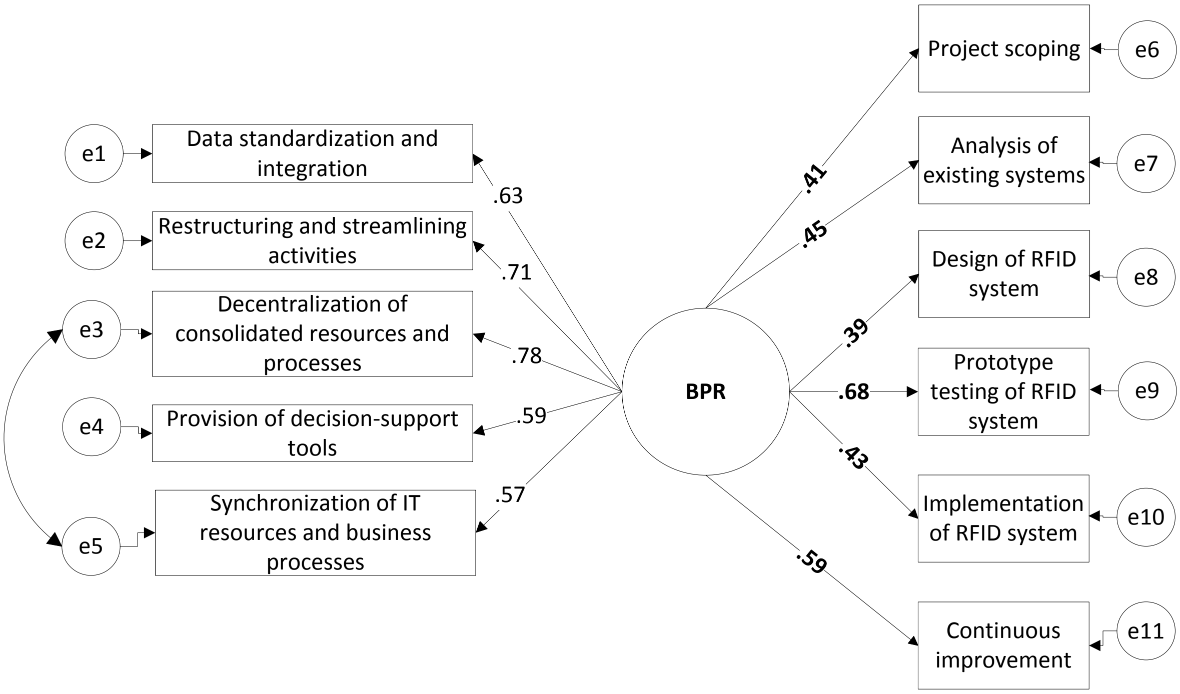


Figure 5.5: Impact of strength of culture on RFID benefits

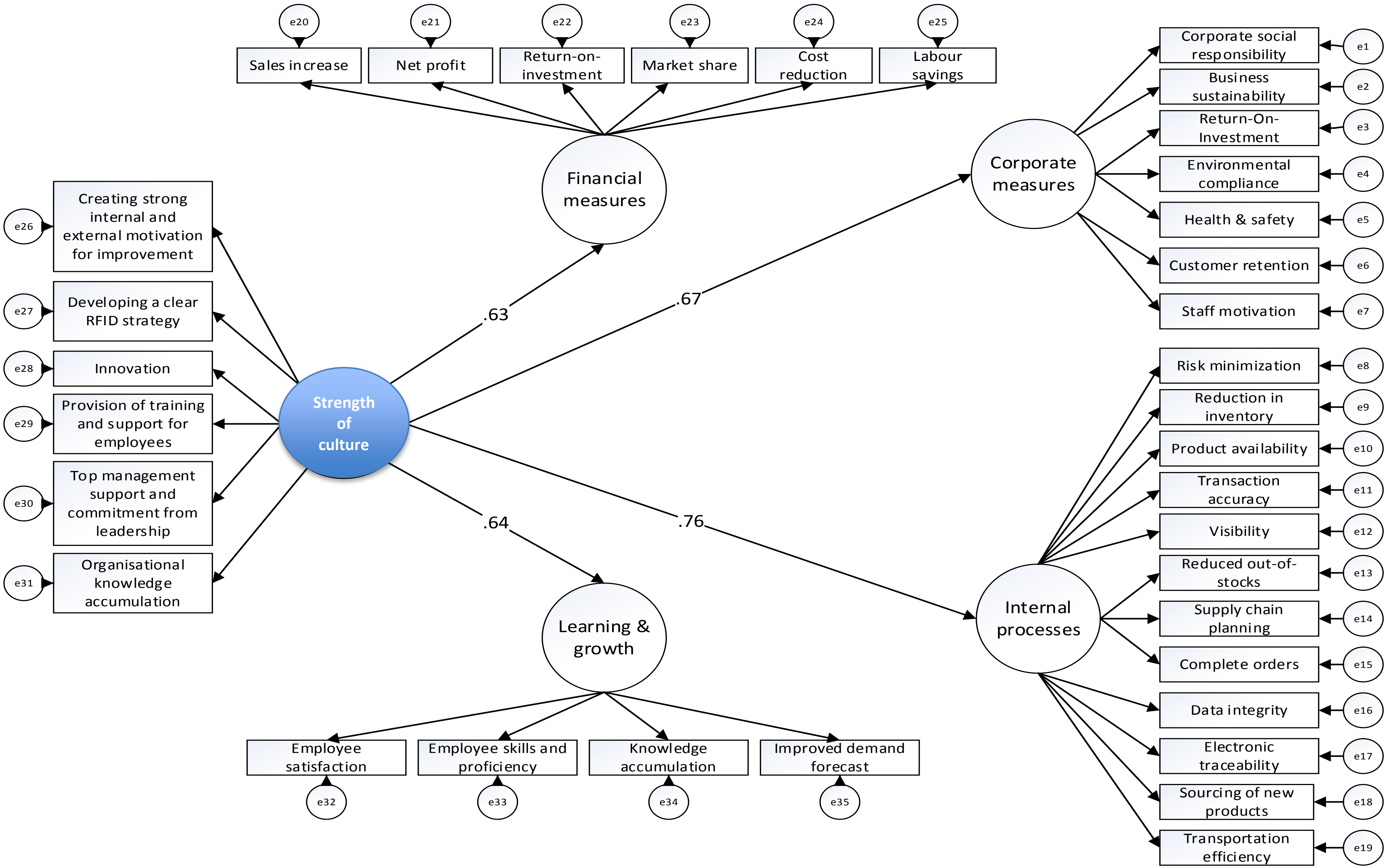


Figure 5.6: Impact of business size on RFID benefits

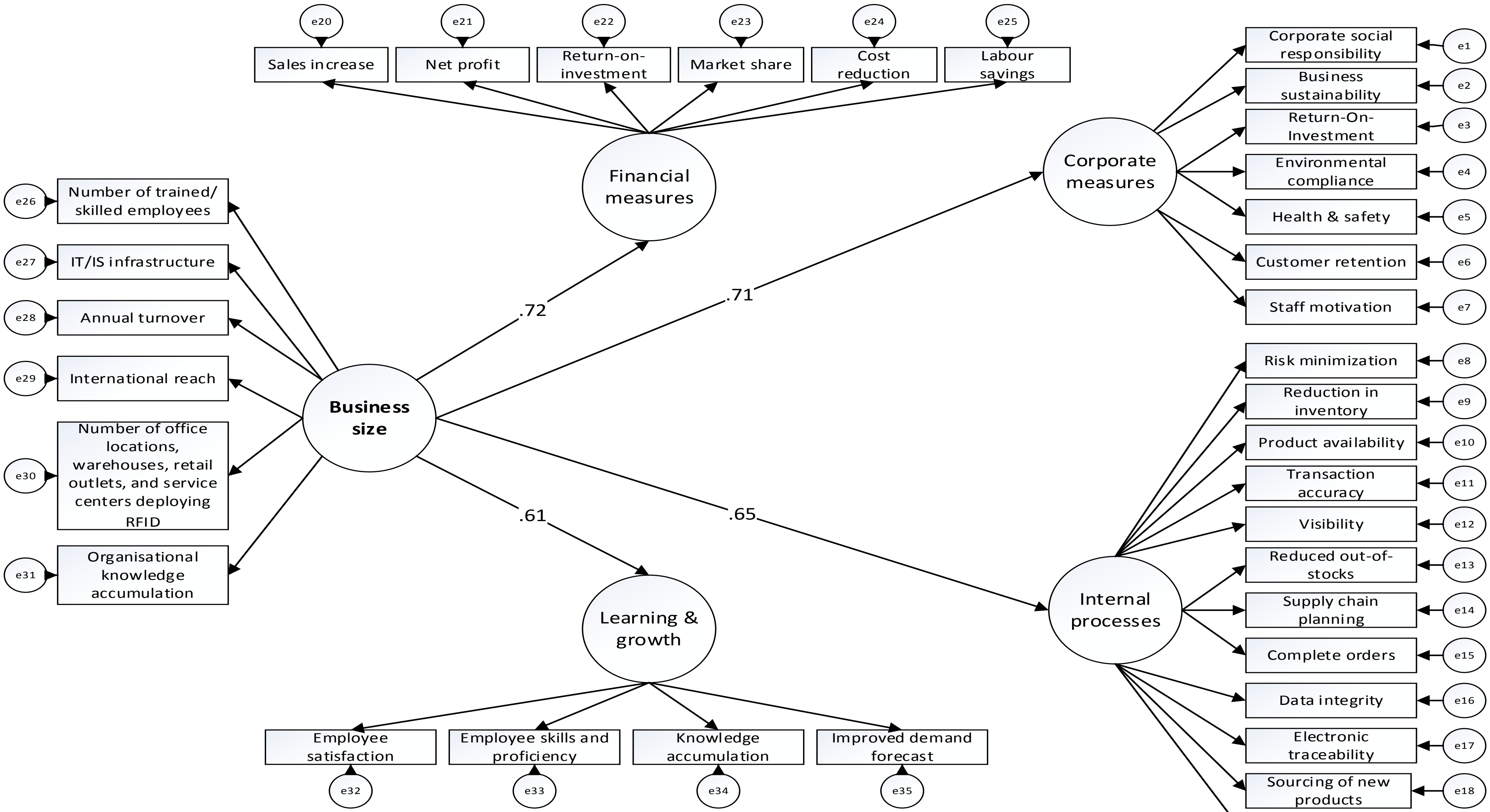
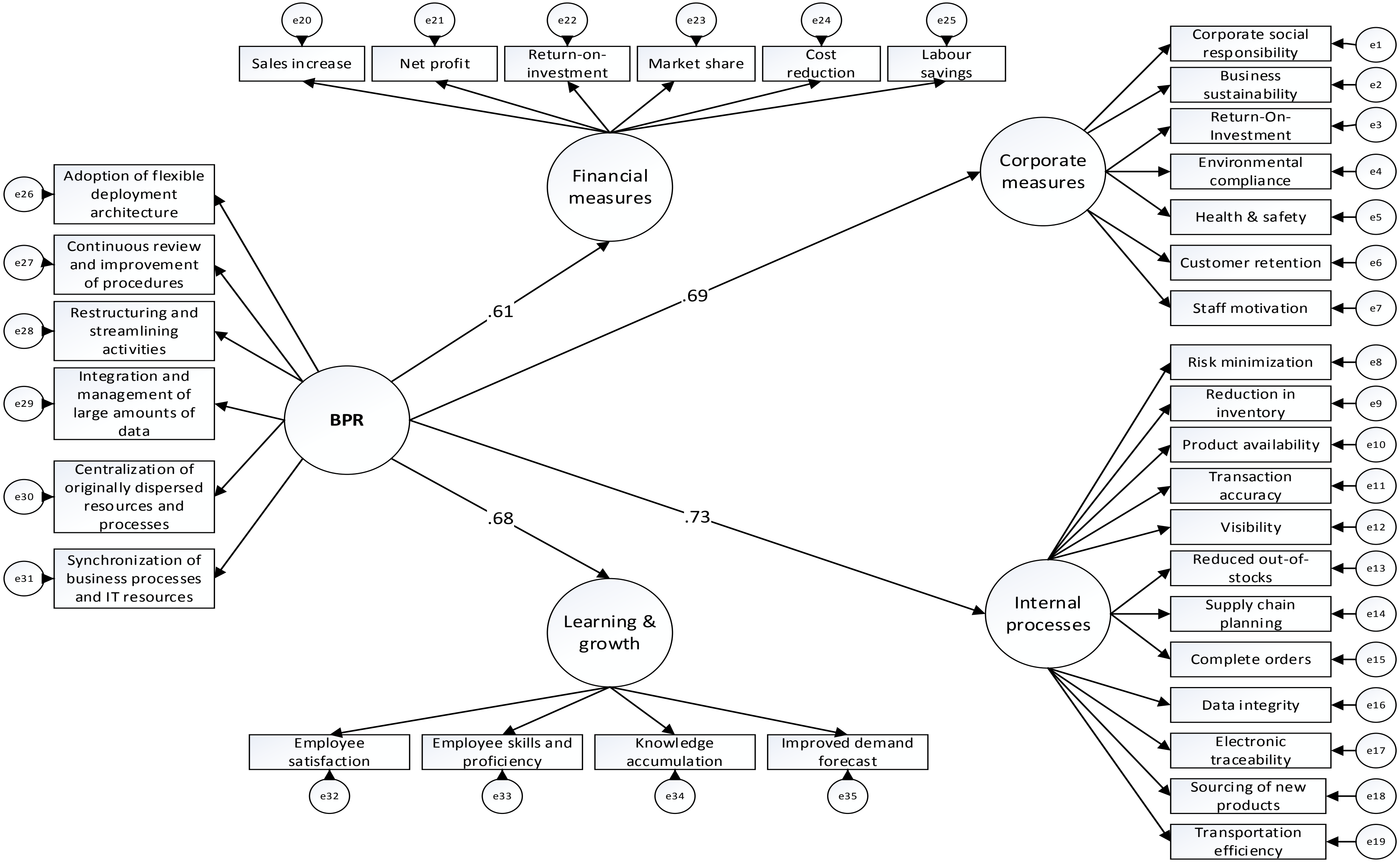


Figure 5.7: Impact of BPR on RFID benefits



Appendix D – One-Way ANOVA results for research question 5

Table 5.30: Descriptives for RFID implementation stage							
Benefits derived from RFID	**RFID implementation stage**	**N**	**Mean**	**Std. Deviation**	**Std. Error**	**Min**	**Max**
Sales increase	Pilot stage	52	3.23	.645	.089	2	5
	Partial implementation	39	3.21	.615	.098	2	5
	Full implementation	6	3.67	.816	.333	3	5
	Total	97	3.25	.646	.066	2	5
Net profit	Pilot stage	52	2.73	.448	.062	2	3
	Partial implementation	39	2.28	.456	.073	2	3
	Full implementation	6	3.18	.610	.087	3	4
	Total	97	2.57	.498	.051	2	3
Return-on-investment	Pilot stage	52	3.37	.486	.067	3	4
	Partial implementation	39	3.13	.339	.054	3	4
	Full implementation	6	3.67	.516	.211	3	4
	Total	97	3.29	.455	.046	3	4
Market share	Pilot stage	52	1.27	.448	.062	1	2
	Partial implementation	39	1.72	.456	.073	1	2
	Full implementation	6	1.00	.510	.063	1	3
	Total	97	1.43	.498	.051	1	2
Cost reduction	Pilot stage	52	4.31	.398	.055	4	5
	Partial implementation	39	4.81	.468	.075	4	5
	Full implementation	6	4.83	.399	.069	4	5
	Total	97	4.62	.488	.050	4	5
Labor savings	Pilot stage	52	4.00	.530	.054	3	5
	Partial implementation	39	4.00	.307	.049	4	5
	Full implementation	6	4.10	.321	.050	4	5
	Total	97	4.04	.200	.020	4	5
Risk minimization	Pilot stage	52	2.87	.627	.087	1	4
	Partial implementation	39	2.85	.630	.101	1	4
	Full implementation	6	3.00	.367	.065	3	4
	Total	97	2.87	.606	.062	1	4
Reduction of inventory	Pilot stage	52	4.60	.823	.114	2	5
	Partial implementation	39	4.67	.772	.124	2	5
	Full implementation	6	4.83	.408	.167	4	5
	Total	97	4.64	.780	.079	2	5
Product availability	Pilot stage	52	4.15	.607	.084	3	5
	Partial implementation	39	4.05	.887	.142	3	5
	Full implementation	6	4.17	.408	.167	4	5
	Total	97	4.11	.720	.073	3	5

Transaction accuracy	Pilot stage	52	4.23	.962	.133	2	5
	Partial implementation	39	4.38	.990	.158	2	5
	Full implementation	6	4.83	.408	.167	4	5
	Total	97	4.33	.954	.097	2	5
Visibility	Pilot stage	52	4.42	.893	.124	2	5
	Partial implementation	39	4.33	1.034	.166	2	5
	Full implementation	6	4.83	.408	.167	4	5
	Total	97	4.41	.933	.095	2	5
Reduced out-of-stock	Pilot stage	52	3.83	.555	.077	2	5
	Partial implementation	39	3.82	.683	.109	2	5
	Full implementation	6	3.92	.408	.167	3	4
	Total	97	3.88	.600	.061	2	5
Supply chain planning	Pilot stage	52	3.00	.658	.091	2	5
	Partial implementation	39	3.05	.605	.097	2	5
	Full implementation	6	3.13	.790	.101	2	4
	Total	97	3.09	.614	.062	2	5
Rate of complete orders	Pilot stage	52	3.69	.466	.065	3	4
	Partial implementation	39	3.26	.442	.071	3	4
	Full implementation	6	4.00	.520	.049	3	4
	Total	97	3.54	.501	.051	3	4
Data integrity	Pilot stage	52	3.56	.502	.070	3	4
	Partial implementation	39	3.21	.409	.066	3	4
	Full implementation	6	3.83	.408	.167	3	4
	Total	97	3.43	.498	.051	3	4
Electronic traceability	Pilot stage	52	4.21	1.073	.149	1	5
	Partial implementation	39	4.23	1.135	.182	2	5
	Full implementation	6	4.67	.516	.211	4	5
	Total	97	4.25	1.071	.109	1	5
Sourcing of new products	Pilot stage	52	3.83	.625	.087	2	5
	Partial implementation	39	3.74	.751	.120	2	5
	Full implementation	6	3.96	.408	.167	3	4
	Total	97	3.87	.671	.068	2	5
Transportation efficiency	Pilot stage	52	3.21	1.054	.146	2	5
	Partial implementation	39	2.95	.887	.142	2	5
	Full implementation	6	3.83	.983	.401	2	5
	Total	97	3.14	1.000	.102	2	5
Corporate social responsibility	Pilot stage	52	1.94	.608	.084	1	3
	Partial implementation	39	1.92	.807	.129	1	3
	Full implementation	6	2.00	.780	.075	2	4
	Total	97	1.94	.674	.068	1	3
Business sustainability	Pilot stage	52	2.00	.657	.091	1	3
	Partial implementation	39	1.92	.774	.124	1	3

	Full implementation	6	2.00	.645	.081	2	3
	Total	97	1.97	.684	.069	1	3
Environmental compliance	Pilot stage	52	2.83	.430	.060	1	3
	Partial implementation	39	2.51	.506	.081	2	3
	Full implementation	6	2.83	.753	.307	2	4
	Total	97	2.70	.503	.051	1	4
Organizational learning	Pilot stage	52	3.29	.498	.069	2	4
	Partial implementation	39	3.33	.498	.080	3	4
	Full implementation	6	3.59	.516	.211	3	4
	Total	97	3.41	.515	.052	2	4
Health and safety	Pilot stage	52	1.25	.437	.061	1	2
	Partial implementation	39	1.44	.502	.080	1	2
	Full implementation	6	1.00	.421	.076	1	2
	Total	97	1.31	.465	.047	1	2
Customer retention	Pilot stage	52	2.67	.382	.053	2	3
	Partial implementation	39	2.82	.451	.072	2	4
	Full implementation	6	2.83	.516	.211	2	3
	Total	97	2.81	.417	.042	2	4
Staff motivation	Pilot stage	52	4.17	.648	.090	3	5
	Partial implementation	39	4.49	.601	.096	3	5
	Full implementation	6	4.00	.632	.258	3	5
	Total	97	4.29	.645	.065	3	5
Demand forecast	Pilot stage	52	3.29	.750	.104	2	5
	Partial implementation	39	3.17	.999	.160	3	4
	Full implementation	6	4.05	.408	.167	3	5
	Total	97	3.59	.921	.094	2	5
Organisation knowledge accumulation	Pilot stage	52	4.23	.962	.133	2	5
	Partial implementation	39	4.28	1.050	.168	2	5
	Full implementation	6	4.67	.516	.211	4	5
	Total	97	4.28	.976	.099	2	5
Employee satisfaction	Pilot stage	52	2.79	.498	.069	1	4
	Partial implementation	39	2.82	.451	.072	1	3
	Full implementation	6	2.67	.516	.211	2	3
	Total	97	2.79	.477	.048	1	4
Employees’ RFID-related skills and proficiency	Pilot stage	52	3.94	.461	.064	3	5
	Partial implementation	39	3.95	.456	.073	3	5
	Full implementation	6	4.00	.398	.043	4	5
	Total	97	3.95	.442	.045	3	5

Table 5.31: Multiple Comparisons for RFID implementation stage						
TUKEY HSD						
	Dependent Variable	(I) State of RFID adoption	(J) State of RFID adoption	Mean Difference (I-J)	Std. Error	Sig.
Financial measures	Sales increase	Pilot stage	Partial implementation	.026	.136	.981
			Full implementation	**-.436***	**.277**	**.013**
		Partial implementation	Pilot stage	-.026	.136	.981
			Full implementation	**-.462***	**.282**	**.006**
		Full implementation	Pilot stage	**.436***	**.277**	**.013**
			Partial implementation	**.462***	**.282**	**.006**
	Net profit	Pilot stage	Partial implementation	**.449***	**.093**	**.000**
			Full implementation	-.269	.189	.334
		Partial implementation	Pilot stage	**-.449***	**.093**	**.000**
			Full implementation	**-.718***	**.193**	**.001**
		Full implementation	Pilot stage	.269	.189	.334
			Partial implementation	**.718***	**.193**	**.001**
	Return-on-investment	Pilot stage	Partial implementation	**.237***	**.092**	**.031**
			Full implementation	-.301	.187	.247
		Partial implementation	Pilot stage	**-.237***	**.092**	**.031**
			Full implementation	**-.538***	**.191**	**.016**
		Full implementation	Pilot stage	.301	.187	.247
			Partial implementation	**.538***	**.191**	**.016**
	Cost reduction	Pilot stage	Partial implementation	**.500***	**.088**	**.000**
			Full implementation	-.192	.180	.536
		Partial implementation	Pilot stage	**-.500***	**.088**	**.000**
			Full implementation	**-.692***	**.183**	**.001**
		Full implementation	Pilot stage	.192	.180	.536
			Partial implementation	**.692***	**.183**	**.001**
	Labor savings	Pilot stage	Partial implementation	**-.103***	**.041**	**.039**
			Full implementation	.000	.084	1.000
		Partial implementation	Pilot stage	**.103***	**.041**	**.039**
			Full implementation	.103	.086	.458
		Full implementation	Pilot stage	.000	.084	1.000

			Partial implementation	-.103	.086	.458
Internal processes	Reduction of inventory	Pilot stage	Partial implementation	-.071	.166	.906
			Full implementation	-.237	.339	.764
		Partial implementation	Pilot stage	.071	.166	.906
			Full implementation	**-.167***	**.345**	**.043**
		Full implementation	Pilot stage	.237	.339	.764
			Partial implementation	**.167***	**.345**	**.043**
	Visibility	Pilot stage	Partial implementation	.090	.198	.893
			Full implementation	**-.410***	**.403**	**.018**
		Partial implementation	Pilot stage	-.090	.198	.893
			Full implementation	**-.500***	**.410**	**.035**
		Full implementation	Pilot stage	**.410***	**.403**	**.018**
			Partial implementation	**.500***	**.410**	**.035**
	Reduced out-of-stock	Pilot stage	Partial implementation	**.103***	**.128**	**.003**
			Full implementation	.090	.260	.937
		Partial implementation	Pilot stage	**-.103***	**.128**	**.003**
			Full implementation	**-.013***	**.265**	**.011**
		Full implementation	Pilot stage	-.090	.260	.937
			Partial implementation	**.013***	**.265**	**.011**
	Supply chain planning	Pilot stage	Partial implementation	.083	.131	.801
			Full implementation	.135	.267	.869
		Partial implementation	Pilot stage	-.083	.131	.801
			Full implementation	**.051***	**.271**	**.000**
		Full implementation	Pilot stage	-.135	.267	.869
			Partial implementation	**-.051***	**.271**	**.000**
	Electronic traceability	Pilot stage	Partial implementation	**-.019***	**.228**	**.046**
			Full implementation	-.455	.464	.591
		Partial implementation	Pilot stage	**.019***	**.228**	**.046**
			Full implementation	**-.436***	**.472**	**.000**
			Pilot stage	.455	.464	.591
			Partial implementation	**.436***	**.472**	**.000**

Corporate measures	Business sustainability	Pilot stage	Partial implementation	**-.019***	**.228**	**.046**
			Full implementation	-.455	.464	.591
		Partial implementation	Pilot stage	**.019***	**.228**	**.046**
			Full implementation	**-.436***	**.472**	**.000**
		Full implementation	Pilot stage	.455	.464	.591
			Partial implementation	**.436***	**.472**	**.000**
	Staff motivation	Pilot stage	Partial implementation	**.500***	**.088**	**.000**
			Full implementation	-.192	.180	.536
		Partial implementation	Pilot stage	**-.500***	**.088**	**.000**
			Full implementation	**-.692***	**.183**	**.001**
		Full implementation	Pilot stage	.192	.180	.536
			Partial implementation	**.692***	**.183**	**.001**
	Customer retention	Pilot stage	Partial implementation	**-.019***	**.228**	**.046**
			Full implementation	-.455	.464	.591
		Partial implementation	Pilot stage	**.019***	**.228**	**.046**
			Full implementation	**-.436***	**.472**	**.000**
		Full implementation	Pilot stage	.455	.464	.591
			Partial implementation	**.436***	**.472**	**.000**
	Environmental compliance	Pilot stage	Partial implementation	**.500***	**.088**	**.000**
			Full implementation	-.192	.180	.536
		Partial implementation	Pilot stage	**-.500***	**.088**	**.000**
			Full implementation	**-.692***	**.183**	**.001**
		Full implementation	Pilot stage	.192	.180	.536
			Partial implementation	**.692***	**.183**	**.001**
	Organisational learning	Pilot stage	Partial implementation	**-.301***	**.106**	**.015**
			Full implementation	-.045	.215	.976
		Partial implementation	Pilot stage	**.301***	**.106**	**.015**
			Full implementation	.256	.219	.473
		Full implementation	Pilot stage	.045	.215	.976
			Partial implementation	-.256	.219	.473
Learning & growt	Demand forecast	Pilot stage	Partial implementation	**-.763***	**.179**	**.000**

			Full implementation	.122	.365	.941
		Partial implementation	Pilot stage	**.763***	**.179**	**.000**
			Full implementation	**.885***	**.371**	**.050**
		Full implementation	Pilot stage	-.122	.365	.941
			Partial implementation	**-.885***	**.371**	**.050**
	Organisation knowledge accumulation	Pilot stage	Partial implementation	**-.051***	**.208**	**.017**
			Full implementation	-.436	.423	.560
		Partial implementation	Pilot stage	**.051***	**.208**	**.017**
			Full implementation	**-.385***	**.430**	**.645**
		Full implementation	Pilot stage	.436	.423	.560
			Partial implementation	.385*	.430	.645
	Employees' RFID-related skills and proficiency	Pilot stage	Partial implementation	**-.006***	**.095**	**.017**
			Full implementation	-.058	.192	.952
		Partial implementation	Pilot stage	**.006***	**.095**	**.017**
			Full implementation	**-.051***	**.196**	**.023**
		Full implementation	Pilot stage	.058	.192	.952
			Partial implementation	**.051***	**.196**	**.023**

Table 5.32: Descriptives for PULT

BENEFITS DERIVED FROM RFID	ORGANISATIONAL PEDIGREE IN RFID	N	Mean	Std. Deviation	Std. Error	Min	Max
Sales increase	Pallet-level	17	3.47	.874	.212	3	5
	Case-level	23	3.39	.656	.137	3	5
	Container-level	15	3.13	.516	.133	3	5
	Item-level	42	3.12	.550	.085	2	5
	Total	97	3.25	.646	.066	2	5
Net profit	Pallet-level	17	2.35	.493	.119	2	3
	Case-level	23	2.30	.470	.098	2	3
	Container-level	15	2.47	.516	.133	2	3
	Item-level	42	2.83	.377	.058	2	3
	Total	97	2.57	.498	.051	2	3
Return-on-investment	Pallet-level	17	3.29	.470	.114	3	4
	Case-level	23	3.17	.388	.081	3	4
	Container-level	15	3.13	.352	.091	3	4
	Item-level	42	3.40	.497	.077	3	4
	Total	97	3.29	.455	.046	3	4

Market share	Pallet-level	17	1.65	.493	.119	1	2
	Case-level	23	1.70	.470	.098	1	2
	Container-level	15	1.53	.516	.133	1	2
	Item-level	42	1.17	.377	.058	1	2
	Total	97	1.43	.498	.051	1	2
Cost reduction	Pallet-level	17	4.47	.514	.125	4	5
	Case-level	23	4.39	.499	.104	4	5
	Container-level	15	4.47	.516	.133	4	5
	Item-level	42	4.86	.354	.055	4	5
	Total	97	4.62	.488	.050	4	5
Labor savings	Pallet-level	17	4.06	.243	.059	4	5
	Case-level	23	4.04	.209	.043	4	5
	Container-level	15	4.13	.352	.091	4	5
	Item-level	42	4.00	.000	.000	4	4
	Total	97	4.04	.200	.020	4	5
Risk minimization	Pallet-level	17	2.94	.556	.135	1	4
	Case-level	23	2.91	.596	.124	1	4
	Container-level	15	2.80	.676	.175	1	4
	Item-level	42	2.83	.621	.096	1	4
	Total	97	2.87	.606	.062	1	4
Reduction of inventory	Pallet-level	17	4.65	.606	.147	3	5
	Case-level	23	4.70	.635	.132	3	5
	Container-level	15	4.33	1.113	.287	2	5
	Item-level	42	4.71	.774	.119	2	5
	Total	97	4.64	.780	.079	2	5
Product availability	Pallet-level	17	4.29	.772	.187	3	5
	Case-level	23	4.17	.887	.185	3	5
	Container-level	15	3.73	.704	.182	3	5
	Item-level	42	4.14	.566	.087	3	5
	Total	97	4.11	.720	.073	3	5
Transaction accuracy	Pallet-level	17	4.53	.624	.151	3	5
	Case-level	23	4.61	.656	.137	3	5
	Container-level	15	3.87	1.246	.322	2	5
	Item-level	42	4.26	1.037	.160	2	5
	Total	97	4.33	.954	.097	2	5
Visibility	Pallet-level	17	4.29	.920	.223	2	5
	Case-level	23	4.43	.843	.176	3	5
	Container-level	15	4.00	1.195	.309	2	5
	Item-level	42	4.60	.857	.132	2	5
	Total	97	4.41	.933	.095	2	5
Reduced out-of-stock	Pallet-level	17	3.88	.485	.118	3	5
	Case-level	23	3.96	.638	.133	2	5

	Container-level	15	3.73	.704	.182	2	5
	Item-level	42	3.88	.593	.091	2	5
	Total	97	3.88	.600	.061	2	5
Supply chain planning	Pallet-level	17	3.18	.809	.196	2	5
	Case-level	23	2.91	.596	.124	2	4
	Container-level	15	3.07	.594	.153	2	5
	Item-level	42	3.17	.537	.083	2	5
	Total	97	3.09	.614	.062	2	5
Rate of complete orders	Pallet-level	17	3.35	.493	.119	3	4
	Case-level	23	3.22	.422	.088	3	4
	Container-level	15	3.47	.516	.133	3	4
	Item-level	42	3.81	.397	.061	3	4
	Total	97	3.54	.501	.051	3	4
Data integrity	Pallet-level	17	3.29	.470	.114	3	4
	Case-level	23	3.22	.422	.088	3	4
	Container-level	15	3.33	.488	.126	3	4
	Item-level	42	3.64	.485	.075	3	4
	Total	97	3.43	.498	.051	3	4
Electronic traceability	Pallet-level	17	4.24	1.033	.250	2	5
	Case-level	23	4.26	.864	.180	3	5
	Container-level	15	3.60	1.454	.375	1	5
	Item-level	42	4.48	.969	.149	2	5
	Total	97	4.25	1.071	.109	1	5
Sourcing of new products	Pallet-level	17	3.94	.429	.104	3	5
	Case-level	23	4.09	.668	.139	2	5
	Container-level	15	3.60	.828	.214	2	5
	Item-level	42	3.81	.671	.104	2	5
	Total	97	3.87	.671	.068	2	5
Transportation efficiency	Pallet-level	17	2.82	.883	.214	2	4
	Case-level	23	2.74	.752	.157	2	4
	Container-level	15	3.33	1.047	.270	2	5
	Item-level	42	3.43	1.063	.164	2	5
	Total	97	3.14	1.000	.102	2	5
Corporate social responsibility	Pallet-level	17	1.76	.752	.182	1	3
	Case-level	23	1.74	.752	.157	1	3
	Container-level	15	2.20	.775	.200	1	3
	Item-level	42	2.02	.517	.080	1	3
	Total	97	1.94	.674	.068	1	3
Business sustainability	Pallet-level	17	1.76	.752	.182	1	3
	Case-level	23	1.78	.736	.153	1	3
	Container-level	15	2.27	.799	.206	1	3
	Item-level	42	2.05	.539	.083	1	3

	Total	97	1.97	.684	.069	1	3
Environmental compliance	Pallet-level	17	2.65	.606	.147	1	3
	Case-level	23	2.70	.470	.098	2	3
	Container-level	15	2.60	.507	.131	2	3
	Item-level	42	2.76	.484	.075	2	4
	Total	97	2.70	.503	.051	1	4
Organizational learning	Pallet-level	17	3.76	.437	.106	3	4
	Case-level	23	3.57	.590	.123	2	4
	Container-level	15	3.33	.488	.126	3	4
	Item-level	42	3.21	.415	.064	3	4
	Total	97	3.41	.515	.052	2	4
Health and safety	Pallet-level	17	1.41	.507	.123	1	2
	Case-level	23	1.48	.511	.106	1	2
	Container-level	15	1.53	.516	.133	1	2
	Item-level	42	1.10	.297	.046	1	2
	Total	97	1.31	.465	.047	1	2
Customer retention	Pallet-level	17	2.94	.429	.104	2	4
	Case-level	23	2.78	.422	.088	2	3
	Container-level	15	2.67	.488	.126	2	3
	Item-level	42	2.83	.377	.058	2	3
	Total	97	2.81	.417	.042	2	4
Staff motivation	Pallet-level	17	4.41	.618	.150	3	5
	Case-level	23	4.57	.590	.123	3	5
	Container-level	15	4.33	.724	.187	3	5
	Item-level	42	4.07	.601	.093	3	5
	Total	97	4.29	.645	.065	3	5
Demand forecast	Pallet-level	17	3.59	.939	.228	3	5
	Case-level	23	4.04	1.022	.213	3	5
	Container-level	15	3.80	1.014	.262	3	5
	Item-level	42	3.26	.701	.108	2	5
	Total	97	3.59	.921	.094	2	5
Organisation knowledge accumulation	Pallet-level	17	4.12	1.054	.256	2	5
	Case-level	23	4.30	.822	.171	3	5
	Container-level	15	3.80	1.082	.279	2	5
	Item-level	42	4.50	.944	.146	2	5
	Total	97	4.28	.976	.099	2	5
Employee satisfaction	Pallet-level	17	2.65	.606	.147	1	3
	Case-level	23	2.87	.344	.072	2	3
	Container-level	15	2.80	.414	.107	2	3
	Item-level	42	2.81	.505	.078	1	4
	Total	97	2.79	.477	.048	1	4
	Pallet-level	17	3.94	.243	.059	3	4

Employees' RFID-related skills and proficiency	Case-level	23	3.91	.417	.087	3	5
	Container-level	15	4.00	.535	.138	3	5
	Item-level	42	3.95	.492	.076	3	5
	Total	97	3.95	.442	.045	3	5

Table 5.33: Multiple Comparisons for PULT

Tukey HSD

	Dependent Variable	(I) Product level of RFID implementation	(J) Product level of RFID implementation	Mean Difference (I-J)	Std. Error	Sig.
Financial measures	Net profit	Pallet-level	Case-level	.049	.142	.986
			Container-level	-.114	.157	.888
			Item-level	**-.480***	**.128**	**.002**
		Case-level	Pallet-level	-.049	.142	.986
			Container-level	-.162	.147	.689
			Item-level	**-.529***	**.115**	**.000**
		Container-level	Pallet-level	.114	.157	.888
			Case-level	.162	.147	.689
			Item-level	**-.367***	**.133**	**.036**
		Item-level	Pallet-level	**.480***	**.128**	**.002**
			Case-level	**.529***	**.115**	**.000**
			Container-level	**.367***	**.133**	**.036**
	Cost reduction	Pallet-level	Case-level	.079	.143	.945
			Container-level	.004	.158	1.000
			Item-level	**-.387***	**.129**	**.018**
		Case-level	Pallet-level	-.079	.143	.945
			Container-level	-.075	.148	.957
			Item-level	**-.466***	**.116**	**.001**
		Container-level	Pallet-level	-.004	.158	1.000
			Case-level	.075	.148	.957
			Item-level	**-.390***	**.134**	**.023**
		Item-level	Pallet-level	**.387***	**.129**	**.018**
			Case-level	**.466***	**.116**	**.001**
			Container-level	**.390***	**.134**	**.023**
	Labor savings	Pallet-level	Case-level	.015	.063	.995
			Container-level	**-.075***	**.070**	**.712**
			Item-level	**.059***	**.057**	**.729**
		Case-level	Pallet-level	-.015	.063	.995
			Container-level	**-.090***	**.066**	**.521**
			Item-level	**.043***	**.051**	**.831**
		Container-level	Pallet-level	**.075***	**.070**	**.712**

			Case-level	**.090***	**.066**	**.521**
			Item-level	**.133***	**.059**	**.119**
		Item-level	Pallet-level	**-.059***	**.057**	**.729**
			Case-level	**-.043***	**.051**	**.831**
			Container-level	**-.133***	**.059**	**.119**
Internal processes	Reduction of inventory	Pallet-level	Case-level	**-.049***	**.250**	**.997**
			Container-level	.314	.276	.669
			Item-level	**-.067***	**.224**	**.991**
		Case-level	Pallet-level	**.049***	**.250**	**.997**
			Container-level	.362	.259	.503
			Item-level	-.019	.202	1.000
		Container-level	Pallet-level	-.314	.276	.669
			Case-level	-.362	.259	.503
			Item-level	-.381	.235	.371
		Item-level	Pallet-level	**.067***	**.224**	**.991**
			Case-level	.019	.202	1.000
			Container-level	.381	.235	.371
	Visibility	Pallet-level	Case-level	**-.141***	**.295**	**.964**
			Container-level	**.294***	**.327**	**.805**
			Item-level	**-.301***	**.265**	**.669**
		Case-level	Pallet-level	**.141***	**.295**	**.964**
			Container-level	**.435***	**.306**	**.491**
			Item-level	**-.160***	**.240**	**.908**
		Container-level	Pallet-level	**-.294***	**.327**	**.805**
			Case-level	**-.435***	**.306**	**.491**
			Item-level	**-.595***	**.278**	**.147**
		Item-level	Pallet-level	**.301***	**.265**	**.669**
			Case-level	**.160***	**.240**	**.908**
			Container-level	**.595***	**.278**	**.147**
	Electronic traceability	Pallet-level	Case-level	-.026	.334	1.000
			Container-level	.635	.370	.321
			Item-level	**-.241***	**.300**	**.853**
		Case-level	Pallet-level	.026	.334	1.000
			Container-level	.661	.347	.233
			Item-level	**-.215***	**.271**	**.857**
		Container-level	Pallet-level	-.635	.370	.321
			Case-level	-.661	.347	.233
			Item-level	**-.876***	**.314**	**.032**
		Item-level	Pallet-level	**.241***	**.300**	**.853**
			Case-level	**.215***	**.271**	**.857**
			Container-level	**.876***	**.314**	**.032**
		Pallet-level	Case-level	.084	.309	.993

			Container-level	-.510	.342	.446
			Item-level	-.605	.277	.136
		Case-level	Pallet-level	-.084	.309	.993
			Container-level	-.594	.320	.254
			Item-level	**-.689***	**.250**	**.035**
	Transportation efficiency	Container-level	Pallet-level	.510	.342	.446
			Case-level	.594	.320	.254
			Item-level	-.095	.290	.988
		Item-level	Pallet-level	.605	.277	.136
			Case-level	**.689***	**.250**	**.035**
			Container-level	.095	.290	.988
Corporate measures	Organisational learning	Pallet-level	Case-level	.199	.152	.560
			Container-level	.431	.169	.058
			Item-level	**.550***	**.137**	**.001**
		Case-level	Pallet-level	-.199	.152	.560
			Container-level	.232	.158	.462
			Item-level	**.351***	**.124**	**.028**
		Container-level	Pallet-level	-.431	.169	.058
			Case-level	-.232	.158	.462
			Item-level	.119	.143	.840
		Item-level	Pallet-level	**-.550***	**.137**	**.001**
			Case-level	**-.351***	**.124**	**.028**
			Container-level	-.119	.143	.840
	Staff motivation	Pallet-level	Case-level	-.153	.199	.867
			Container-level	.078	.220	.984
			Item-level	.340	.179	.233
		Case-level	Pallet-level	.153	.199	.867
			Container-level	.232	.206	.675
			Item-level	**.494***	**.161**	**.015**
		Container-level	Pallet-level	-.078	.220	.984
			Case-level	-.232	.206	.675
			Item-level	.262	.187	.502
		Item-level	Pallet-level	-.340	.179	.233
			Case-level	**-.494***	**.161**	**.015**
			Container-level	-.262	.187	.502
Learning & growth	Demand forecast	Pallet-level	Case-level	-.455	.281	.371
			Container-level	-.212	.311	.904
			Item-level	.326	.252	.569
		Case-level	Pallet-level	.455	.281	.371
			Container-level	.243	.291	.837
			Item-level	**.782***	**.228**	**.005**
		Container-level	Pallet-level	.212	.311	.904

			Case-level	-.243	.291	.837
			Item-level	.538	.264	.181
		Item-level	Pallet-level	-.326	.252	.569
			Case-level	**-.782***	**.228**	**.005**
			Container-level	-.538	.264	.181

Table 5.34: Descriptives for organisational pedigree in RFID							
BENEFITS DERIVED FROM RFID	**ORGANISATIONAL PEDIGREE IN RFID**	**N**	**Mean**	**Std. Deviation**	**Std. Error**	**Min**	**Max**
Sales increase	Fully conversant with aspects of RFID	51	2.98	.616	.086	1	5
	Understand most of the concepts of RFID	78	2.83	.780	.088	1	5
	Understand the principles of RFID	24	2.21	.509	.104	2	4
	Little knowledge of RFID principles but the system works for us	10	3.20	1.549	.490	2	5
	Total	163	2.81	.805	.063	1	5
Net profit	Fully conversant with aspects of RFID	51	2.80	.491	.069	1	3
	Understand most of the concepts of RFID	78	2.04	.440	.050	1	3
	Understand the principles of RFID	24	1.38	.647	.132	1	3
	Little knowledge of RFID principles but the system works for us	10	1.50	.707	.224	1	3
	Total	163	2.15	.713	.056	1	3
Return-on-investment	Fully conversant with aspects of RFID	51	3.22	.879	.123	1	5
	Understand most of the concepts of RFID	78	2.79	.827	.094	1	5
	Understand the principles of RFID	24	1.88	.850	.174	1	4
	Little knowledge of RFID principles but the system works for us	10	1.80	1.033	.327	1	4
	Total	163	2.73	.982	.077	1	5
Market share	Fully conversant with aspects of RFID	51	1.18	.434	.061	1	3
	Understand most of the concepts of RFID	78	1.94	.406	.046	1	3
	Understand the principles of RFID	24	2.08	.504	.103	1	3
	Little knowledge of RFID principles but the system works for us	10	2.50	.707	.224	1	3
	Total	163	1.75	.610	.048	1	3
Cost reduction	Fully conversant with aspects of RFID	51	4.29	1.171	.164	1	5
	Understand most of the concepts of RFID	78	3.81	.898	.102	1	5
	Understand the principles of RFID	24	3.38	.711	.145	3	5
	Little knowledge of RFID principles but the system works for us	10	2.90	1.197	.379	2	5
	Total	163	3.84	1.054	.083	1	5
Labour savings	Fully conversant with aspects of RFID	51	3.88	.621	.087	1	5
	Understand most of the concepts of RFID	78	4.13	.985	.112	1	5

	Understand the principles of RFID	24	3.88	1.154	.236	1	5
	Little knowledge of RFID principles but the system works for us	10	3.00	1.247	.394	1	5
	Total	163	3.94	.964	.075	1	5
Risk minimization	Fully conversant with aspects of RFID	51	3.10	.878	.123	1	5
	Understand most of the concepts of RFID	78	3.12	.911	.103	1	5
	Understand the principles of RFID	24	2.13	.947	.193	1	5
	Little knowledge of RFID principles but the system works for us	10	1.90	.994	.314	1	3
	Total	163	2.89	1.000	.078	1	5
Reduction of inventory	Fully conversant with aspects of RFID	51	4.78	.610	.085	2	5
	Understand most of the concepts of RFID	78	4.47	.963	.109	1	5
	Understand the principles of RFID	24	3.75	.897	.183	1	5
	Little knowledge of RFID principles but the system works for us	10	4.00	.816	.258	3	5
	Total	163	4.44	.910	.071	1	5
Product availability	Fully conversant with aspects of RFID	51	3.92	.845	.118	1	5
	Understand most of the concepts of RFID	78	3.56	.877	.099	2	5
	Understand the principles of RFID	24	3.08	.282	.058	3	4
	Little knowledge of RFID principles but the system works for us	10	3.10	.316	.100	3	4
	Total	163	3.58	.831	.065	1	5
Transaction accuracy	Fully conversant with aspects of RFID	51	4.80	.664	.093	2	5
	Understand most of the concepts of RFID	78	3.99	1.304	.148	1	5
	Understand the principles of RFID	24	3.50	1.216	.248	1	5
	Little knowledge of RFID principles but the system works for us	10	3.50	1.269	.401	1	5
	Total	163	4.14	1.217	.095	1	5
Product/Process visibility	Fully conversant with aspects of RFID	51	4.12	1.423	.199	1	5
	Understand most of the concepts of RFID	78	4.31	1.177	.133	1	5
	Understand the principles of RFID	24	3.67	.963	.197	2	5
	Little knowledge of RFID principles but the system works for us	10	3.70	1.160	.367	2	5
	Total	163	4.12	1.244	.097	1	5
Out-of-stock items	Fully conversant with aspects of RFID	51	3.61	.981	.137	1	5
	Understand most of the concepts of RFID	78	3.74	.973	.110	1	5
	Understand the principles of RFID	24	4.08	1.501	.306	1	5
	Little knowledge of RFID principles but the system works for us	10	4.20	1.317	.416	1	5
	Total	163	3.78	1.094	.086	1	5
Supply chain planning	Fully conversant with aspects of RFID	51	3.02	.678	.095	1	5
	Understand most of the concepts of RFID	78	2.91	.809	.092	1	5

	Understand the principles of RFID	24	2.54	1.318	.269	1	5
	Little knowledge of RFID principles but the system works for us	10	3.40	.966	.306	2	5
	Total	163	2.92	.889	.070	1	5
Rate of complete orders	Fully conversant with aspects of RFID	51	3.88	.653	.091	2	5
	Understand most of the concepts of RFID	78	3.08	.864	.098	1	5
	Understand the principles of RFID	24	3.04	.751	.153	2	5
	Little knowledge of RFID principles but the system works for us	10	2.60	1.075	.340	1	5
	Total	163	3.29	.895	.070	1	5
Data integrity	Fully conversant with aspects of RFID	51	3.29	.923	.129	1	5
	Understand most of the concepts of RFID	78	3.13	.691	.078	1	5
	Understand the principles of RFID	24	2.79	.721	.147	2	5
	Little knowledge of RFID principles but the system works for us	10	2.40	.843	.267	1	4
	Total	163	3.09	.812	.064	1	5
Electronic traceability	Fully conversant with aspects of RFID	51	4.45	1.137	.159	1	5
	Understand most of the concepts of RFID	78	4.50	.977	.111	1	5
	Understand the principles of RFID	24	4.13	.992	.202	2	5
	Little knowledge of RFID principles but the system works for us	10	4.20	.919	.291	2	5
	Total	163	4.41	1.029	.081	1	5
Sourcing of new products	Fully conversant with aspects of RFID	51	3.71	.879	.123	1	5
	Understand most of the concepts of RFID	78	3.99	1.087	.123	1	5
	Understand the principles of RFID	24	3.17	.917	.187	1	5
	Little knowledge of RFID principles but the system works for us	10	3.40	1.265	.400	2	5
	Total	163	3.74	1.046	.082	1	5
Transportation efficiency	Fully conversant with aspects of RFID	51	3.49	1.155	.162	1	5
	Understand most of the concepts of RFID	78	2.86	.785	.089	1	5
	Understand the principles of RFID	24	2.96	.806	.165	1	5
	Little knowledge of RFID principles but the system works for us	10	2.70	.675	.213	1	3
	Total	163	3.06	.954	.075	1	5
Corporate social responsibility	Fully conversant with aspects of RFID	51	2.27	.918	.129	1	5
	Understand most of the concepts of RFID	78	2.55	1.065	.121	1	5
	Understand the principles of RFID	24	2.83	.868	.177	1	5
	Little knowledge of RFID principles but the system works for us	10	2.90	.738	.233	1	4
	Total	163	2.53	.990	.078	1	5
Business sustainability	Fully conversant with aspects of RFID	51	2.20	.693	.097	1	5
	Understand most of the concepts of RFID	78	1.73	.801	.091	1	5

	Understand the principles of RFID	24	2.21	1.179	.241	1	5
	Little knowledge of RFID principles but the system works for us	10	2.60	.843	.267	1	4
	Total	163	2.00	.875	.069	1	5
Environmental compliance	Fully conversant with aspects of RFID	51	2.69	.648	.091	1	4
	Understand most of the concepts of RFID	78	2.47	.936	.106	1	5
	Understand the principles of RFID	24	2.33	1.049	.214	1	5
	Little knowledge of RFID principles but the system works for us	10	2.30	1.418	.448	1	5
	Total	163	2.51	.912	.071	1	5
Organizational learning	Fully conversant with aspects of RFID	51	3.04	.720	.101	1	5
	Understand most of the concepts of RFID	78	3.82	.785	.089	1	5
	Understand the principles of RFID	24	2.42	.974	.199	1	5
	Little knowledge of RFID principles but the system works for us	10	3.00	1.247	.394	2	5
	Total	163	3.32	.973	.076	1	5
Health and safety	Fully conversant with aspects of RFID	51	1.53	1.065	.149	1	5
	Understand most of the concepts of RFID	78	1.94	.811	.092	1	5
	Understand the principles of RFID	24	2.54	.977	.199	1	5
	Little knowledge of RFID principles but the system works for us	10	2.50	.707	.224	1	3
	Total	163	1.93	.976	.076	1	5
Customer retention	Fully conversant with aspects of RFID	51	2.82	.713	.100	1	4
	Understand most of the concepts of RFID	78	3.01	.933	.106	1	5
	Understand the principles of RFID	24	2.83	1.308	.267	1	5
	Little knowledge of RFID principles but the system works for us	10	2.90	.994	.314	1	4
	Total	163	2.92	.936	.073	1	5
Staff motivation	Fully conversant with aspects of RFID	51	3.84	.784	.110	1	5
	Understand most of the concepts of RFID	78	3.67	1.245	.141	1	5
	Understand the principles of RFID	24	2.88	.992	.202	1	5
	Little knowledge of RFID principles but the system works for us	10	3.20	.789	.249	2	5
	Total	163	3.58	1.099	.086	1	5
Demand forecast	Fully conversant with aspects of RFID	51	3.02	.761	.107	1	5
	Understand most of the concepts of RFID	78	3.81	1.058	.120	1	5
	Understand the principles of RFID	24	3.67	1.007	.206	1	5
	Little knowledge of RFID principles but the system works for us	10	4.00	.471	.149	3	5
	Total	163	3.55	1.001	.078	1	5
	Fully conversant with aspects of RFID	51	3.75	.868	.122	1	5
	Understand most of the concepts of RFID	78	3.74	1.200	.136	1	5

Organisation knowledge accumulation	Understand the principles of RFID	24	2.92	1.060	.216	1	5
	Little knowledge of RFID principles but the system works for us	10	2.60	.843	.267	2	4
	Total	163	3.55	1.123	.088	1	5
Employee satisfaction	Fully conversant with aspects of RFID	51	2.92	.523	.073	1	5
	Understand most of the concepts of RFID	78	3.36	1.019	.115	1	5
	Understand the principles of RFID	24	3.42	.974	.199	2	5
	Little knowledge of RFID principles but the system works for us	10	2.70	1.059	.335	2	5
	Total	163	3.19	.913	.072	1	5
Employees' RFID-related skills and proficiency	Fully conversant with aspects of RFID	51	3.76	.737	.103	1	5
	Understand most of the concepts of RFID	78	3.73	.963	.109	1	5
	Understand the principles of RFID	24	3.83	1.373	.280	1	5
	Little knowledge of RFID principles but the system works for us	10	3.10	1.101	.348	1	5
	Total	163	3.72	.985	.077	1	5

Table 5.35: Multiple Comparisons for organisational pedigree in RFID

Tukey HSD

	Dependent Variable	(I) Organisational pedigree in RFID	(J) Organisational pedigree in RFID	Mean Difference (I-J)	Std. Error	Sig.
Financial measures	Cost reduction	Fully conversant with aspects of RFID	Understand most of the concepts of RFID	**.486***	**.178**	**.035**
			Understand the principles of RFID	**.919***	**.245**	**.001**
			Little knowledge of RFID principles but the system works for us	**1.394***	**.342**	**.000**
		Understand most of the concepts of RFID	Fully conversant with aspects of RFID	**-.486***	**.178**	**.035**
			Understand the principles of RFID	.433	.231	.243
			Little knowledge of RFID principles but the system works for us	**.908***	**.332**	**.035**
		Understand the principles of RFID	Fully conversant with aspects of RFID	**-.919***	**.245**	**.001**
			Understand most of the concepts of RFID	-.433	.231	.243

			Little knowledge of RFID principles but the system works for us	.475	.372	.579
		Little knowledge of RFID principles but the system works for us	Fully conversant with aspects of RFID	**-1.394***	**.342**	**.000**
			Understand most of the concepts of RFID	**-.908***	**.332**	**.035**
			Understand the principles of RFID	-.475	.372	.579
	Labour savings	Fully conversant with aspects of RFID	Understand most of the concepts of RFID	-.246	.168	.463
			Understand the principles of RFID	.007	.231	1.000
			Little knowledge of RFID principles but the system works for us	**.882***	**.323**	**.035**
		Understand most of the concepts of RFID	Fully conversant with aspects of RFID	.246	.168	.463
			Understand the principles of RFID	.253	.218	.652
			Little knowledge of RFID principles but the system works for us	**1.128***	**.314**	**.002**
		Understand the principles of RFID	Fully conversant with aspects of RFID	-.007	.231	1.000
			Understand most of the concepts of RFID	-.253	.218	.652
			Little knowledge of RFID principles but the system works for us	.875	.351	.065
		Little knowledge of RFID principles but the system works for us	Fully conversant with aspects of RFID	**-.882***	**.323**	**.035**
			Understand most of the concepts of RFID	**-1.128***	**.314**	**.002**
			Understand the principles of RFID	-.875	.351	.065
Internal processes	Supply chain planning	Fully conversant with aspects of RFID	Understand most of the concepts of RFID	.109	.158	.899
			Understand the principles of RFID	.478	.217	.426

			Little knowledge of RFID principles but the system works for us	**-.380***	**.303**	**.012**
		Understand most of the concepts of RFID	Fully conversant with aspects of RFID	-.109	.158	.899
			Understand the principles of RFID	.369	.204	.275
			Little knowledge of RFID principles but the system works for us	-.490	.294	.345
		Understand the principles of RFID	Fully conversant with aspects of RFID	**-.478***	**.217**	**.126**
			Understand most of the concepts of RFID	-.369	.204	.275
			Little knowledge of RFID principles but the system works for us	**-.858***	**.329**	**.049**
		Little knowledge of RFID principles but the system works for us	Fully conversant with aspects of RFID	**.380***	**.303**	**.012**
			Understand most of the concepts of RFID	.490	.294	.345
			Understand the principles of RFID	**.858***	**.329**	**.049**
Corporate/Customers measures	Business sustainability	Fully conversant with aspects of RFID	Understand most of the concepts of RFID	**.465***	**.151**	**.013**
			Understand the principles of RFID	-.012	.208	1.000
			Little knowledge of RFID principles but the system works for us	-.404	.290	.505
		Understand most of the concepts of RFID	Fully conversant with aspects of RFID	**-.465***	**.151**	**.013**
			Understand the principles of RFID	-.478	.196	.074
			Little knowledge of RFID principles but the system works for us	**-.869***	**.282**	**.013**
		Understand the principles of RFID	Fully conversant with aspects of RFID	.012	.208	1.000
			Understand most of the concepts of RFID	.478	.196	.074

			Little knowledge of RFID principles but the system works for us	-.392	.316	.602
		Little knowledge of RFID principles but the system works for us	Fully conversant with aspects of RFID	.404	.290	.505
			Understand most of the concepts of RFID	**.869***	**.282**	**.013**
			Understand the principles of RFID	.392	.316	.602
	Organisational learning	Fully conversant with aspects of RFID	Understand most of the concepts of RFID	**-.781***	**.149**	**.000**
			Understand the principles of RFID	**.623***	**.205**	**.015**
			Little knowledge of RFID principles but the system works for us	.039	.287	.999
		Understand most of the concepts of RFID	Fully conversant with aspects of RFID	**.781***	**.149**	**.000**
			Understand the principles of RFID	**1.404***	**.193**	**.000**
			Little knowledge of RFID principles but the system works for us	**.821***	**.278**	**.019**
		Understand the principles of RFID	Fully conversant with aspects of RFID	**-.623***	**.205**	**.015**
			Understand most of the concepts of RFID	**-1.404***	**.193**	**.000**
			Little knowledge of RFID principles but the system works for us	-.583	.312	.245
		Little knowledge of RFID principles but the system works for us	Fully conversant with aspects of RFID	-.039	.287	.999
			Understand most of the concepts of RFID	**-.821***	**.278**	**.019**
			Understand the principles of RFID	.583	.312	.245
	Staff motivation	Fully conversant with aspects of RFID	Understand most of the concepts of RFID	.176	.191	.791
			Understand the principles of RFID	**.968***	**.262**	**.002**

			Little knowledge of RFID principles but the system works for us	.643	.366	.299
		Understand most of the concepts of RFID	Fully conversant with aspects of RFID	-.176	.191	.791
			Understand the principles of RFID	**.792***	**.247**	**.009**
			Little knowledge of RFID principles but the system works for us	.467	.356	.557
		Understand the principles of RFID	Fully conversant with aspects of RFID	**-.968***	**.262**	**.002**
			Understand most of the concepts of RFID	**-.792***	**.247**	**.009**
			Little knowledge of RFID principles but the system works for us	-.325	.399	.847
		Little knowledge of RFID principles but the system works for us	Fully conversant with aspects of RFID	-.643	.366	.299
			Understand most of the concepts of RFID	-.467	.356	.557
			Understand the principles of RFID	.325	.399	.847
Learning & growth	Organisational knowledge accumulation	Fully conversant with aspects of RFID	Understand most of the concepts of RFID	.002	.192	1.000
			Understand the principles of RFID	**.828***	**.264**	**.011**
			Little knowledge of RFID principles but the system works for us	**1.145***	**.369**	**.012**
		Understand most of the concepts of RFID	Fully conversant with aspects of RFID	-.002	.192	1.000
			Understand the principles of RFID	**.827***	**.249**	**.006**
			Little knowledge of RFID principles but the system works for us	**1.144***	**.358**	**.009**
		Understand the principles of RFID	Fully conversant with aspects of RFID	**-.828***	**.264**	**.011**
			Understand most of the concepts of RFID	**-.827***	**.249**	**.006**

			Little knowledge of RFID principles but the system works for us	.317	.401	.859
		Little knowledge of RFID principles but the system works for us	Fully conversant with aspects of RFID	**-1.145***	**.369**	**.012**
			Understand most of the concepts of RFID	**-1.144***	**.358**	**.009**
			Understand the principles of RFID	-.317	.401	.859
	Employee satisfaction	Fully conversant with aspects of RFID	Understand most of the concepts of RFID	**-.437***	**.160**	**.035**
			Understand the principles of RFID	-.495	.220	.114
			Little knowledge of RFID principles but the system works for us	.222	.307	.889
		Understand most of the concepts of RFID	Fully conversant with aspects of RFID	**.437***	**.160**	**.035**
			Understand the principles of RFID	-.058	.207	.992
			Little knowledge of RFID principles but the system works for us	.659	.298	.126
		Understand the principles of RFID	Fully conversant with aspects of RFID	.495	.220	.114
			Understand most of the concepts of RFID	.058	.207	.992
			Little knowledge of RFID principles but the system works for us	.717	.334	.144
		Little knowledge of RFID principles but the system works for us	Fully conversant with aspects of RFID	-.222	.307	.889
			Understand most of the concepts of RFID	-.659	.298	.126
			Understand the principles of RFID	-.717	.334	.144

Appendix E – Case study interview questions

About RFID technology in your industry
What is the primary use of RFID in your industry?
Where do you see the major business benefits of RFID in your industry?
About RFID at the organisation
What was the motivation for the introduction of RFID technology in your organisation?
How long has your organisation been using RFID for?
At what state of RFID adoption is your organisation? (pilot, impartial, or full implementation stages)
At what product level(s) is your organisation implementing RFID?
How would you describe your company's knowledge of RFID? (Prompt: The different levels investigated in the questionnaire survey should be suggested)
Who is the key champion or has the greatest responsibility in your organisation in your organisation for RFID adoption?
Decision to adopt
What factors played a major role in your organisation's decision to adopt RFID? (Prompt: The list of drivers derived from the questionnaire survey should be listed out to the respondent)
What factors constrained your organisation's decision to adopt RFID? (Prompt: The list of constraints derived from the questionnaire survey should be listed out to the respondent)
To what extent has your organisation's underlying business culture influenced its decision to adopt RFID? (Prompt: The list of factors used to define business culture in the questionnaire survey should be listed out to the respondent)
To what extent has the size of your organisation influenced its decision to adopt RFID? (Prompt: The list of factors used to define business size in the questionnaire survey should be listed out to the respondent)
To what extent has the BPR necessitated its decision to adopt RFID? (Prompt: The list of factors used to define BPR in the questionnaire survey should be listed out to the respondent)

Implementation process
To what extent has your organisation's underlying business culture influenced the implementation process of RFID? (Prompt: The list of factors used to define business culture and implementation process in the questionnaire survey should be listed out to the respondent)
To what extent has the size of your organisation influenced the implementation process of RFID? (Prompt: The list of factors used to define business size and implementation process in the questionnaire survey should be listed out to the respondent)
To what extent has the BPR influenced the implementation process of RFID? (Prompt: The list of factors used to define business culture and implementation process in the questionnaire survey should be listed out to the respondent)
Benefits derived from implementation
What benefits does your company derive from its implementation of RFID?
To what extent does your organisation's underlying business culture affect the benefits derived from RFID? (Prompt: The list of factors used to define business culture in the questionnaire survey should be listed out to the respondent)
To what extent does the size of your organisation affect the benefits derived from RFID? (Prompt: The list of factors used to define business size in the questionnaire survey should be listed out to the respondent)
To what extent does BPR affect business derived from RFID? (Prompt: The list of factors used to define BPR in the questionnaire survey should be listed out to the respondent)
To what extent are the benefits derived from RFID implementation moderated by your stage of RFID implementation?
To what extent are the benefits derived from RFID implementation moderated by the level of tagging used in your organisation?
To what extent are the benefits derived from RFID implementation moderated by the knowledge of RFID within the organisation?
End: Thank you notes

APPENDIX F – Correlation Matrix

Correlation matrix of some of the drivers of RFID (derived from the TOE framework) with the decision to adopt RFID

		Decision to adopt RFID (Yes or No)?	Top management support	Availability of IT/IS infrastructure	Financial readiness/affordability	Perceived RFID benefits	Organisational technical capability	Government support	Regulatory pressure	Perceived RFID standards convergence	Competitive pressure
Decision to adopt RFID (Yes or No)?	Pearson Correlation	1	.272**	.570**	.292**	.272**	.128	.288**	.262**	.712**	.029
	Sig. (2-tailed)		.000	.000	.000	.000	.105	.000	.001	.000	.711
	N	163	163	163	163	163	163	163	163	163	163
Top management support	Pearson Correlation	.272**	1	.315**	.209**	.058	.075	.188*	.039	-.197*	.228**
	Sig. (2-tailed)	.000		.000	.008	.460	.343	.017	.617	.012	.003
	N	163	163	163	163	163	163	163	163	163	163
Availability of IT/IS infrastructure	Pearson Correlation	.570**	.315**	1	.294**	-.146	.105	.085	.147	-.600**	.205**
	Sig. (2-tailed)	.000	.000		.000	.062	.182	.279	.061	.000	.009
	N	163	163	163	163	163	163	163	163	163	163
Financial readiness/affordability	Pearson Correlation	.292**	.209**	.294**	1	-.124	.133	.019	-.042	-.238**	.317**
	Sig. (2-tailed)	.000	.008	.000		.115	.091	.807	.598	.002	.000
	N	163	163	163	163	163	163	163	163	163	163
Perceived RFID benefits	Pearson Correlation	-.272**	.058	-.146	-.124	1	.014	-.008	-.065	.411**	.099
	Sig. (2-tailed)	.000	.460	.062	.115		.859	.916	.406	.000	.210
	N	163	163	163	163	163	163	163	163	163	163
Organisational technical capability	Pearson Correlation	-.128	.075	.105	.133	.014	1	-.114	-.212**	.018	.283**
	Sig. (2-tailed)	.105	.343	.182	.091	.859		.147	.007	.818	.000
	N	163	163	163	163	163	163	163	163	163	163
Regulatory pressure	Pearson Correlation	.288**	.188*	.085	.019	-.008	-.114	1	.019	-.079	-.122
	Sig. (2-tailed)	.000	.017	.279	.807	.916	.147		.813	.314	.120
	N	163	163	163	163	163	163	163	163	163	163

Government support	Pearson Correlation	.262**	.039	.147	-.042	-.065	-.212**	.019	1	-.107	-.221**
	Sig. (2-tailed)	.001	.617	.061	.598	.406	.007	.813		.173	.004
	N	163	163	163	163	163	163	163	163	163	163
Perceived RFID standards convergence	Pearson Correlation	-.712**	-.197*	-.600**	-.238**	.411**	.018	-.079	-.107	1	-.192*
	Sig. (2-tailed)	.000	.012	.000	.002	.000	.818	.314	.173		.014
	N	163	163	163	163	163	163	163	163	163	163
Competitive pressure	Pearson Correlation	.029	.228**	.205**	.317**	.099	.283**	-.122	-.221**	-.192*	1
	Sig. (2-tailed)	.711	.003	.009	.000	.210	.000	.120	.004	.014	
	N	163	163	163	163	163	163	163	163	163	163
Industry pressure	Pearson Correlation	-.664**	-.155*	-.551**	-.161*	.243**	.119	-.230**	-.186*	.651**	-.035
	Sig. (2-tailed)	.000	.048	.000	.040	.002	.131	.003	.017	.000	.653
	N	163	163	163	163	163	163	163	163	163	163

Correlation matrix of some of the constraints of RFID (derived from the TOE framework) with the decision to adopt RFID

Correlation matrix of some of the constraints of RFID (derived from the TOE framework) with the decision to adopt RFID

		Has your company adopted RFID?	Cost issues	Manpower (skills) issues	Compliance issues	Privacy issues	Security issues	Technical issues	Lack of industry standards	A high degree of business process change required	The unwillingness of the customer and supplier to use RFID
Has your company adopted RFID?	Pearson Correlation	1	-.470**	-.625**	-.635**	-.241**	-.312**	.559**	-.843**	-.815**	-.560**
	Sig. (2-tailed)		.000	.000	.000	.002	.000	.000	.000	.000	.000
	N	163	163	163	163	163	163	163	163	163	163
Cost issues	Pearson Correlation	-.470**	1	.067	.150	.227**	.276**	-.201*	.333**	-.264**	.085
	Sig. (2-tailed)	.000		.392	.056	.004	.000	.010	.000	.001	.281
	N	163	163	163	163	163	163	163	163	163	163
	Pearson Correlation	-.625**	.067	1	.802**	.169*	.256**	-.548**	.842**	-.800**	.785**

Manpower (skills) issues	Sig. (2-tailed)	.000	.392		.000	.031	.001	.000	.000	.000	.000
	N	163	163	163	163	163	163	163	163	163	163
Compliance issues	Pearson Correlation	-.635**	.150	.802**	1	.339**	.474**	-.703**	.773**	-.831**	.888**
	Sig. (2-tailed)	.000	.056	.000		.000	.000	.000	.000	.000	.000
	N	163	163	163	163	163	163	163	163	163	163
Privacy issues	Pearson Correlation	-.241**	.227**	.169*	.339**	1	.849**	-.272**	.227**	-.309**	.238**
	Sig. (2-tailed)	.002	.004	.031	.000		.000	.000	.004	.000	.002
	N	163	163	163	163	163	163	163	163	163	163
Security issues	Pearson Correlation	-.312**	.276**	.256**	.474**	.849**	1	-.373**	.343**	-.449**	.395**
	Sig. (2-tailed)	.000	.000	.001	.000	.000		.000	.000	.000	.000
	N	163	163	163	163	163	163	163	163	163	163
Technical issues	Pearson Correlation	.559**	-.201*	-.548**	-.703**	-.272**	-.373**	1	-.580**	.658**	-.645**
	Sig. (2-tailed)	.000	.010	.000	.000	.000	.000		.000	.000	.000
	N	163	163	163	163	163	163	163	163	163	163
Lack of industry standards	Pearson Correlation	-.843**	.333**	.842**	.773**	.227**	.343**	-.580**	1	-.856**	.763**
	Sig. (2-tailed)	.000	.000	.000	.000	.004	.000	.000		.000	.000
	N	163	163	163	163	163	163	163	163	163	163
A high degree of business process change required	Pearson Correlation	.815**	-.264**	-.800**	-.831**	-.309**	-.449**	.658**	-.856**	1	-.850**
	Sig. (2-tailed)	.000	.001	.000	.000	.000	.000	.000	.000		.000
	N	163	163	163	163	163	163	163	163	163	163
The unwillingness of the customer and supplier to use RFID	Pearson Correlation	-.560**	.085	.785**	.888**	.238**	.395**	-.645**	.763**	-.850**	1
	Sig. (2-tailed)	.000	.281	.000	.000	.002	.000	.000	.000	.000	
	N	163	163	163	163	163	163	163	163	163	163
**. Correlation is significant at the 0.01 level (2-tailed).											
*. Correlation is significant at the 0.05 level (2-tailed).											

Correlation matrix of organisational culture attributes (derived from the TOE framework) with the decision to adopt RFID

Correlations									
		Has your company adopted RFID?	Organisational goals and objectives	Company focus on performance relative to competitors	Company focus on customer satisfaction	Top management involvement	Effective decision making	Innovation	How drive to implement new technologies into business processes
Has your company adopted RFID?	Pearson Correlation	1	.112	-.570**	.786**	.837**	.190*	.494**	-.100
	Sig. (2-tailed)		.154	.000	.000	.000	.015	.000	.206
	N	163	163	163	163	163	163	163	163
company goals and objectives	Pearson Correlation	.112	1	-.219**	.196*	.242**	.415**	.383**	-.300**
	Sig. (2-tailed)	.154		.005	.012	.002	.000	.000	.000
	N	163	163	163	163	163	163	163	163
company focus on performance relative to competitors	Pearson Correlation	-.570**	-.219**	1	-.542**	-.566**	-.211**	-.465**	-.026
	Sig. (2-tailed)	.000	.005		.000	.000	.007	.000	.740
	N	163	163	163	163	163	163	163	163
company focus on customer satisfaction	Pearson Correlation	.786**	.196*	-.542**	1	.866**	.328**	.554**	.061
	Sig. (2-tailed)	.000	.012	.000		.000	.000	.000	.439
	N	163	163	163	163	163	163	163	163
top management involvement	Pearson Correlation	.837**	.242**	-.566**	.866**	1	.429**	.650**	-.055
	Sig. (2-tailed)	.000	.002	.000	.000		.000	.000	.488
	N	163	163	163	163	163	163	163	163
Effective decision making	Pearson Correlation	.190*	.415**	-.211**	.328**	.429**	1	.575**	-.185*
	Sig. (2-tailed)	.015	.000	.007	.000	.000		.000	.018
	N	163	163	163	163	163	163	163	163
innovation	Pearson Correlation	.494**	.383**	-.465**	.554**	.650**	.575**	1	-.133
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000		.091
	N	163	163	163	163	163	163	163	163
drive to implement new technologies into business processes	Pearson Correlation	-.100	-.300**	-.026	.061	-.055	-.185*	-.133	1
	Sig. (2-tailed)	.206	.000	.740	.439	.488	.018	.091	
	N	163	163	163	163	163	163	163	163

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Correlation matrix of organisational size attributes (derived from the TOE framework) with the decision to adopt RFID

		Has your company adopted RFID?	Number of employees	Annual turnover	International reach	Scale of in-house and cross-company networking	Scale of business IS/IT usage	Number of offices, retail outlets, service centres, etc.	Range of products and services
Has your company adopted RFID?	Pearson Correlation	1	-.616**	.789**	.456**	.221**	.650**	.077	.738**
	Sig. (2-tailed)		.000	.000	.000	.005	.000	.330	.000
	N	163	163	163	163	163	163	163	163
Number of employees	Pearson Correlation	-.616**	1	-.149	.309**	.403**	-.043	.401**	-.312**
	Sig. (2-tailed)	.000		.057	.000	.000	.587	.000	.000
	N	163	163	163	163	163	163	163	163
Annual turnover	Pearson Correlation	.789**	-.149	1	.747**	.492**	.886**	.363**	.712**
	Sig. (2-tailed)	.000	.057		.000	.000	.000	.000	.000
	N	163	163	163	163	163	163	163	163
International reach	Pearson Correlation	.456**	.309**	.747**	1	.670**	.801**	.494**	.499**
	Sig. (2-tailed)	.000	.000	.000		.000	.000	.000	.000
	N	163	163	163	163	163	163	163	163
Scale of in-house and cross-company networking	Pearson Correlation	.221**	.403**	.492**	.670**	1	.513**	.781**	.159*
	Sig. (2-tailed)	.005	.000	.000	.000		.000	.000	.043
	N	163	163	163	163	163	163	163	163
Scale of business IS/IT usage	Pearson Correlation	.650**	-.043	.886**	.801**	.513**	1	.398**	.534**
	Sig. (2-tailed)	.000	.587	.000	.000	.000		.000	.000
	N	163	163	163	163	163	163	163	163
Number of offices, retail outlets, service centres, etc	Pearson Correlation	.077	.401**	.363**	.494**	.781**	.398**	1	-.095
	Sig. (2-tailed)	.330	.000	.000	.000	.000	.000		.229
	N	163	163	163	163	163	163	163	163

Range of products or services	Pearson Correlation	.738**	-.312**	.712**	.499**	.159*	.534**	-.095	1
	Sig. (2-tailed)	.000	.000	.000	.000	.043	.000	.229	
	N	163	163	163	163	163	163	163	163

Correlation matrix of BPR attributes (derived from the TOE framework) with the decision to adopt RFID

		Has your company adopted RFID?	adoption of expert systems	restructuring and streamlining activities including removal of non-value adding tasks, controls and checks	centralization of originally dispersed resources and processes, including decision making	provision of decision-support tools	synchronization of IT resources and business processes?	creating strong internal and external motivation for improvement	developing a clear RFID strategy	team orientation and capability development	provision of training and support
Has your company adopted RFID?	Pearson Correlation	1	.697**	.702**	.641**	-.801**	-.195*	.470**	.714**	.389**	.520**
	Sig. (2-tailed)		.000	.000	.000	.000	.013	.000	.000	.000	.000
	N	163	163	163	163	163	163	163	163	163	163
Adoption of expert systems	Pearson Correlation	.697**	1	.870**	.124	-.465**	-.190*	.473**	.817**	.211**	.807**
	Sig. (2-tailed)	.000		.000	.113	.000	.015	.000	.000	.007	.000
	N	163	163	163	163	163	163	163	163	163	163
Restructuring and streamlining activities including removal of non-value adding tasks, controls and checks	Pearson Correlation	.702**	.870**	1	.095	-.639**	.018	.799**	.959**	.109	.822**
	Sig. (2-tailed)	.000	.000		.230	.000	.817	.000	.000	.167	.000
	N	163	163	163	163	163	163	163	163	163	163

Centralization of originally dispersed resources and processes, including decision making	Pearson Correlation	.641**	.124	.095	1	-.428**	-.258**	-.013	.108	.429**	-.135
	Sig. (2-tailed)	.000	.113	.230		.000	.001	.870	.172	.000	.087
	N	163	163	163	163	163	163	163	163	163	163
Provision of decision-support tools	Pearson Correlation	-.801**	-.465**	-.639**	-.428**	1	-.011	-.635**	-.650**	-.136	-.473**
	Sig. (2-tailed)	.000	.000	.000	.000		.892	.000	.000	.083	.000
	N	163	163	163	163	163	163	163	163	163	163
Synchronization of IT resources and business processes	Pearson Correlation	-.195*	-.190*	.018	-.258**	-.011	1	.164*	.031	-.064	-.222**
	Sig. (2-tailed)	.013	.015	.817	.001	.892		.036	.690	.415	.004
	N	163	163	163	163	163	163	163	163	163	163

Correlation matrix of culture attributes and RFID benefits

		company goals and objectives	company focus on performance relative to competitors	company focus on customer satisfaction	top management involvement	Effective decision making	innovation	drive to implement new technologies into business processes	Sales increase	Net profit	Return-on-investment	Market share	Cost reduction	Labor savings	Risk minimization
company goals and objectives	Pearson Correlation	1	-.219**	.196*	.242**	.415**	.383**	-.300**	.110	.344**	.183*	-.175*	.248**	.324**	.406**
	Sig. (2-tailed)		.005	.012	.002	.000	.000	.000	.162	.000	.019	.026	.001	.000	.000
	N	163	163	163	163	163	163	163	163	163	163	163	163	163	163
	Pearson Correlation	-.219**	1	-.542**	-.566**	-.211**	-.465**	-.026	-.209**	-.544**	-.545**	.491**	-.287**	-.052	-.181*

company focus on performance relative to competitors	Sig. (2-tailed)	.005		.000	.000	.007	.000	.740	.007	.000	.000	.000	.000	.506	.020
	N	163	163	163	163	163	163	163	163	163	163	163	163	163	163
company focus on customer satisfaction	Pearson Correlation	.196*	-.542**	1	.866**	.328**	.554**	.061	.158*	.882**	.649**	-.889**	.511**	.146	.318**
	Sig. (2-tailed)	.012	.000		.000	.000	.000	.439	.043	.000	.000	.000	.000	.063	.000
	N	163	163	163	163	163	163	163	163	163	163	163	163	163	163
top management involvement	Pearson Correlation	.242**	-.566**	.866**	1	.429**	.650**	-.055	.197*	.747**	.592**	-.740**	.455**	.193*	.335**
	Sig. (2-tailed)	.002	.000	.000		.000	.000	.488	.012	.000	.000	.000	.000	.013	.000
	N	163	163	163	163	163	163	163	163	163	163	163	163	163	163
Effective decision making	Pearson Correlation	.415**	-.211**	.328**	.429**	1	.575**	-.185*	.288**	.275**	.350**	-.137	.162*	.204**	.433**
	Sig. (2-tailed)	.000	.007	.000	.000		.000	.018	.000	.000	.000	.081	.039	.009	.000
	N	163	163	163	163	163	163	163	163	163	163	163	163	163	163
innovation	Pearson Correlation	.383**	-.465**	.554**	.650**	.575**	1	-.133	.231**	.502**	.437**	-.438**	.304**	.241**	.439**
	Sig. (2-tailed)	.000	.000	.000	.000	.000		.091	.003	.000	.000	.000	.000	.002	.000
	N	163	163	163	163	163	163	163	163	163	163	163	163	163	163
drive to implement new technologies into business processes	Pearson Correlation	-.300**	-.026	.061	-.055	-.185*	-.133	1	-.295**	-.105	-.123	-.071	-.040	-.010	-.282**
	Sig. (2-tailed)	.000	.740	.439	.488	.018	.091		.000	.183	.119	.369	.615	.902	.000
	N	163	163	163	163	163	163	163	163	163	163	163	163	163	163
Sales increase	Pearson Correlation	.110	-.209**	.158*	.197*	.288**	.231**	-.295**	1	.199*	.255**	-.071	-.029	-.053	.142
	Sig. (2-tailed)	.162	.007	.043	.012	.000	.003	.000		.011	.001	.371	.716	.499	.070
	N	163	163	163	163	163	163	163	163	163	163	163	163	163	163
Net profit	Pearson Correlation	.344**	-.544**	.882**	.747**	.275**	.502**	-.105	.199*	1	.612**	-.910**	.557**	.129	.343**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.183	.011		.000	.000	.000	.102	.000
	N	163	163	163	163	163	163	163	163	163	163	163	163	163	163

Return-on-investment	Pearson Correlation	.183*	-.545**	.649**	.592**	.350**	.437**	-.123	.255**	.612**	1	-.514**	.245**	-.035	.284**
	Sig. (2-tailed)	.019	.000	.000	.000	.000	.000	.119	.001	.000		.000	.002	.654	.000
	N	163	163	163	163	163	163	163	163	163	163	163	163	163	163
Market share	Pearson Correlation	-.175*	.491**	-.889**	-.740**	-.137	-.438**	-.071	-.071	-.910**	-.514**	1	-.532**	-.170*	-.257**
	Sig. (2-tailed)	.026	.000	.000	.000	.081	.000	.369	.371	.000	.000		.000	.030	.001
	N	163	163	163	163	163	163	163	163	163	163	163	163	163	163
Cost reduction	Pearson Correlation	.248**	-.287**	.511**	.455**	.162*	.304**	-.040	-.029	.557**	.245**	-.532**	1	.131	.147
	Sig. (2-tailed)	.001	.000	.000	.000	.039	.000	.615	.716	.000	.002	.000		.095	.061
	N	163	163	163	163	163	163	163	163	163	163	163	163	163	163
Labor savings	Pearson Correlation	.324**	-.052	.146	.193*	.204**	.241**	-.010	-.053	.129	-.035	-.170*	.131	1	.346**
	Sig. (2-tailed)	.000	.506	.063	.013	.009	.002	.902	.499	.102	.654	.030	.095		.000
	N	163	163	163	163	163	163	163	163	163	163	163	163	163	163
Risk minimization	Pearson Correlation	.406**	-.181*	.318**	.335**	.433**	.439**	-.282**	.142	.343**	.284**	-.257**	.147	.346**	1